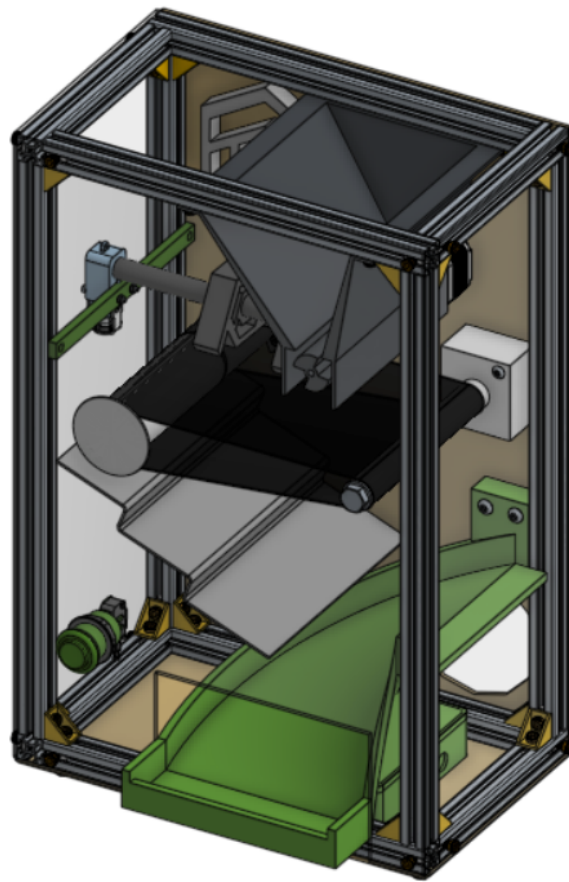


# Onshape Pen Pal

## Final Report



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## Executive Summary

This report presents the design, analysis, and validation of the Onshape Pen Pal, an interactive, self-contained pen dispensing system developed for deployment at Onshape events and conferences. The primary goal of the project was to create a reliable, engaging, and portable device that demonstrates engineering creativity while consistently dispensing one pen per user interaction. The system was designed to operate safely in public settings, comply with airline travel constraints, and function independently without external power.

The final design integrates a multi-stage Rube Goldberg-style mechanism consisting of a controlled hopper, a motor-driven conveyor with rotating obstacles, and a guided exit slide. User interaction is initiated through a QR-code interface and physical controls, triggering a sequence that results in the release of a single pen while collecting user information. This approach balances entertainment value with functional reliability, ensuring that engagement does not compromise performance.

Engineering analysis guided key design decisions, particularly in motor selection and conveyor operation. Torque and speed calculations were performed to determine the minimum mechanical requirements for reliable pen transport, and a motor with sufficient margin was selected to prevent stalling and slipping under load. Pulse-width modulation was implemented to achieve a controlled conveyor speed, ensuring smooth motion and gentle handling of pens throughout the system.

The prototype was validated through functional testing, repeated operation cycles, and direct measurement. Testing confirmed consistent single-pen dispensing, stable conveyor performance, and reliable operation across multiple consecutive cycles. Dimensional and weight measurements verified compliance with airline carry-on size limits and portability requirements. Battery selection and runtime testing demonstrated that the system operates continuously for over one hour on a single charge while remaining within airline safety regulations.

User engagement and usability were assessed through observational testing, confirming that the system provides an intuitive and entertaining experience while remaining simple to operate. Safety considerations were addressed through low-speed actuation, enclosed moving components, and the elimination of exposed sharp edges or wiring. While formal standards testing was beyond the project scope, clear plans for future validation—such as electrical safety checks and accessibility testing—were identified.

Overall, the Onshape Pen Pal successfully meets its defined user needs and engineering requirements. The final design demonstrates a balance of mechanical reliability, user engagement, portability, and safety, making it well-suited for its intended use as a functional and attention-grabbing promotional device at Onshape events.

## Introduction

### Problem Statement:

The Onshape Education team currently lacks an efficient, engaging way to collect visitor contact information and distribute branded giveaways at conferences in a fun, entertaining, and interactive fashion.

### Motivation

The motivation for this project was established in its entirety through early meetings with our client, Chris Tilton [1], who identified the need for an engaging, portable outreach device to enhance Onshape's presence at educational conferences. He noted that current event setups are limited in their ability to collect attendee information efficiently and fail to demonstrate Onshape's engineering capabilities in a memorable way. The motivation stems from the specific outreach goals of the Onshape Education team and a broader technical objective of showcasing all Onshape functionality. The education team attends many events and conferences where they market, teach, and educate students and professionals about the Onshape software and design processes [2]. The immediate problem they face is a two-fold operational and engagement challenge. They need a quick and easy way to collect people's information at these events, and simultaneously, they must provide a compelling "wow" factor to attendees to ensure they remember the Onshape brand. This proves critical because effective brand recall is essential to maximizing their return on investment from expensive conference appearances [1]. Additionally, Onshape wishes to cement their brand as a formidable and direct competitor to well-established CAD applications that have been in circulation for decades. Because of this, brand recall and recognition are paramount to a company still very much in the early stages of establishing an identity in a large industry [1].

The impact of solving this problem extends to several stakeholders. For the Onshape Education team, a successful, portable solution will streamline their workflow, reduce the time spent on manual client information collection, and significantly increase the quality and quantity of valuable sales leads [1]. For conference attendees, the solution provides a memorable, interactive experience that effectively reinforces the brand, turning a simple pen giveaway into a moment of positive engagement [1]. Beyond the direct use at conferences, another key motivation is to provide an educational example for the Onshape company as a whole. The final machine, the Onshape Pen Pal, will serve as a concrete demonstration that an entire, fully functioning system, from CAD modeling to PCB wiring to CNC toolpathing, can be created exclusively using Onshape software. This internal impact is vital for marketing the platform's comprehensive capabilities and advancing the company's reputation as a leader in integrated design-to-manufacture solutions [3].

## Design Solution

### User Needs

The primary stakeholders driving the final need list are the Onshape Education team employees and the conference attendees [1, 3]. The Onshape employees are key because they are the ultimate users of the device at events, and their needs translate directly into the high-importance requirements of portability and reliability. The conference attendees are critical because their positive experience is the measure of the device's success, driving the need for functionality and engagement [1, 3].

The most important user needs, each rated as high importance, are those that directly address the core problem of efficient outreach and brand reinforcement. Engagement is paramount, as it defines the Onshape Pen Pal's ability to capture attention and deliver a memorable, "wow"-inducing experience that reinforces the Onshape brand [1, 3]. Without an engaging display of motion and engineering, the device would fail to stand out in a crowded conference environment. Reliability is equally essential, ensuring the Pen Pal dispenses a pen without fail every time it is prompted; failure here would degrade the intended impact and waste valuable staff time [1]. Functionality is also crucial, as the machine must successfully execute its intended job of collecting visitor information and securely storing all records locally to later be exported, which is necessary for the Onshape team to grow its network of potential clients and users [1]. Additionally, the product must be demonstrative, requiring the entire design process and final output to properly showcase Onshape's modeling and manufacturing capabilities, allowing the marketing team to use it as a tangible example for other students and clients. Finally, the machine must be portable, a need driven by the Onshape employees' busy travel schedule, to ensure it isn't cumbersome and is easy to transport to various conferences [1, 2].

These five needs—engaging, reliable, functional, demonstrative, and portable—collectively drive the entire design process, as they define the minimum acceptable performance for the Onshape Pen Pal to succeed in its intended role.

The user needs listed in Table 1 define the functional and experiential goals that guided all subsequent design decisions. These needs were derived through discussions with the Onshape Education team and reflect both operational constraints and user-facing priorities. Each need is rated by importance to emphasize those that most directly impact conference deployment and attendee engagement. Table 1 serves as supporting evidence for the narrative discussion below.

(Table 1. User Needs)

| Need  | Importance | Description - The Onshape Pen Pal Must...        |
|-------|------------|--------------------------------------------------|
| Quick | Medium     | Dispense a pen quickly to maintain user interest |

|                   |        |                                                                                                  |
|-------------------|--------|--------------------------------------------------------------------------------------------------|
| Reliable          | High   | Dispense a pen without fail every time it is prompted to.                                        |
| Engaging          | High   | Reward engagement through a display of engineering that is memorable.                            |
| Accessible        | Low    | Be usable by everybody, irrespective of physical condition.                                      |
| Safe              | Low    | Present no hazards to conference attendees.                                                      |
| Functional        | High   | Collect visitor information and store all records in Airtable.                                   |
| Airline Compliant | Medium | Abide by all applicable standards for airline travel, including those for batteries and luggage. |
| Demonstrative     | High   | Properly showcase Onshape functionality for use by the organization's marketing team.            |
| Portable          | High   | Not be cumbersome to Onshape employees at conferences.                                           |
| Self Contained    | Medium | Operate continuously for a prolonged period of time without human intervention.                  |

## Key Product Stakeholders

(Table 2. Stakeholder Definition)

| Stakeholders                | Description                                                                                                             |
|-----------------------------|-------------------------------------------------------------------------------------------------------------------------|
| Onshape Education Employees | The Onshape Education Employees will be traveling with the machine, setting it up, and operating it during conferences. |
| Conference Attendees        | Conference attendees interact with the Pen Pal and provide client information to it.                                    |

## Engineering Requirements

Engineering requirements translate the qualitative user needs into measurable, verifiable targets that constrain the final design. These requirements are summarized in Table 3 and are directly referenced throughout this section. For clarity, the relationship between key user needs and key engineering requirements is explicitly mapped in Appendix B, allowing the reader to trace how stakeholder priorities informed technical decisions.

The device must operate autonomously for a minimum of one hour without external power (Target: >1 hour), as it is intended for use at conference booths where access to outlets may be limited or impractical. Typical conference interactions occur in bursts during peak foot-traffic periods, often lasting 60–90 minutes between staff rotations or charging opportunities [1]. A one-hour minimum runtime therefore represents a conservative baseline

that ensures uninterrupted operation during high-engagement intervals while maintaining compliance with airline battery restrictions. The storage capacity must accommodate a minimum of 30 pens (Target: >30 pens) to meet the Pen Capacity requirement, which ensures continuous operation for at least one hour, assuming an average user interaction rate of one pen dispensed every two minutes, before requiring a refill [1]. The setup time for the Pen Pal system shall be under five minutes (Target: <5 min) to minimize operator burden and ensure rapid deployment.

Another critical requirement, the “Fun Factor,” directly supports the engaging user need by ensuring the Pen Pal includes three individual Goldberg modules. These modules introduce movement, variety, and visual intrigue—key attributes that attract and retain attendee attention. Each module serves as an independent mechanical feature that contributes to the overall spectacle of the design, providing a balance of entertainment and engineering demonstration. This requirement (Target: 3 modules) quantifies engagement, transforming a subjective design goal into a measurable engineering target. By setting a minimum of three modules, the design guarantees sufficient complexity and motion to create the desired “wow factor” for users while maintaining repeatability and reliability in operation.

The most important engineering requirements, rated as high, directly relate back to the key user needs of portability and airline compliance (addressed by the battery power and frame size requirements). The total system weight shall not exceed 20 pounds (target: <20 lbs.) to meet the high user need for portability and ease of transport for the Onshape employees. Similarly, the external frame size must remain within 22” × 14” × 8” (target: 22” × 14” × 8”) to meet the high user need for portability by fitting within standard carry-on luggage constraints. Crucially, the battery power requirement enforces a cap of <100 Wh to meet the airline-compliant user need, ensuring the battery is allowed in carry-on luggage according to IATA Dangerous Goods Regulations.

Standards are crucial for the design, as they provide mandated safety and logistical boundaries that ensure the device can be used successfully in its intended environment (air travel and conferences). The most important code and standard for this project is the IATA Dangerous Goods Regulations. This standard applies directly to the design of the power system and the overall physical assembly. Crucially, the battery power requirement enforces a cap of <100 Wh to meet the airline-compliant user need. According to the International Air Transport Association (IATA) Dangerous Goods Regulations, lithium-ion batteries carried in passenger luggage must not exceed 100 Wh [4]. This standard directly constrains battery selection and ensures that the Pen Pal can be transported legally in carry-on luggage. Additionally, federal regulations governing air travel and carry-on dimensions implicitly set the requirement for frame size and weight. We would ensure compliance by selecting a battery explicitly rated at less than 100 Wh from a certified manufacturer and by having the final assembled frame measured against the 22” × 14” × 8” limit to confirm it fits within a standard carry-on sizer before deployment. Compliance with these standards is

non-negotiable, as failure to meet them would render the machine unusable by the Onshape team due to travel restrictions.

(Table 3. Engineering Standards)

| Req.             | Importance | Unit                     | Target         | Description - The Onshape Pen Pal must...                                                                                       |
|------------------|------------|--------------------------|----------------|---------------------------------------------------------------------------------------------------------------------------------|
| Battery Life     | Medium     | hour                     | > 1 hour       | Be able to power all components simultaneously for a minimum of one hour without charge.                                        |
| Weight           | High       | lbs.                     | < 20 lbs.      | Not weigh, with all included components, more than 20 lbs.                                                                      |
| Pen Capacity     | Medium     | # Pens                   | > 30 pens      | be able to hold a minimum of thirty pens at a time without needing to be refilled.                                              |
| Set-up Time      | Medium     | min                      | < 5 min        | be fully operational in less than five minutes.                                                                                 |
| Frame Size       | High       | inches                   | 22" × 14" × 8" | not exceed the dimensions of carry-on luggage.                                                                                  |
| Battery Power    | High       | Wh                       | < 100 Wh       | Not use Lithium-ion batteries that exceed 100 Wh [4].                                                                           |
| Fun Factor       | High       | # Modules                | ≥ 3            | have at least three individual goldberg modules.                                                                                |
| Onshape Showcase | Medium     | # Onshape Branded Pieces | ≥ 2            | use new Onshape functionality (PCB Studio, toolpathing) to showcase the full breadth of Onshape services.                       |
| Data Capacity    | Medium     | # contact info collected | > 100          | be able to store, at minimum, 100 individual clients and their information, which is an expected number of booth attendees [1]. |

(Table 4. Carry-on Luggage Requirements)

| Airline   | Size Restrictions [5] |
|-----------|-----------------------|
| American  | 22" × 14" × 9"        |
| Delta     | 22" × 14" × 9"        |
| Southwest | 22" × 16" × 10"       |
| United    | 22" × 14" × 9"        |

## Competitive Benchmarking

To contextualize the Onshape Pen Pal within the existing solution space, a competitive benchmarking analysis was conducted to evaluate current approaches to conference-based data collection and promotional item distribution. This analysis focuses on how existing solutions address the key user needs of engagement, portability, reliability, and demonstrative engineering value, and highlights the gaps that motivate the Onshape Pen Pal.



*Courtesy of Cvent [9]*



*Courtesy of VendX [7]*



*Courtesy of Rentacomputer [8]*

Cvent Lead Capture is a data collection tool designed to help event attendees efficiently collect, manage, and qualify visitor information during in-person events. Using mobile devices or tablets, users can scan attendee badges, business cards, or QR codes to instantly capture contact details and track engagement. Lead Capture doesn't innately fulfill all of Onshape's needs, as it doesn't provide an engaging experience and does not demonstrate Onshape's key functionality.

VendX is an experiential, interactive vending machine platform. At events, trade shows, or permanent brand activations, VendX lets companies dispense samples or products in exchange for consumer engagement actions like social shares, surveys, game play, or email capture. It supports both touch-screen and touchless interactions and is fully brandable in terms of UI. However, these machines are not portable, meaning they cannot be brought across conventions and are used at permanent locations.

Rentacomputer's Branded Vending Machines are customizable, tech-enabled vending units designed to create an interactive and memorable experience at events, trade shows, and expos. Companies can rent these machines and fully wrap them with their own branding, allowing them to stand out while distributing promotional items or giveaways. Similarly to VendX, these machines are stationary, leaving the portability need unsatisfied. Additionally, they are only available through renting.

Collectively, these benchmarking examples reveal a clear gap in the current market for an outreach device that is simultaneously engaging, portable, and demonstrative of engineering capability. Existing solutions such as Cvent Lead Capture prioritize efficient data collection but lack physical engagement and fail to showcase technical creativity. Conversely,

experiential vending platforms like VendX and Rentacomputer's branded machines deliver strong visual impact and interactivity but are large, stationary, and impractical for frequent air travel, making them unsuitable for conference-to-conference deployment. None of the evaluated alternatives balance user engagement, portability, airline compliance, and on-site autonomy within a single, self-contained system. This gap directly motivates the Onshape Pen Pal: a compact, carry-on-compliant device that combines reliable data capture with a mechanically engaging experience while simultaneously serving as a tangible demonstration of Onshape's end-to-end design and manufacturing capabilities.

## **Concept Generation & Selection**

Concept generation and selection were used to explore a broad range of potential solutions and systematically converge on a design that best satisfies the identified user needs and engineering requirements. Concepts were generated, refined, and compared to understand tradeoffs in engagement, reliability, portability, and functionality, ultimately informing the evolution of the Onshape Pen Pal across multiple design iterations.

### **Early Concept Generation and Client Discussion**

All concept sketches referenced in this section can be found in Appendix A: Concept Sketches.

Concept generation began with individual ideation, where all four members of our group created preliminary ideas reflecting their initial vision for the product. Prior to this session, we met with our client, Chris Tilton, for an initial discussion. Chris elaborated on his specific user needs and requirements, providing a document that outlined these needs [3]. Notably, he emphasized the 'engagement' requirement, expressing a desire for the final product to share similarities with a Rube Goldberg machine [10] while still maintaining core functionality, easy setup, and high repeatability. With this conversation in mind, our group generated four separate sketches, one from each member, as a preliminary vision for the project.

### **Concept Selection**

Each preliminary concept sketch emphasized a different user need, ensuring that early ideas addressing all requirements were considered from the project's inception.

One sketch focused heavily on the data collection device, utilizing a touchscreen to gather visitor information. However, following discussions with course instructors, we determined that the scope of the first prototype would not include data collection. Consequently, the associated data collection strategies and concept sketch were shelved for the initial prototype phase.

The other ideas, the Rube-Goldberg concept, the rotary dispensation concept, and the pen dispensation concept, were deemed within the scope of the first prototype and were revisited frequently during subsequent brainstorming.

## Design Adoption and Refinement

Ideas from the pen dispensation concept were quickly adopted due to their practicality and ability to hold a substantial reservoir of pens. This directly addressed the high-importance user need for reliability, ensuring a consistent single-pen dispense each time, and the functional need to distribute branded pens effectively.

We selected the hopper design as the primary method for pen storage and dispensing. This choice was driven by its ability to be self-contained within the device, easily mounted to the main frame, and its capacity to dispense one pen at a time using a simple, rotating inner mechanism driven by a stepper motor. By being compact and modular, this design also satisfies the self-contained and portable user needs, enabling easy transport and setup at conferences.

We also adopted the conveyor idea to serve as one of the device's 'Goldberg modules'. Its simplicity, driven by a single wheel with a DC motor with an idler wheel for stabilization, makes it easy and reliable to integrate while providing a visually engaging, "flashy" motion for the audience. This element was chosen primarily to meet the engaging and demonstrative user needs, providing visible motion and engineering appeal to attract conference attendees.

Finally, we adopted the concept's vertical design, believing it offered the greatest potential for leveraging gravity to create controlled and visible motion. The vertical frame also reinforces portability by maintaining a compact footprint while enhancing engagement through clear, viewable motion.

For the project's requirement of a CNC machined part, we designed a 3D Onshape logo and toolpathed it in Onshape's new software. The software is relatively new and not as reliable or easy to use yet so it was a challenge to toolpath the part correctly. After several meetings with Vinn, the part was machined in two sessions. The part is large and heavy, but was a first run at working with the Onshape toolpathing, and will continue to be reiterated for the final prototype.

The rotary dispensation concept offered little thought on how pens would be fed to the rotating 'carousel.' Moreover, since the pen hopper held pens horizontally, the rotary device would require complex manipulation to orient the pen vertically for display. These challenges made the rotary dispensing concept impractical, and no ideas from it were incorporated into our first prototype. This concept was rejected because it failed to meet the reliability and quick user needs, introducing unnecessary complexity that risked inconsistent pen delivery and longer setup time.

The final preliminary sketch, the Rube Goldberg concept, featured numerous ideas for preliminary 'Goldberg modules.' While some proved practical, others were quickly discounted. Specifically, the Ferris wheel and the unstable bucket structures were deemed unviable for a prototype due to their unpredictability and excessive dependence on precise,

time-consuming setup. These features conflicted with the quick and reliable user needs, as they increased setup time and reduced repeatability. However, the slide idea was adopted into our first prototype. The slide effectively uses the vertical frame and gravity to create a show, while its deterministic path ensures predictability and repeatability. This feature strongly supports the engaging and reliable user needs by maintaining controlled, repeatable motion that still provides visual appeal.

Ultimately, ideas from two key sketches—the Rube Goldberg concept and the pen dispensation concept—were adopted into the design of the first prototype. Together, these concepts balance engagement, reliability, and portability, the three highest-priority user needs defined by the client and design team. Ideas from the data collection concept were adopted for the second prototype. The focus for the second prototype was to incorporate data acquisition to the Pen Pal, primarily satisfying the functionality user need and data capacity engineering requirement. For the second prototype data acquisition was handled using a QR code that sends the client to a website where they fill in their information. This was chosen for its simplicity and accessibility.

### Decision Matrix

To evaluate our design concepts systematically, we developed a decision matrix comparing our initial ideas and both prototype iterations against key engineering requirements [11]. Each requirement was assigned a weighted value adding up to 100, reflecting its relative importance to the overall design. We then rated each prototype on a scale of 1 to 5 based on how effectively it met each requirement. After calculating the weighted totals, our second prototype achieved the highest overall score, indicating the most successful performance.

(Table 5. Decision Matrix)

|                          | Criteria         |                | Early Concept Ideas         |                         |                             |                                | Prototypes      |                  |
|--------------------------|------------------|----------------|-----------------------------|-------------------------|-----------------------------|--------------------------------|-----------------|------------------|
| Engineering Requirements |                  | Weighted score | Large Rube Goldberg concept | Data collection concept | Rotary Dispensation Concept | Early Pen Dispensation concept | First Prototype | Second Prototype |
|                          | Fun Factor       | 3.0            | 15                          | 6                       | 9                           | 6                              | 12              | 12               |
|                          | Weight           | 1.0            | 2                           | 3                       | 4                           | 3                              | 2               | 2                |
|                          | Pen Capacity     | 2.0            | 6                           | 6                       | 2                           | 10                             | 10              | 10               |
|                          | Set-Up Time      | 2.0            | 2                           | 6                       | 4                           | 8                              | 8               | 8                |
|                          | Onshape Showcase | 2.0            | 8                           | 4                       | 4                           | 4                              | 4               | 8                |
|                          | Total Score      | 50             | 33                          | 25                      | 23                          | 31                             | 36              | 40               |

### Engineering Analysis<sup>1</sup>

With many of our ‘Goldberg modules’ being motorized, determining motor speed, torque, and size is of particular importance and hones the skills learned in ME30 - Electronics and Controls I and ME41 - Engineering Design II [12, 13]. The driven spool of our conveyor requires the most analysis, as it is required to handle a substantial amount of torque to drive the conveyor belt while maintaining a low speed so as to not launch the pen off of the conveyor and place it gently on the next ‘Goldberg module.’

We first need to define characteristics on the belt itself. The length of one of the Onshape branded pens is roughly five and a half inches. We would like the entire pen to fit on the conveyor belt, with some additional room on each side of the belt. Therefore, we chose to use a 6-inch belt width. Additionally, we would like the belt to run nearly the entire usable horizontal expanse of our frame, which is slightly above ten inches. Therefore, when accounting for both the top and bottom of the conveyor as well as the distance around the guiding spools, which are 2 inches and 0.8 inches respectively, the belt as a whole will be roughly twenty inches long. Additionally, we assume the belt makes solid contact with the guiding spools for 180° or  $\pi$  radians, the coefficient of friction between the belt and spool is 0.5. The slack-side belt preload was taken as 5 lbf, based on an experimental measurement in which the driven spool was held stationary and the idler spool was pulled using a force meter to tension the belt by hand. The thickness of the belt is 0.13 in, and the material is PVC 120 [14]. Assuming the width is negligible.

$$\text{Belt Weight} = L \cdot W \cdot H \cdot \rho = 20 \text{ in} \cdot 6 \text{ in} \cdot 0.13 \text{ in} \cdot \left(\frac{1 \text{ ft}}{12 \text{ in}}\right)^2 = 1.152 \text{ lb}$$

The most crucial variable to determine is how much torque needs to be provided by the 12 V motor to spin the belt. This can be determined from a series of equations that relate the tension in the top and bottom sides of the belt to other system variables that have been assumed, such as spool radius and spool contact angle. In the following equations,  $F_1$  represents the tight-side tension,  $F_2$  represents the slack-side tension,  $r$  represents the pulley radius,  $T$  represents the required torque of the motor,  $\mu$  represents the friction coefficient between the pulley and spool, and  $\theta$  represents the spool-belt contact angle.

$$\begin{aligned} \frac{F_1}{F_2} &= \frac{F_t}{F_i} = e^{\mu\theta} \Rightarrow F_1 = F_i e^{\mu\theta} = (5 \text{ lbf})e^{(0.5)(\pi)} = 24.052 \text{ lbf} \\ T &= (F_1 - F_2)r \Rightarrow T = (24.052 \text{ lbf} - 5 \text{ lbf})(0.75 \text{ in}) = 14.29 \text{ lbf} \cdot \text{in} \approx 1.161 \text{ Nm} \\ \eta &= 2.5 \Rightarrow T_{req} = 2.9025 \text{ Nm} \end{aligned}$$

This is the torque required to move the belt itself with no additional applied load. In the case of the Pen Pal, the only load it is carrying is a single pen, which is assumed to be negligible as an account for its lightweight.

---

<sup>1</sup> Analysis learned from ME30 - Electronics and Controls I and ME41 - Engineering Design II

This analysis was used to verify that the selected motor could reliably drive the conveyor under worst-case conditions rather than to optimize conveyor geometry. At the time of analysis, belt length, pulley radius, and layout were already constrained by the frame dimensions and pen geometry. The primary design decision informed by this calculation was motor selection, ensuring sufficient torque margin to overcome static friction and avoid stalling while maintaining gentle pen handling.

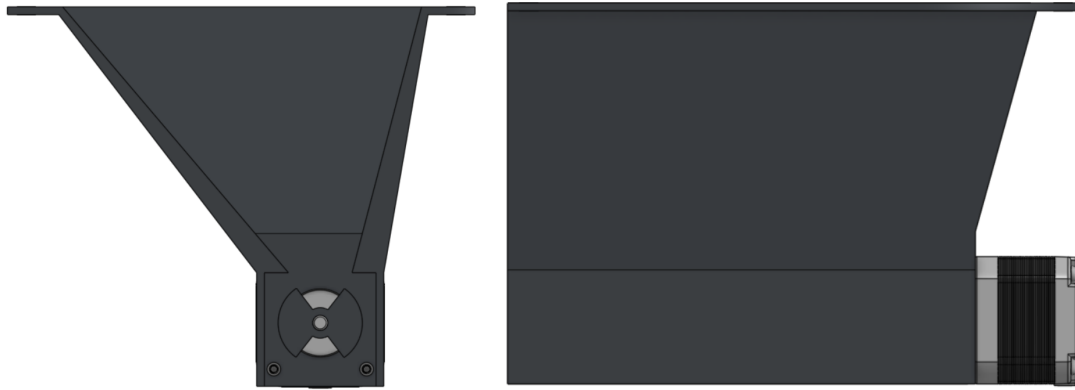
This 2.9025 Nm requirement directly drives the motor selection, as the motor used needs to be able to supply enough torque at a sufficiently slow speed. Because the torque of the motor is directly related to the speed at which it turns, the desired speed of the conveyor and the consequent rotation speed of the motor need to be determined. It was estimated that the pen should leave the conveyor with a horizontal velocity of  $0.05 \text{ m/s} \approx 2 \text{ in/s}$ , so it does not travel far horizontally while moving to the next 'Goldberg module'. This yields a rotational speed of the motor shown below:

$$\omega = \frac{v}{2\pi r} = \frac{2 \text{ in/s}}{2\pi(0.75)} = 0.4244 \frac{\text{rad}}{\text{s}} \approx 4 \text{ rpm}$$

Therefore, we need a motor that can pull, at a minimum, 2.9025 Nm at 4 rpm. The Pen Pal features a Greartisan 12 VDC Gear Motor that is specified to have a stall torque of  $42 \text{ kg cm} \approx 4.12 \text{ Nm}$ , which satisfies the torque requirement.

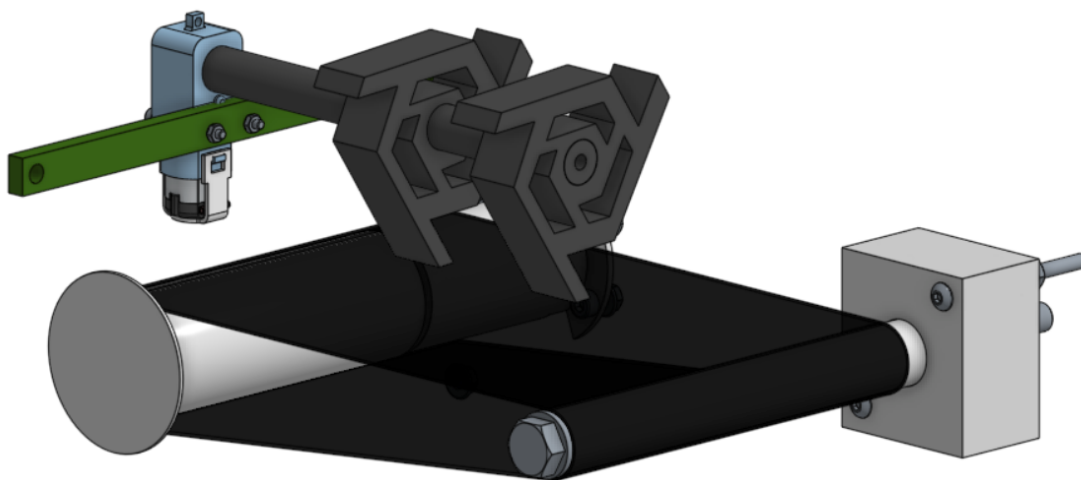
### Final Solution Description

The final design solution for the Onshape Pen Pal contains four separate Goldberg modules. At the top of the Pen Pal, there is a hopper full of pens. The hopper is actuated when a user enters their information to the Pen Pal's Raspberry Pi. This is achieved through scanning a QR code located on the bench where the Onshape Pen Pal is situated. The QR code sends the user to a site that is hosted publicly by the Raspberry Pi. The website is served by a Flask application managed by a dedicated system service (flask.service), which handles the input. Once the user presses the button labeled "Dispense Me a Pen!", the Flask app receives a web request, records the user's data to a CSV file (also the location where user information may be accessed), and immediately writes a timestamp to a local flag file (new\_data\_flag.txt). This flag is detected by a separate motor control service (motor.service) running in the background, which then validates the request and begins the dispensing sequence. The Raspberry Pi actuates the stepper motor attached to the hopper. The stepper motor is attached to a pinwheel that rotates 180 degrees with each activation. Through this, a single pen is dispensed for each user. This brings the pen to the second Goldberg module, a conveyor that also serves as a gamification of the pen dispensation process.

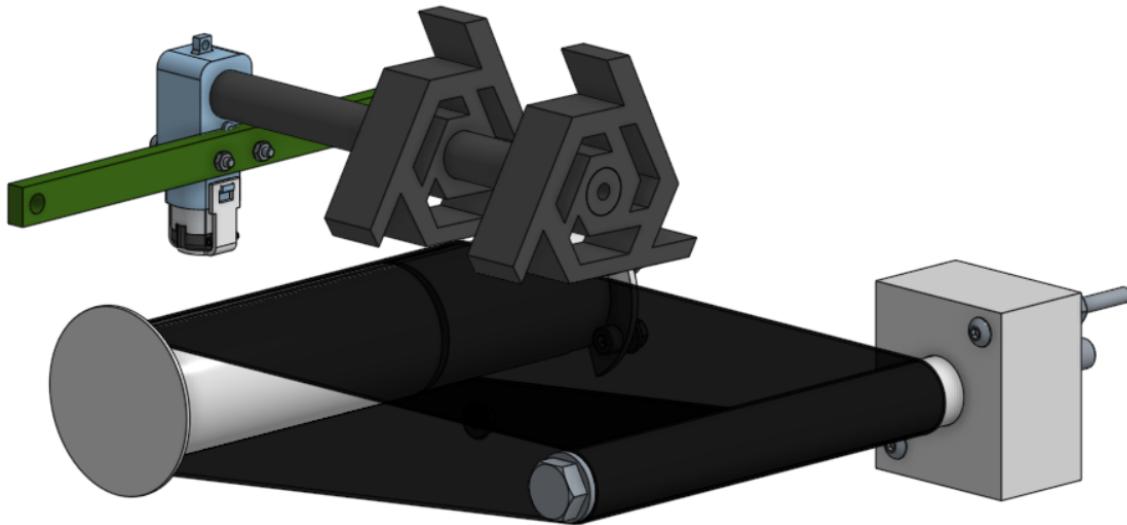


(Figure 1. Carry-on Front and Side Profiles of the Hopper showcasing Pinwheel and Motor)

Once the pen is dispensed to the hopper, the motor.service actuates a motor located on the side of the enclosure. This gear motor has an attachment containing Onshape logos. The Onshape logos spin, providing an obstacle the pen must avoid. The user guides the pen through the use of a button on the front piece of acrylic. This button actuates a 12V gear motor that controls the conveyor's movement. Through this, the user is in control of the pen's journey past the rotating obstacles. The obstacles are designed such that at certain angles, the pen can safely pass through, while at other angles, the path of the pen is obstructed. Additionally, the motor controlling the obstacles is slowed with pulse width modulation to be an appropriate speed to provide a moderate challenge. The end goal of this gamification is to provide safe engagement. Ideally, even if the pen is obstructed from passing, it will not fall from the conveyor or change orientation in a way that makes the game harder. This safety, in turn, provides a reliable way of engaging the user that also guarantees the pen is dispensed to the end user.

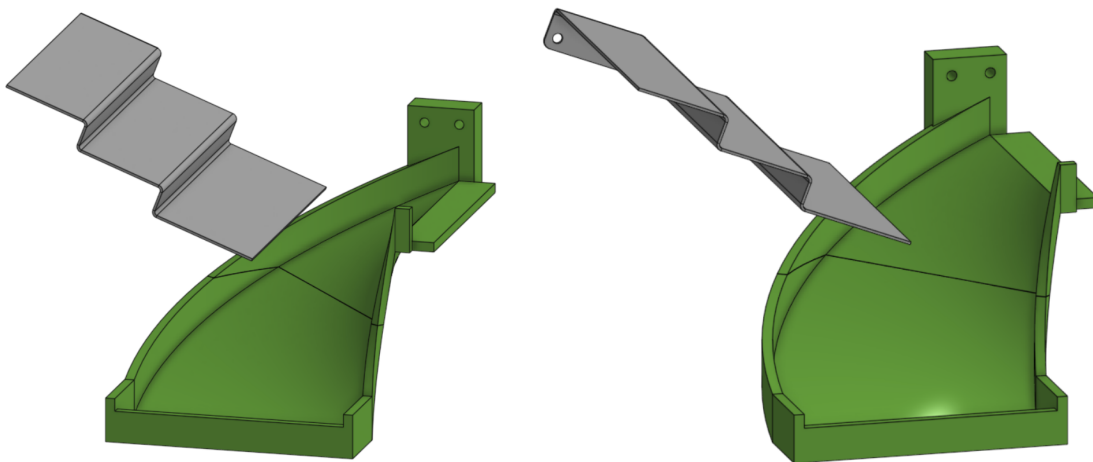


(Figure 2. Photo Highlighting Conveyor and Obstacles in Blocked Position)

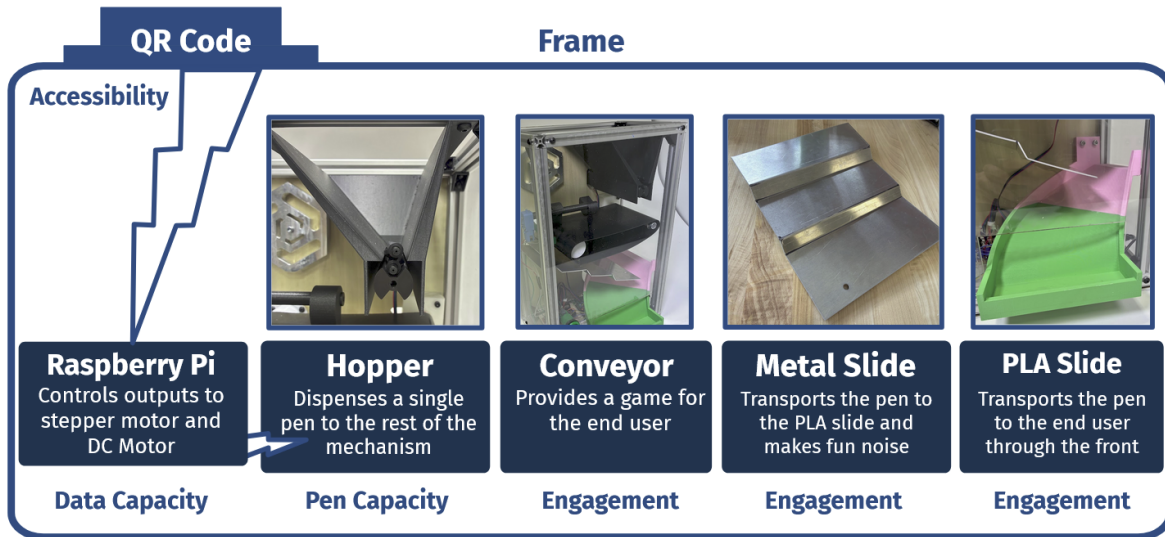


(Figure 3. Photo Highlighting Conveyor and Obstacles in Open Position)

From the conveyor, the pen is brought to a series of slides, the first being a bent sheet metal slide and the second being a 3D-printed PLA slide. In the first prototype, course instructors and classmates provided feedback about the use of noise as an engagement factor. They noted that the noise of the pen hitting sheet metal was a highlight of the first iteration [15]. To supplement this, a staircase-inspired sheet metal bend slide was created. As the pen falls from one stair to the next, the end user receives successive noises of the pen hitting the metal, maximizing engagement. This then brings the PLA slide, a feature that has been in our design since the first prototype. The purpose of the PLA slide is to reorient the pen to the end user out the front of the enclosure. The conjunction of these slides provided an engagement factor from sensory stimuli while providing the culmination of the pen's journey to the end user.

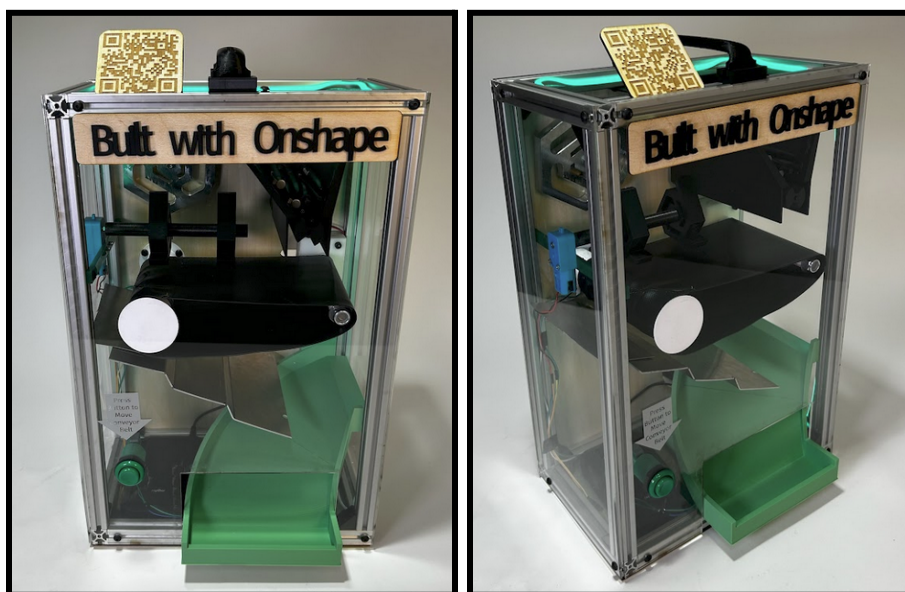


(Figure 4. Photo Showcasing both Slides and how they Intermesh)



(Figure 5. Process flow of pen dispensation)

This Goldberg machine-inspired process is self-contained within an enclosure made of 8020 aluminum extrusion, acrylic, and plywood sheets. There are acrylic sheets on the front, left, and right views of the Pen Pal for easy viewing access of the contents and process of delivering a pen. The bottom and back views use plywood to provide rigid connecting points for Goldberg modules to be attached. Additionally, careful consideration was put into the dimensions of the frame so as to satisfy the carry-on compliance user need. All 8020 framing fasteners were of the same variety, that being M5 socket head fasteners. This was the preferred fastener type; however, some other fastener sizes had to be used for the conveyor and slide. Aesthetic features, such as green LED lights, were also included to serve as an attraction at conferences and conventions.



(Figure 6. Front and Isometric Views of Physical Prototype)

## Validation of Design Solution

The final Onshape Pen Pal design was validated against the previously defined user needs and engineering requirements through a combination of analytical calculations, physical prototyping, functional testing, and dimensional verification.

### *Reliability, Set Up and Functional Performance*

The highest-priority user need for reliability was validated through repeated functional testing of the full pen-dispensing sequence. During bench testing, the Pen Pal was actuated over multiple consecutive cycles, with each cycle consisting of QR-code activation, hopper rotation, conveyor traversal, obstacle interaction, and final pen delivery. In all observed trials, exactly one pen was dispensed per user input, with no double-feeds or jams occurring. This directly validates the Reliable user need and the Pen Capacity (> 30 pens) and Functional engineering requirements.

The hopper dispensing mechanism was validated through its stepper-motor-driven pinwheel design, which rotates a fixed 180° per actuation. This discrete motion physically constrains the system to release only one pen at a time, independent of user behavior. Because this behavior is enforced by geometry rather than timing alone, reliability is not dependent on precise motor speed control, increasing robustness during extended use.

To set up the Onshape Pen Pal, all that is required is turning the power supplies on. This involves flipping the power switch for the power supply controlling the motors, and plugging the Raspberry Pi into its USB A power supply. Both devices are powered by the same power supply, which has both 12 and 5 V outputs. This results in a set-up time far less than one minute, satisfying the Set Up time engineering requirement.

### *Engineering Calculations and Mechanical Validation*

Quantitative engineering analysis was used to validate motor selection and ensure smooth, controlled motion throughout the system. As detailed in the Engineering Analysis section, the conveyor belt system was analyzed to determine required torque based on belt tension, friction coefficient, pulley radius, and contact angle. The calculated minimum required torque of 2.90 N·m at approximately 4 rpm directly informed motor selection. The chosen 12 V DC gear motor provides a stall torque of 4.12 N·m, exceeding the required torque with margin and validating that the system can overcome both static friction and operational loads [12, 13].

This analytical validation is supported experimentally by successful conveyor operation under load, where pens traverse the belt without slipping, stalling, or excessive acceleration. In testing, it was found the conveyor moves at an appropriate speed without the need of modification through the use of pulse width modulation (PWM) [16]. An appropriate conveyor speed ensures gentle pen handling and controlled transitions between Goldberg modules.

### *Engagement and User Interaction*

The Engaging user need and the Fun Factor ( $\geq 3$  modules) requirement were validated through direct observation of user interaction during informal testing with classmates and instructors [16]. The final design incorporates four distinct Goldberg modules: the hopper, conveyor with rotating obstacles, sheet metal staircase slide, and PLA exit slide. These modules provide visible motion, auditory feedback, and user-controlled interaction.

User testing showed that the button-controlled conveyor successfully creates a gamified experience while nearly guaranteeing pen delivery. While not appearing in pre-demo testing, some users found that the pen changed orientation as a result of hitting the obstacle. Additionally, this change in orientation caused the pen to not be reliably delivered to the user. This, however, happened rarely, and confirms that engagement was achieved with minor compromises to reliability [16].

### *Portability, Weight, and Dimensional Compliance*

Portability and airline compliance were validated through direct measurement of the assembled prototype. The external frame dimensions were measured and confirmed to be within 22" × 14" × 8" at final dimensions of 19.7" × 13.0" × 8.0", satisfying the Frame Size requirement and aligning with carry-on limits for major airlines [5]. The full system weight was measured below the 20 lb target at 15 pounds 6 ounces, validating ease of transport for Onshape employees [1].

Battery compliance with IATA Dangerous Goods Regulations was validated by design selection rather than destructive testing. A lithium-ion battery rated below 100 Wh, at 72 Wh, was selected from a certified manufacturer, ensuring airline compliance by specification [4]. If additional time were available, validation would include documentation review of battery certification and labeling, followed by verification of electrical load to confirm the battery operates within its rated discharge limits during continuous use.

### *Battery Life and Continuous Operation*

The Battery Life (>1 hour) requirement was validated through power budgeting and timed runtime testing. The system was operated continuously with all motors, LEDs, and the Raspberry Pi active for a period exceeding one hour without voltage drop or functional degradation [16]. At the final design showcase, the entire system stayed fully functional without recharging for over 90 minutes. While this test confirms the minimum requirement, extended runtime testing over multiple charge cycles would be conducted in future iterations to evaluate battery aging and long-term reliability. It should be noted that the battery pack used contains an indicator of remaining charge represented by four green LEDs. In the 90 minutes that the Pen Pal was in use during the showcase, the indicator showed no change in charge.

### *Accessibility and Safety*

Accessibility was addressed by ensuring that all user interactions require minimal physical effort and fine motor control. The primary user interface relies on a QR code and mobile device, allowing users to enter information using their own accessible technology. The conveyor button is large, front-facing, and reachable from a standing or seated position, aligning with ADA reach guidelines [17]. If additional time were available, formal accessibility validation would include user testing with individuals of varying heights and mobility to confirm comfortable reach and interaction.

Safety was validated through visual inspection and controlled operation of all moving components. Motors operate at low speeds and torques, and all moving mechanisms are enclosed behind acrylic panels, eliminating direct access to pinch points during normal use [18]. No sharp edges or exposed wiring were present on the prototype. With additional time, a formal safety assessment would be conducted, including pinch-point analysis and electrical safety testing, to fully certify the system for public deployment.

### *Standards and Future Validation*

While dimensional, weight, and battery power standards were validated through measurement and component selection, additional standards testing would be conducted with more time. Specifically, safety validation would include a formal pinch-point analysis and guarding assessment per common machinery safety guidelines [18]. Electrical validation would include fuse testing, insulation checks, and verification of grounding continuity. Accessibility validation would involve structured testing against ADA reach and height requirements using standardized anthropometric data [17].

## **Production Plan and Ethical Considerations**

### **Production Plan**

Manufacturing the Pen Pal would involve fabricating multiple components using a range of methods, followed by an involved assembly process to bring them together. Beginning with the frame—while it currently provides a solid foundation and flexibility for prototyping—it could be replaced with custom-extruded aluminum profiles joined by welds. This change would reduce the overall part count and significantly decrease assembly time by removing the most finicky elements: the screws and brackets [19, 20]. The slide could be redesigned for injection molding, with geometry adjustments to improve manufacturability and consistency. The hopper would also benefit from injection molding, as its complex geometry makes it difficult to machine efficiently. The switch to injection molded parts opposed to 3D printed parts provides a better surface finish, increasing the functionality of both the feeding mechanism and the slide [21]. The conveyor system could transition to a molded plastic roller paired with a CNC-machined motor mount, with a similar support assembly on the opposite

end. Lastly, the clink-clank component could be formed using a CNC press brake to ensure repeatable geometry, though its current sheet metal bending process is already well-suited for manufacturing, as sheet metal processes can be automated, especially for simple geometries like the clink clank [22]. Overall, these adjustments would allow the Pen Pal to transition smoothly from a prototype to a manufacturable product. By standardizing materials, reducing part complexity, and refining fabrication methods, the design could be produced efficiently at either small or large scale while maintaining the functionality and aesthetic of the original concept.

### **Ethical and Social Considerations**

Accessibility is a primary ethical consideration for the design and deployment of the Onshape Pen Pal, as the device is intended for use in public conference environments with diverse users and varying physical, sensory, and technological abilities. Because conference attendees may include individuals with limited mobility, reduced reach, visual impairments, or differing levels of comfort with physical interaction, the system must be designed to minimize barriers to participation and ensure equitable access to its core functionality. Failing to account for accessibility could unintentionally exclude certain users from engagement, undermining both the ethical responsibility of inclusive design and the outreach goals of the Onshape Education team [17].

To address these concerns, the Pen Pal was designed with interaction mechanisms that require minimal physical effort and fine motor control. User engagement is initiated primarily through a QR code interface, allowing attendees to input information using their own mobile devices and any accessibility features already enabled on those devices, such as screen readers, magnification, or alternative input methods [17]. This approach reduces reliance on fixed, potentially inaccessible input hardware and supports a broader range of user needs. Additionally, the physical interaction required to operate the conveyor system is limited to a single, large, front-facing button, reducing dexterity demands and allowing use from both standing and seated positions.

Physical accessibility considerations were guided by the Americans with Disabilities Act (ADA) Standards for Accessible Design, particularly Section 308, which specifies allowable reach ranges for operable controls [17]. Button placement and QR code positioning were selected to fall within these recommended reach envelopes, supporting access for wheelchair users and individuals of shorter stature. Visual accessibility was also considered through the use of transparent acrylic panels that clearly expose internal motion, reducing reliance on auditory cues alone to understand system operation. While the current prototype does not include tactile or auditory guidance features, the design avoids unnecessary complexity that could hinder accessibility and establishes a foundation for future inclusive enhancements.

If additional development time were available, further accessibility validation would be conducted through structured user testing with individuals representing a range of physical

abilities and assistive technology use. This testing would assess reach comfort, interaction clarity, and ease of understanding the dispensing process. Potential future improvements include incorporating visual status indicators (e.g., LED cues), optional auditory feedback, and alternative activation methods to further reduce barriers to use. By explicitly prioritizing accessibility, the Onshape Pen Pal aligns with ethical engineering principles of inclusivity and ensures that engagement opportunities at conferences are available to the widest possible audience [17].

## **Conclusions**

### **Strengths of Design Solution**

The Onshape Pen Pal successfully addresses the core challenge identified by the client: creating an engaging, portable device that efficiently collects visitor information while demonstrating Onshape's comprehensive design capabilities [1]. The final design's greatest strength lies in its successful integration of engagement with little compromise to reliability, two competing priorities that are often difficult to balance. Through implementing four distinct Goldberg modules (hopper, conveyor with obstacles, sheet metal staircase, and PLA slide), the device consistently dispenses exactly one pen per user interaction while providing a memorable, gamified experience that generates the desired "wow factor" for conference attendees.

The design excels in portability and airline compliance, measuring 19.7" × 13.0" × 8.0" and weighing only 15 pounds 6 ounces, well within carry-on requirements for all major airlines [5]. The 72 Wh battery ensures over 90 minutes of continuous operation while remaining compliant with IATA regulations, and the setup process requires less than one minute, simply involving powering on two components, which minimizes operational burden on Onshape employees during busy conference environments [1, 3, 4].

From a technical demonstration perspective, the Pen Pal effectively showcases Onshape's end-to-end capabilities, from CAD modeling to CNC toolpathing to PCB design integration. The modular construction using 8020 aluminum extrusion, acrylic panels, and precisely engineered mechanical components provides both visibility into the system's operation and a tangible example of what can be achieved using Onshape's platform. The QR-code-based data collection system successfully meets the functional requirement while maintaining accessibility and ease of use [17, 23].

### **Limitations of Design Solution**

Despite its successes, the current design has several notable limitations. The CNC-machined Onshape logo, while demonstrating the new toolpathing software, proved challenging to produce due to the relative newness of the software and required multiple machining sessions. The part's large size and weight also make it less practical for the overall portability

goal, suggesting that future iterations should prioritize functionality over size in showcasing capabilities [25].

The conveyor-based gamification, while engaging, introduces a potential point of user frustration if the timing challenge is perceived as too difficult or if users are unclear about the button's function. Although the system is designed to prevent pen loss even when obstacles block passage, the interaction could benefit from clearer visual or instructional cues to guide first-time users [16].

The current frame construction, while functional for prototyping, relies heavily on numerous M5 socket head fasteners and brackets, making assembly time-consuming and potentially introducing points of loosening during transport [20]. The reliance on 3D-printed components for the hopper and slide, while suitable for the prototype phase, may not provide the surface finish consistency and durability required for extended use at multiple conferences over time [21]. Battery life, though meeting the minimum one-hour requirement with demonstrated operation exceeding 90 minutes, leaves a limited margin for extended events or situations where charging opportunities are scarce, and long-term battery performance under repeated charge cycles has not been fully validated and may degrade over the product's intended lifespan.

### **Future Revisions to Design Solution**

Future iterations of the Onshape Pen Pal should focus on transitioning from prototype-grade components to production-ready manufacturing processes. The frame should be redesigned using custom-extruded aluminum profiles joined by welds rather than fasteners, significantly reducing part count, assembly time, and the risk of loosening during transport. Both the hopper and slide should be redesigned for injection molding, which would improve surface finish, increase durability, and ensure consistent performance across multiple units.

The CNC-machined logo should be scaled down to reduce weight and machining complexity while still effectively demonstrating Onshape's toolpathing capabilities [25]. Alternatively, the demonstration component could be integrated more functionally into the mechanism itself, such as using a toolpathed gear or structural element that serves both aesthetic and mechanical purposes. User interaction could be enhanced through the addition of clearer visual feedback systems, such as LED indicators that show when the conveyor button should be pressed or provide real-time guidance during the obstacle navigation game. Further instructional graphics on the front acrylic panel could reduce the learning curve for first-time users and improve the overall experience [16].

Implementing a battery management system with visible charge level indication would give Onshape employees better control over deployment timing and prevent unexpected shutdowns during events [1]. Finally, formal safety and accessibility testing should be conducted with diverse user groups to validate ADA compliance and ensure that the device

can be comfortably used by individuals of varying heights, abilities, and familiarity with technology. This testing would inform refinements to button placement, QR code positioning, and overall interaction design to maximize inclusivity [16].

From a reliability standpoint, it was found that the Pen Pal functions as intended most of the time. However, if the pen became misaligned while falling to the conveyor or when hit by the obstacle, challenges in getting the pen to transition to the sequence of slides ensued. There also exists a gap between the sheet metal slide and the 8020 frame of the model. In one instance, a pen fell through this gap, heavily impacting the user experience of the system. In future revisions, this gap will be eliminated to ensure the pen reaches the end user in all cases.

The Onshape Pen Pal represents a successful proof-of-concept that meets its primary objectives of engagement, reliability, and portability while effectively demonstrating Onshape's comprehensive design platform. With targeted improvements in manufacturing processes, user interaction design, and long-term durability, the device is well-positioned to become a valuable asset for the Onshape Education team's outreach efforts at conferences and events. Additionally, these accessibility considerations directly support the user need for inclusive engagement and the engineering requirement for safe and intuitive operation in public environments.

## **AI Attribution**

Our group used AI to grammar check this report. All sections were initially written by one or many of the group members and then fed to generative AI to improve fluency, clarity, and grammatical accuracy. Additionally, we used generative AI to search for applicable flight standards relevant to battery size and carry-on luggage. Outside of this use, all ideas expressed in this report are our own.

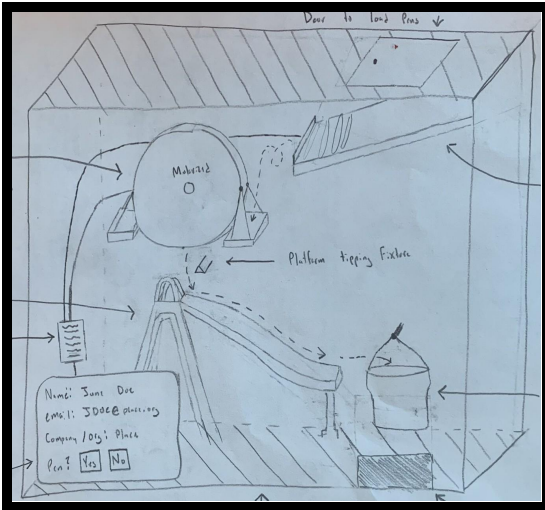
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## Appendix A - Concept Sketches

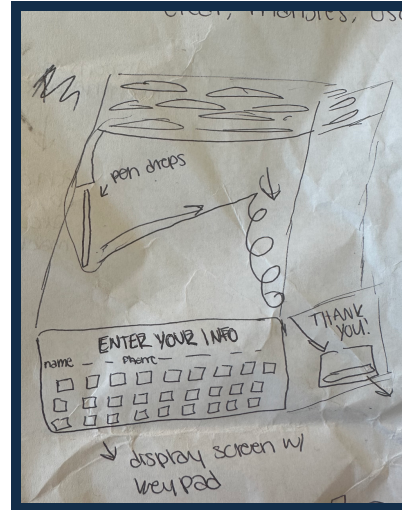
### Rube Goldberg Style Concept



(Figure 7. Rube Goldberg Concept)

This early concept draws inspiration from Rube-Goldberg machines and their intentionally overengineered mechanisms to create a sense of engagement and entertainment for the end user. There are three 'Goldberg Modules' highlighted in this design. The first being a motorized ferris wheel structure that would carry a pen in a circular motion. The platform holding the pen would then hit a protruding peg that would flip the pen onto a slide. The slide transports the pen to a bucket that tips over under the weight of the pen, dispensing it.

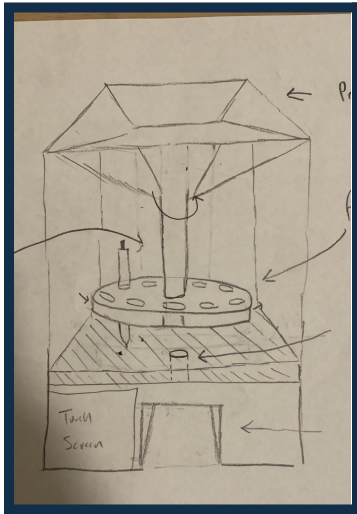
### Data Collection Concept



(Figure 8. Data Collection Concept)

Rather than focusing on how the pen is dispensed, this concept focused on the primary functional aspect of the Pen Pal: Data Collection. This concept highlights a touchscreen on the bottom of the machine that has a built-in keyboard. Here the user will enter vital information, such as name, email and organization. The preliminary method of achieving this is through a Raspberry Pi and a Raspberry Pi Screen. Additionally, this concept also highlights pen dispensation concepts, such as pens being stored at the top of the machine and being dispensed in an engaging fashion.

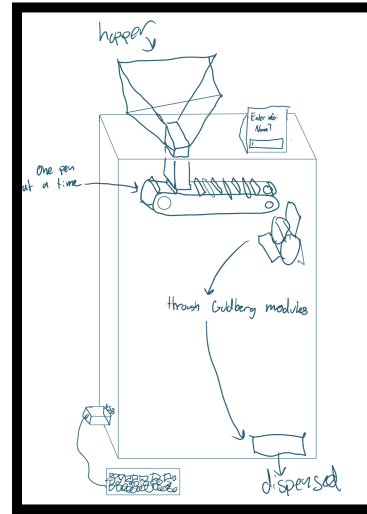
### Rotary Dispensation Concept



(Figure 9. Rotary Dispensation Concept)

This concept focused on a single engaging aspect of pen dispensation rather than multiple. In this design, a pen makes its way to a carousel structure that is powered by a standard DC motor. The bottom of the pen rests on a secondary plate, allowing it to move with the carousel without toppling over. A hole is situated on the carousel's path that allows the pen to fall free of both the carousel and the plate. From here, the pen would slide out of the bottom of the machine for the end user to grab. A screen for data collection is also featured.

### Early Pen Dispensation Concept



(Figure 10. Pen Dispensation Concept)

This sketch focuses primarily on the dispensation mechanism for the Pen Pal. Utilizing both a hopper, the mechanism is intended to dispense a single pen at a time onto a conveyor belt from a reservoir. The purpose of the conveyor is to release a single pen from a line of pens to the rest of the system. The vision for the conveyor belt was for it to be controlled by a stepper motor which would move discrete intervals corresponding to a pen's length. The conveyor features ridges that would separate all pens, ensuring one gets dispensed at all times.

## Appendix B - User Needs & Engineering Requirements Matrix

(Table 6. User Needs vs. Engineering Requirements)

| Engineering Requirements |                   |              |        |              |             |            |               |            |                  |               |
|--------------------------|-------------------|--------------|--------|--------------|-------------|------------|---------------|------------|------------------|---------------|
| User Needs               |                   | Battery Life | Weight | Pen Capacity | Set-up time | Frame Size | Battery Power | Fun Factor | Onshape Showcase | Data Capacity |
|                          | Quick             |              |        | ✓            | ✓           |            |               |            |                  | ✓             |
|                          | Reliable          | ✓            |        | ✓            | ✓           |            | ✓             |            |                  |               |
|                          | Engaging          | ✓            |        | ✓            |             |            |               | ✓          | ✓                |               |
|                          | Accessible        |              | ✓      |              | ✓           | ✓          |               |            |                  |               |
|                          | Safe              |              | ✓      |              |             |            | ✓             |            |                  | ✓             |
|                          | Functional        | ✓            |        | ✓            | ✓           |            |               |            | ✓                |               |
|                          | Airline Compliant | ✓            | ✓      |              |             | ✓          | ✓             |            |                  |               |
|                          | Demonstrative     |              |        | ✓            |             |            |               | ✓          | ✓                |               |
|                          | Portable          |              | ✓      |              | ✓           | ✓          | ✓             |            |                  |               |
|                          | Self Contained    | ✓            |        | ✓            | ✓           |            |               |            |                  | ✓             |

## Appendix C - BOM

(Table 7. Complete Bill of Materials (BOM))

| Component     | Part No. | Part Name                              | Count | Material      | Mfg. Method           | Vendor     | Note                                 | Cost Per | Total Cost      |
|---------------|----------|----------------------------------------|-------|---------------|-----------------------|------------|--------------------------------------|----------|-----------------|
| Frame         | FR-01    | 18" 20-2020 Profile Aluminum Extrusion | 4     | Aluminum      | Cut to length         | McMaster   | Cut from 36" Stock                   | \$6.55   | \$26.20         |
|               | FR-02    | 12" 20-2020 Profile Aluminum Extrusion | 4     | Aluminum      | Cut to length         | McMaster   | Cut from 24" Stock                   | \$5.42   | \$21.68         |
|               | FR-03    | 7" 20-2020 Profile Aluminum Extrusion  | 4     | Aluminum      | Cut to length         | McMaster   | Cut from 24" Stock                   | \$5.42   | \$21.68         |
|               | FR-04    | 20-2020 Profile Corner Brackets        | 16    | Aluminum      | N/A                   | Amazon     | Comes with nuts and screws (20 Pack) | \$0.94   | \$14.99         |
|               | FR-05    | Acrylic Side Piece                     | 2     | Acrylic       | Laser Cut             | Nolop      | Stock from Nolop                     | \$3.00   | \$6.00          |
|               | FR-06    | Acrylic Front Piece                    | 1     | Acrylic       | Laser Cut             | Grainger   | From Grainger                        | \$19.26  | \$19.26         |
|               | FR-07    | Plywood Back Piece                     | 1     | Plywood       | Laser Cut             | Home Depot | Made from same piece of plywood      | \$8.99   | \$8.99          |
|               | FR-08    | Plywood Bottom Piece                   | 1     | Plywood       | Laser Cut             | Home Depot |                                      | \$0.00   | \$0.00          |
| Dispense      | DI-01    | Hopper                                 | 1     | PLA           | 3D Print              | N/A        | Use CoreOne Printer                  | \$0.00   | \$0.00          |
|               | DI-02    | Pinwheel                               | 1     | PLA           | 3D Print              | N/A        | Use CoreOne Printer                  | \$0.00   | \$0.00          |
|               | DI-03    | NEMA 17 x 34 mm Stepper Motor          | 1     | Various       | N/A                   | Amazon     | Drives Hopper                        | \$29.99  | \$29.99         |
| Entertainment | EN-01    | Slide                                  | 1     | PLA           | 3D Print              | N/A        | Use CoreOne Printer                  | \$0.00   | \$0.00          |
|               | EN-02    | M6 x 35 mm Hex Head Screw              | 2     | Steel         | N/A                   | Bray       | For Slide                            | \$0.00   | \$0.00          |
|               | EN-03    | M6 Hex Nut                             | 2     | Steel         | N/A                   | Bray       | For Slide                            | \$0.00   | \$0.00          |
|               | EN-04    | Sheetmetal Slide                       | 1     | Steel         | Sheetmetal Bending    | Grainger   | Cut sheet with water jet first       | \$10.54  | \$10.54         |
|               | EN-05    | Conveyor Idler Mount                   | 1     | Delrin        | Drill Press / Bandsaw | Bray       | Sand to length                       | \$0.00   | \$0.00          |
|               | EN-06    | Idler Pipe                             | 1     | PVC           | Bandsaw               | Bray       | Cut to length                        | \$0.00   | \$0.00          |
|               | EN-07    | Conveyor Driven Spool                  | 1     | PLA           | 3D Print              | N/A        | Use CoreOne Printer                  | \$0.00   | \$0.00          |
|               | EN-08    | Conveyor Belt                          | 1     | Rubber        | Make to Length        | Bray       | Made From Scrap                      | \$0.00   | \$0.00          |
|               | EN-09    | Greatisan 12V DC Gear Motor            | 1     | Various       | N/A                   | Amazon     | Drives Belt                          | \$14.99  | \$14.99         |
|               | EN-10    | 6V TT Gearmotor                        | 1     | Various       | N/A                   | Bray       | Drives Obstacle                      | \$4.00   | \$4.00          |
|               | EN-11    | M3 x 30 mm Screw                       | 2     | Steel         | N/A                   | Bray       | For 6V TT Motor                      | \$0.00   | \$0.00          |
|               | EN-12    | M3 Lock nut                            | 2     | Steel / Nylon | N/A                   | Bray       | For M3 x 30 mm                       | \$0.00   | \$0.00          |
|               | EN-13    | Obstacle Mount                         | 1     | Acrylic       | Laser Cut             | Bray       | 1/4" Acrylic                         | \$0.00   | \$0.00          |
|               | EN-14    | Conveyor Button                        | 1     | Various       | N/A                   | Nolop      | Drives Conveyor                      | \$0.00   | \$0.00          |
|               | EN-15    | M10 x 200 Hex Head Screw               | 1     | Steel         | N/A                   | Bray       | For Idler Pipe                       | \$0.00   | \$0.00          |
|               | EN-16    | M10 Washer                             | 1     | Steel         | N/A                   | Bray       | For Idler Pipe                       | \$0.00   | \$0.00          |
|               | EN-17    | M5 x 60 Hex Head Screw                 | 2     | Steel         | N/A                   | Bray       | For Idler Mount                      | \$0.00   | \$0.00          |
|               | EN-18    | Conveyor Motor Mount                   | 1     | PLA           | 3D Print              | N/A        | Use CoreOne Printer                  | \$0.00   | \$0.00          |
|               | EN-19    | Obstacle                               | 2     | PLA           | 3D Print              | N/A        | Use CoreOne Printer                  | \$0.00   | \$0.00          |
|               | EN-20    | Obstacle Shaft                         | 1     | PLA           | 3D Print              | N/A        | Use CoreOne Printer                  | \$0.00   | \$0.00          |
| Electronics   | EL-01    | Raspberry Pi 3B+                       | 1     | Various       | N/A                   | DigiKey    | Drives whole system                  | \$39.99  | \$39.99         |
|               | EL-02    | Raspberry Pi Screen                    | 1     | Various       | N/A                   | DigiKey    | Optional Inclusion                   | \$60.00  | \$60.00         |
|               | EL-03    | Custom PCB                             | 1     | Various       | N/A                   | OshPark    | Three screw terminals attached       | \$10.87  | \$10.87         |
|               | EL-04    | Raptor Battery Pack                    | 1     | Various       | N/A                   | Amazon     | Airline Compliant                    | \$31.99  | \$31.99         |
|               | EL-05    | Electronics Enclosure Base             | 1     | PLA           | 3D Print              | N/A        | Use CoreOne Printer                  | \$0.00   | \$0.00          |
|               | EL-06    | Electronics Enclosure Lide             | 1     | PLA           | 3D Print              | N/A        | Use CoreOne Printer                  | \$0.00   | \$0.00          |
|               | EL-07    | Jumper Wires                           | 2     | Various       | N/A                   | Nolop      | Connecting PCBs                      | \$2.00   | \$4.00          |
|               | EL-08    | H-Bridge PCB                           | 2     | Various       | N/A                   | Nolop      | Drives both motors                   | \$2.50   | \$5.00          |
| Miscellaneous | MI-01    | M5 Hex Bolt                            | 9     | Steel         | N/A                   | Bray       | For all non 8020 connections         | \$0.00   | \$0.00          |
|               | MI-02    | M5 x 8mm Screw                         | 61    | Steel         | N/A                   | Amazon     | Come in the same package (hex head)  | \$0.16   | \$9.99          |
|               | MI-03    | M5 x 10mm Screw                        | 4     | Steel         | N/A                   | Amazon     |                                      | \$0.00   | \$0.00          |
|               | MI-04    | M5 T-nut                               | 58    | Steel         | N/A                   | Amazon     |                                      | \$0.00   | \$0.00          |
|               | MI-05    | Machined Onshape Logo                  | 1     | Aluminum      | CNC                   | Bray       | Scrap Material from Bray             | \$0.00   | \$0.00          |
|               | MI-06    | M3 x 8mm Screw                         | 6     | Steel         | N/A                   | Bray       | For Mounting Motors                  | \$0.00   | \$0.00          |
|               |          |                                        |       |               |                       |            |                                      |          | <b>\$340.16</b> |

## **Appendix D - Video and User Guide**

 Onshape Pen Pal Video.mov

## Appendix E - Software Code

### motor\_control.py

```
# PenPal Motor Control Script - Reads flag and executes dispensing
sequence.
#
# SEQUENCE: Stepper Rotation (180 degrees) -> DC Motor ON (5 seconds)
-> Motors
OFF
#

import time
import csv
import os
import RPi.GPIO as GPIO

# --- CONFIGURATION CONSTANTS ---
DATA_FILE_PATH = '/home/pi/user_data.csv'
FLAG_FILE_PATH = '/home/pi/new_data_flag.txt'
FIELDNAMES = ['timestamp', 'name', 'email', 'company', 'draw_flag']

# PWM & DC Motor Constants
PWM_FREQ = 100          # Frequency (Hz) for the PWM signal
DEFAULT_SPEED = 25      # Default speed/duty cycle (0-100)
DC_RUN_TIME = 15.0      # TIME ADJUSTMENT: DC motor runs for 5.0 seconds

# --- GPIO PIN SETUP ---
# DC Motor Pins (PWM for speed control, IN2 for direction)
PWM_PIN = 14            # Pin for PWM speed control (e.g., L298N IN1)
MOTOR_IN2_PIN = 15      # Pin for direction (e.g., L298N IN2, set LOW for
forward)

# Stepper Motor Pins (Adjust these to match your wiring!)
STEPPER_IN1 = 17
STEPPER_IN2 = 27
STEPPER_IN3 = 22
STEPPER_IN4 = 23
STEPPER_PINS = [STEPPER_IN1, STEPPER_IN2, STEPPER_IN3, STEPPER_IN4]

# Stepper Constants
STEP_DELAY = 0.05      # Time in seconds between steps (controls speed)
TARGET_STEPS = 100     # Example: 100 steps for a 180-degree rotation
(Adjust as ne
eded)
```

```

# Full step sequence for a typical 4-wire stepper
STEP_SEQUENCE = [
    [1, 0, 0, 0],
    [0, 1, 0, 0],
    [0, 0, 1, 0],
    [0, 0, 0, 1]
]

# --- INITIAL SETUP ---
GPIO.setmode(GPIO.BCM)
GPIO.setwarnings(False)

# Setup DC Motor Pins
GPIO.setup(PWM_PIN, GPIO.OUT)
GPIO.setup(MOTOR_IN2_PIN, GPIO.OUT)

# Initialize PWM Object
pwm_motor = GPIO.PWM(PWM_PIN, PWM_FREQ)
pwm_motor.start(0) # Start PWM with 0% duty cycle (motor off)

# Setup Stepper Motor Pins
GPIO.setup(STEPPER_PINS, GPIO.OUT)
for pin in STEPPER_PINS:
    GPIO.output(pin, GPIO.LOW)

# --- HELPER FUNCTION ---
def safe_int(value, default=0):
    """Safely converts a string value (like from CSV) to an integer,
    returning a
    default on error."""
    if value is None or value == '':
        return default
    try:
        return int(value)
    except ValueError:
        return default

# --- DC MOTOR CONTROL FUNCTION (NOW USES PWM) ---
def set_dc_motor(speed_percent):
    """Controls the DC motor speed (0-100) and direction (always
    forward)."""

    # Ensure speed is within the valid range

```

```

    speed_percent = max(0, min(100, speed_percent))

    if speed_percent > 0:
        # Set direction to forward (IN2 LOW)
        GPIO.output(MOTOR_IN2_PIN, GPIO.LOW)

        # Set speed using PWM
        pwm_motor.ChangeDutyCycle(speed_percent)
        print(f"DC Motor ON at {speed_percent}% speed (Dispensing)")
    else:
        # Stop DC Motor (0% duty cycle)
        pwm_motor.ChangeDutyCycle(0)
        GPIO.output(MOTOR_IN2_PIN, GPIO.LOW) # Ensure direction pin
is low
        print("DC Motor OFF (Stopped)")

# --- STEPPER CONTROL FUNCTION ---
def rotate_stepper(steps):
    """Rotates the stepper motor a specified number of steps."""

    # Ensure all stepper pins are low before starting
    for pin in STEPPER_PINS:
        GPIO.output(pin, GPIO.LOW)

    # Rotate the motor
    for i in range(abs(steps)):
        step_index = (i % 4)
        coil_sequence = STEP_SEQUENCE[step_index]

        GPIO.output(STEPPER_IN1, coil_sequence[0])
        GPIO.output(STEPPER_IN2, coil_sequence[1])
        GPIO.output(STEPPER_IN3, coil_sequence[2])
        GPIO.output(STEPPER_IN4, coil_sequence[3])

        time.sleep(STEP_DELAY)

    # Stop Stepper Coils
    for pin in STEPPER_PINS:
        GPIO.output(pin, GPIO.LOW)

    print(f"Stepper rotated {steps} steps (Release Mechanism).")

# --- DISPENSING ROUTINE (User-Specified Sequence) ---
def execute_dispensing_sequence():

```

```

    """Executes the hard-coded physical sequence: Stepper -> DC."""
    print("--- Starting DISPENSING SEQUENCE: Stepper -> DC ---")

    # 1. Stepper Motor runs 180 degrees (Release Mechanism)
    print(f"Executing Stepper Motor movement ({TARGET_STEPS}
steps)...")
    rotate_stepper(TARGET_STEPS)

    # 2. DC Motor runs for 5 seconds (Dispensing)
    set_dc_motor(DEFAULT_SPEED)
    time.sleep(DC_RUN_TIME)
    set_dc_motor(0) # Stop DC motor immediately by setting speed to 0

    print("--- DISPENSING SEQUENCE Complete ---")

# --- MAIN LOOP ---
def main_loop():
    """Checks the flag file and processes new data entries."""
    print("PenPal Motor Controller is running. Waiting for new data
from web...")
)

    # Initialize last_processed_time to None to force a check on
startup
    last_processed_time = None

    while True:
        try:
            flag_content = None

            # Check for the existence of the flag file
            if os.path.exists(FLAG_FILE_PATH):
                with open(FLAG_FILE_PATH, 'r') as f:
                    # CRUCIAL: .strip() cleans up any hidden
whitespace/newlines
                    flag_content = f.read().strip()

            # Check if the flag content is valid AND has changed
since last check
            if flag_content and flag_content != last_processed_time:
                print(f"\n[ALERT] New data flag detected at
{flag_content}. Proc
essing CSV...")

                # 1. Read the last entry to confirm draw_flag=1

```

```

        with open(DATA_FILE_PATH, 'r', newline='') as
csvfile:
            # Use DictReader with correct FIELDNAMES
            reader = csv.DictReader(csvfile,
fieldnames=FIELDNAMES)
            rows = list(reader)

            # Find the last row that isn't the header
            last_entry = rows[-1] if rows and
rows[-1].get('timestamp') != 'timestamp' else None

            # Use the safe_int function to prevent the ValueError
crash
            if last_entry and
safe_int(last_entry.get('draw_flag')) == 1:

                # 2. Run the physical sequence (Stepper then DC)
                execute_dispensing_sequence()

                # 3. Update the flag marker to prevent
reprocessing
                last_processed_time = flag_content
                print(f"Successfully processed entry at
{last_processed_time}.")
            else:
                print("Flag found, but latest data entry is not
marked for dispensing. Flag updated.")
                last_processed_time = flag_content

            time.sleep(1) # Check every 1 second

    except FileNotFoundError:
        print("CSV or Flag file not found yet. Sleeping...")
        last_processed_time = None
        time.sleep(5)

    except Exception as e:
        # Catch all other errors (like GPIO errors or data
reading exception
s)
        print(f"\n[CRASH] An unexpected error occurred:
{e.__class__.__name__
_} - {e}")
        time.sleep(5)

```

```

if __name__ == '__main__':
    try:
        main_loop()
    except KeyboardInterrupt:
        print("\nExiting safely...")
    finally:
        # CRITICAL: Stop PWM and clean up GPIO upon exit
        pwm_motor.stop()
        GPIO.cleanup()

```

### App.py

```

cat app.py
import csv
import os
import time
from flask import Flask, render_template_string, request, jsonify

app = Flask(__name__)

# Note: Simple triple quotes are used instead of f-string to avoid
complex brace escaping.
# Minimal custom CSS is used to avoid Python SyntaxErrors.
index_html_content = """
<!DOCTYPE html>
<html lang="en">
<head>
    <meta charset="UTF-8">
    <meta name="viewport" content="width=device-width,
initial-scale=1.0">
    <title>PenPal Interactive Kiosk</title>
    <script src="https://cdn.tailwindcss.com"></script>
    <style>
        /* Custom styles for Inter font, simple gradient, and mobile
optimization */
        body {
            font-family: 'Inter', sans-serif;
            background-color: #f7fafc; /* Light gray background */
        }
        .gradient-button {
            background-image: linear-gradient(to right, #4c51bf,
#6b46c1); /* Indigo to Purple */
        }
        .gradient-button:hover {
            background-image: linear-gradient(to left, #5a67d8,
#7f9cf5);

```

```

    }
  </style>
</head>
<body class="min-h-screen flex items-center justify-center p-4">
  <div id="app" class="w-full max-w-md">
    <div class="bg-white p-8 rounded-xl shadow-2xl">
      <h1 class="text-3xl font-bold text-gray-800 mb-2">👋
Welcome to PenPal</h1>
      <p class="text-gray-600 mb-8">Enter your details for a
pen to dispense.</p>
      <p class="text-gray-600 mb-8">The game will start once
the pen hits the conveyor. Be ready!</p>

      <form id="controlForm" class="space-y-6">
        <div>
          <label for="name" class="block text-sm
font-medium text-gray-700">Name</label>
          <input type="text" id="name" name="name" required
            class="mt-1 block w-full px-4 py-2 border
border-gray-300 rounded-lg shadow-sm focus:ring-indigo-500
focus:border-indigo-500 transition duration-150 ease-in-out"
            placeholder="Your Full Name">
        </div>

        <div>
          <label for="email" class="block text-sm
font-medium text-gray-700">Email</label>
          <input type="email" id="email" name="email"
required
            class="mt-1 block w-full px-4 py-2 border
border-gray-300 rounded-lg shadow-sm focus:ring-indigo-500
focus:border-indigo-500 transition duration-150 ease-in-out"
            placeholder="you@example.com">
        </div>

        <!-- Company Input (Optional) -->
        <div>
          <label for="company" class="block text-sm font-medium
text-gray-700">Company (Optional)</label>
          <input type="text" id="company" name="company"
            class="mt-1 block w-full px-4 py-2 border
border-gray-300 rounded-lg shadow-sm focus:ring-indigo-500
focus:border-indigo-500 transition duration-150 ease-in-out"
            placeholder="Your Company Name">
        </div>
      </form>
    </div>
  </div>
</body>
</html>

```

```

        <input type="hidden" id="draw_flag" name="draw_flag"
value="1">

        <button type="submit" id="submitBtn"
            class="gradient-button w-full flex
justify-center py-3 px-4 border border-transparent rounded-lg text-lg
font-semibold text-white shadow-md focus:outline-none focus:ring-2
focus:ring-offset-2 focus:ring-indigo-500 transition duration-300
ease-in-out">
            Dispense me a pen!
        </button>
    </form>
</div>

    <div id="messageBox" class="mt-6 p-4 rounded-lg text-sm
text-white font-medium hidden transition duration-300
ease-in-out"></div>
</div>

<script>

document.getElementById('controlForm').addEventListener('submit',
async function(event) {
    event.preventDefault();

    const form = event.target;
    const submitBtn = document.getElementById('submitBtn');
    const messageBox = document.getElementById('messageBox');

    // 1. Prepare Data
    const formData = new FormData(form);
    const data = {};
    formData.forEach((value, key) => {
        data[key] = value;
    });

    const url = '/submit';

    // 2. Disable Button and Show Loading
    submitBtn.disabled = true;
    submitBtn.textContent = 'Processing request...';
    submitBtn.classList.remove('gradient-button');
    submitBtn.classList.add('bg-gray-400');
    messageBox.classList.add('hidden');

    try {

```

```
// 3. POST Data to Flask Endpoint
const response = await fetch(url, {
  method: 'POST',
  headers: {
    'Content-Type': 'application/json'
  },
  body: JSON.stringify(data)
});

// 4. Handle Response
const result = await response.json();

if (response.ok && result.status === 'success') {
  // Success case
  messageBox.textContent = 'Success! Your pen is
now being dispensed.';
  messageBox.classList.remove('hidden',
'bg-red-500');
  messageBox.classList.add('bg-green-500');

  // Reset form fields except hidden ones
  form.reset();

} else {
  // Error case (e.g., Flask returned a 400 or
status: error)
  const errorMsg = result.message || 'An unexpected
error occurred on the server.';
  messageBox.textContent = 'Error: ' + errorMsg;
  messageBox.classList.remove('hidden',
'bg-green-500');
  messageBox.classList.add('bg-red-500');
}

} catch (error) {
  // Network or internal client-side error
  console.error('Fetch error:', error);
  messageBox.textContent = 'Network Error: Could not
reach the server. Please try again.';
  messageBox.classList.remove('hidden',
'bg-green-500');
  messageBox.classList.add('bg-red-500');
} finally {
  // 5. Re-enable button
  submitBtn.disabled = false;
```

```

        submitBtn.textContent = 'Dispense me a pen!';
        submitBtn.classList.remove('bg-gray-400');
        submitBtn.classList.add('gradient-button');
    }
    });
</script>
</body>
</html>
"""

# The path where the CSV data file resides
DATA_FILE_PATH = '/home/pi/user_data.csv'
FLAG_FILE_PATH = '/home/pi/new_data_flag.txt'

# Define the expected fields for CSV writing (Company is now mandatory in the
list)
FIELDNAMES = ['timestamp', 'name', 'email', 'company', 'draw_flag']

# --- Flask Routes ---

@app.route('/', methods=['GET'])
def index():
    """Serves the main HTML page."""
    # We use render_template_string because the HTML is stored as a
    variable above
    return render_template_string(index_html_content)

@app.route('/submit', methods=['POST'])
def submit_data():
    """Handles the form submission via POST request."""
    try:
        data = request.get_json()

        # 1. Input Validation and Coercion
        name = data.get('name', '').strip() or 'N/A'
        email = data.get('email', '').strip() or 'N/A'
        company = data.get('company', '').strip() or 'N/A'

        # Ensure the flag is 1 for drawing, or 0/any other value for
no draw
        draw_flag = int(data.get('draw_flag', 0))

        if not name or not email:
            return jsonify({'status': 'error', 'message': 'Name and
Email are required.'}), 400

```

```
# 2. Prepare Data for CSV
    current_time = time.strftime('%Y-%m-%d %H:%M:%S')

    row_data = {
        'timestamp': current_time,
        'name': name,
        'email': email,
        'company': company,
        # Ensure 'motor1_speed' and 'motor2_speed' are REMOVED if
they were here
        'draw_flag': draw_flag
    }

    # 3. Write to CSV file
    file_exists = os.path.isfile(DATA_FILE_PATH)
    with open(DATA_FILE_PATH, 'a', newline='') as csvfile:
        writer = csv.DictWriter(csvfile, fieldnames=FIELDNAMES)

        # Write header only if the file is being created for the
first time
        if not file_exists:
            writer.writeheader()

        writer.writerow(row_data)

    # 4. Write the Flag file to notify the motor script
    with open(FLAG_FILE_PATH, 'w') as f:
        f.write(current_time)

        f.flush()
        os.fsync(f.fileno())

    return jsonify({'status': 'success', 'message': 'Data saved
and motor flag set.'})

except Exception as e:
    print(f"An error occurred: {e}")
    return jsonify({'status': 'error', 'message': 'Internal
Server Error'}), 500

if __name__ == '__main__':
    # Execution block (typically handled by systemd/gunicorn)
    pass
```

## **Appendix F - Engineering Drawings**

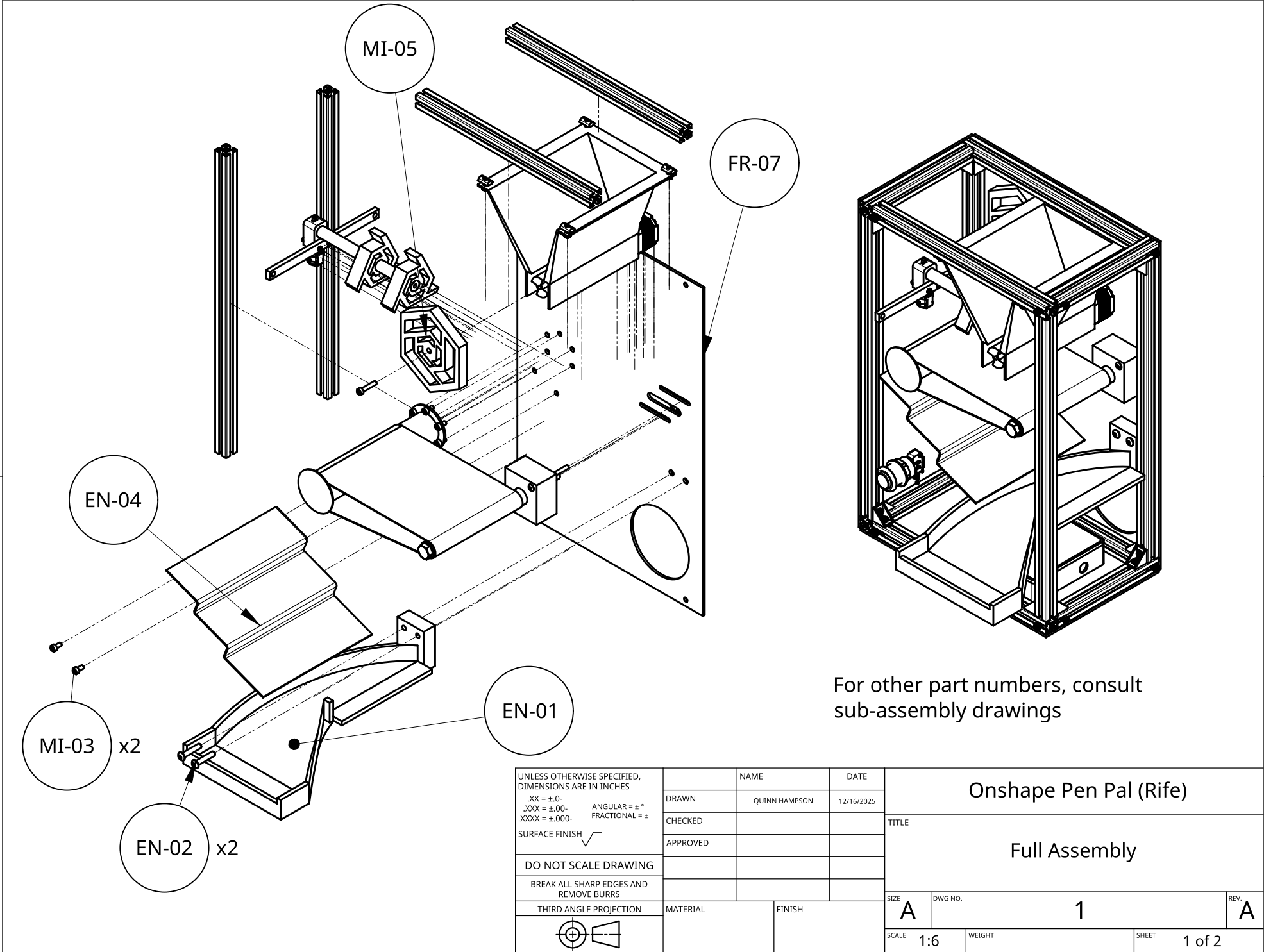
See below.

B

A

B

A



For other part numbers, consult  
sub-assembly drawings

|                                                                                                                                                                                                                            |  |  |  |          |               |                        |               |        |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|--|----------|---------------|------------------------|---------------|--------|
| UNLESS OTHERWISE SPECIFIED,<br>DIMENSIONS ARE IN INCHES<br>.XX = ±.0-<br>.XXX = ±.00-<br>.XXXX = ±.000-<br>SURFACE FINISH ✓<br>DO NOT SCALE DRAWING<br>BREAK ALL SHARP EDGES AND<br>REMOVE BURRS<br>THIRD ANGLE PROJECTION |  |  |  | NAME     | DATE          | Onshape Pen Pal (Rife) |               |        |
|                                                                                                                                                                                                                            |  |  |  | DRAWN    | QUINN HAMPSON | 12/16/2025             | TITLE         |        |
|                                                                                                                                                                                                                            |  |  |  | CHECKED  |               |                        | Full Assembly |        |
|                                                                                                                                                                                                                            |  |  |  | APPROVED |               |                        |               |        |
|                                                                                                                                                                                                                            |  |  |  |          |               |                        | SIZE          | REV.   |
|                                                                                                                                                                                                                            |  |  |  | MATERIAL | FINISH        |                        | A             | A      |
|                                                                                                                                                                                                                            |  |  |  |          |               |                        | DWG NO.       |        |
|                                                                                                                                                                                                                            |  |  |  |          |               |                        | 1             |        |
|                                                                                                                                                                                                                            |  |  |  |          |               |                        | SCALE         | 1:6    |
|                                                                                                                                                                                                                            |  |  |  |          |               |                        | WEIGHT        |        |
|                                                                                                                                                                                                                            |  |  |  |          |               |                        | SHEET         | 1 of 2 |

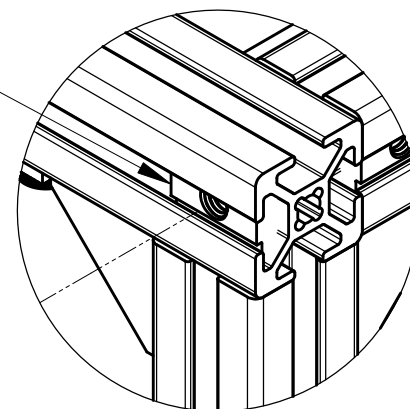
2

1

B

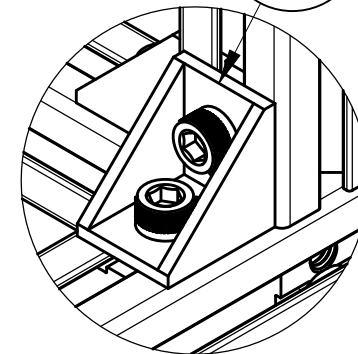
A

MI-04

DETAIL A  
SCALE 1:1

FR-05 x2

FR-04



FR-08

MI-02

FR-06

EN-14

DWG NO.

1

SIZE

A

SCALE

1:6

SHEET

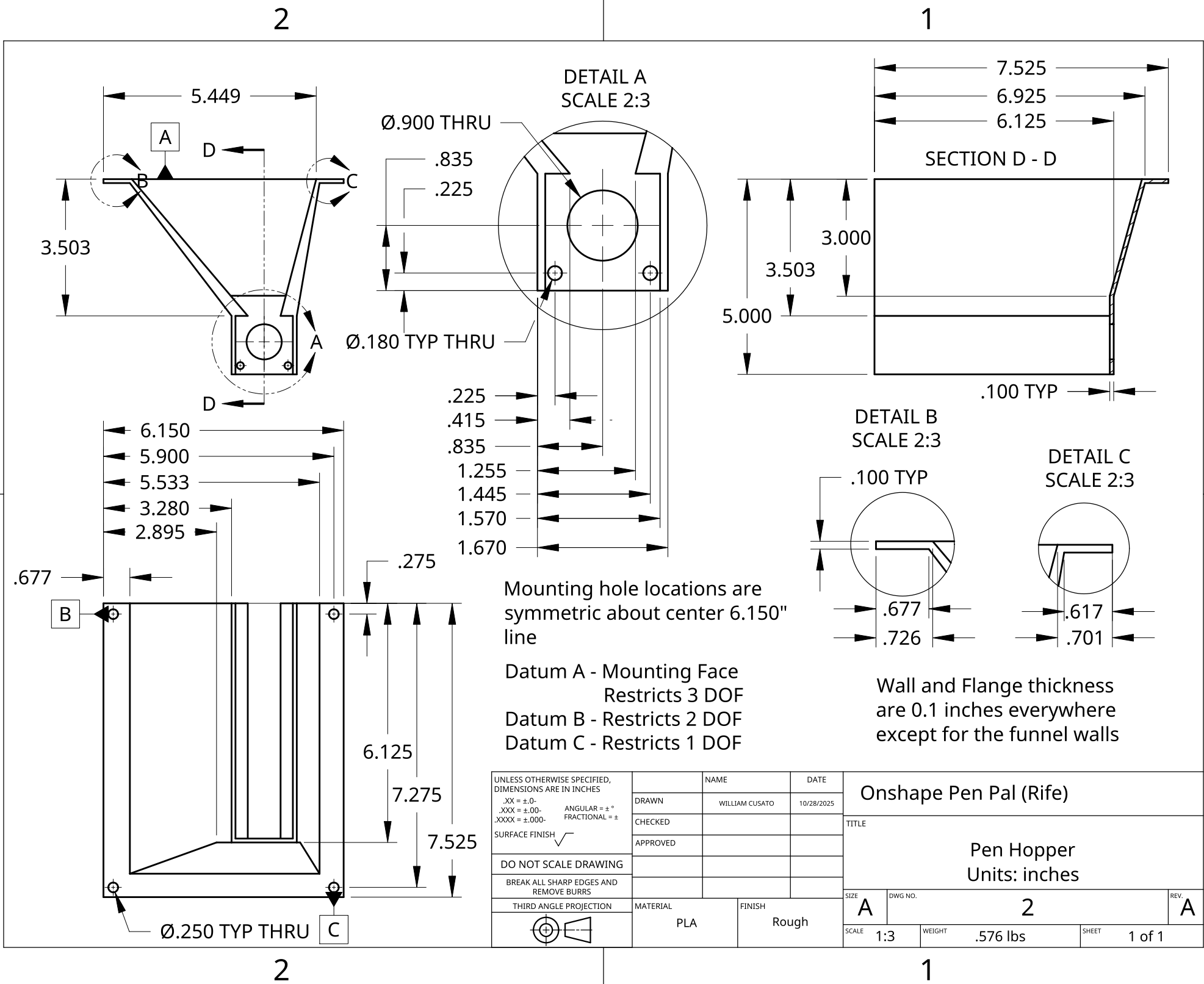
2 of 2

REV.

A

2

1

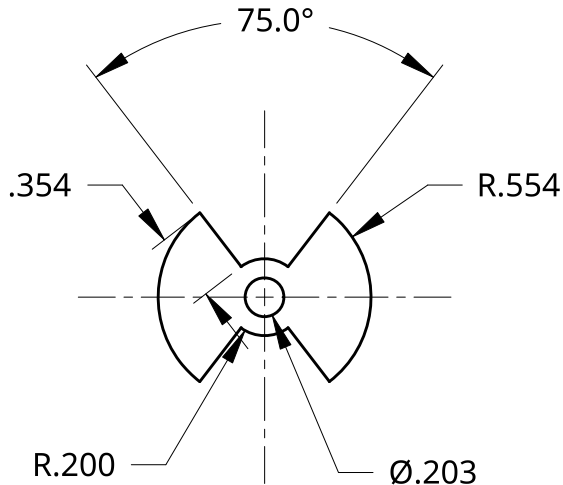


B

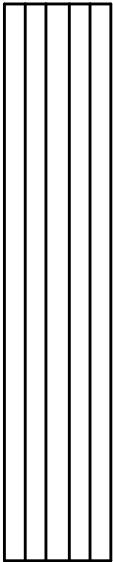
A

B

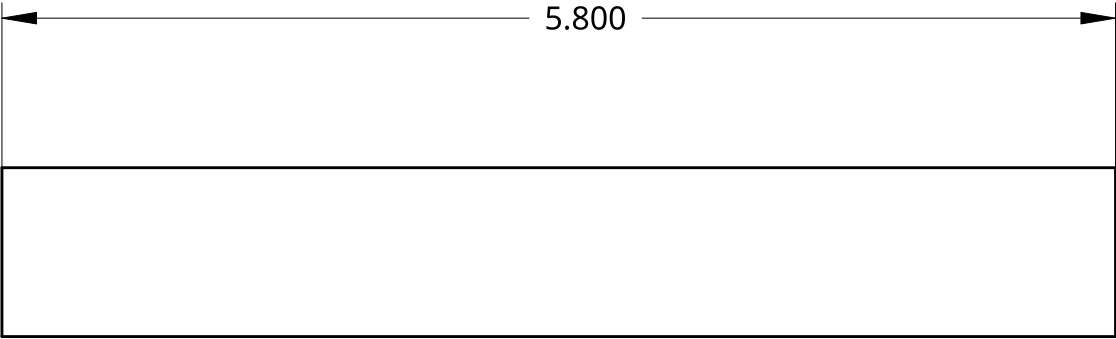
A



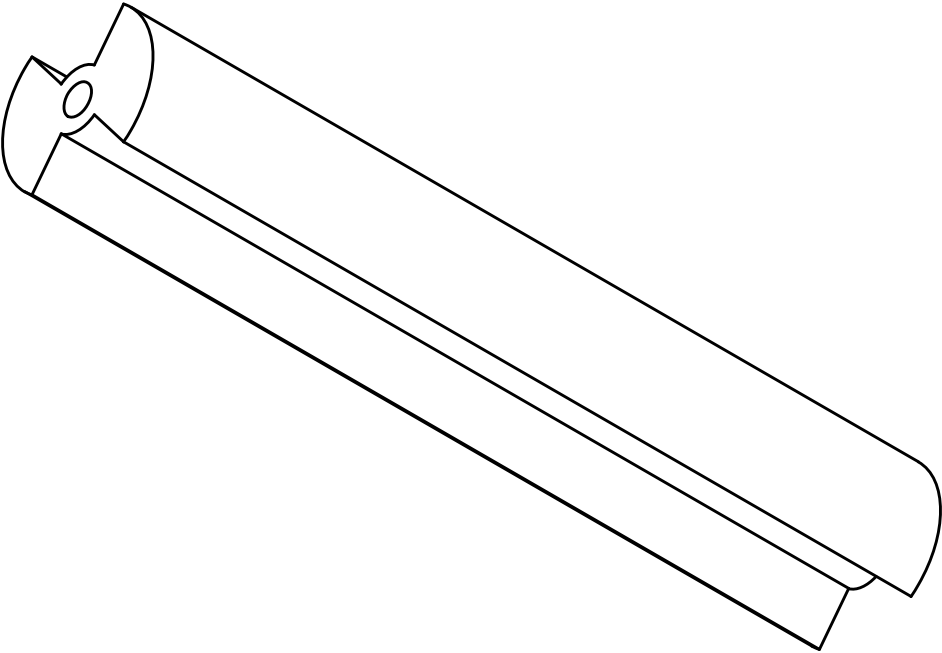
0.354 in line features intersect normal to circular profile with a radius of 0.200 in



SCALE 1:2



5.800



|                                                                                                                                                                                                                            |          |                        |                        |                        |                     |                        |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|------------------------|------------------------|------------------------|---------------------|------------------------|
| UNLESS OTHERWISE SPECIFIED,<br>DIMENSIONS ARE IN INCHES<br>.XX = ±.0-<br>.XXX = ±.00-<br>.XXXX = ±.000-<br>SURFACE FINISH ✓<br>DO NOT SCALE DRAWING<br>BREAK ALL SHARP EDGES AND<br>REMOVE BURRS<br>THIRD ANGLE PROJECTION |          | NAME                   | DATE                   | Onshape Pen Pal (Rife) |                     |                        |
|                                                                                                                                                                                                                            | DRAWN    | WILLIAM CUSATO         | 12/14/2025             | TITLE<br><br>Pinwheel  |                     |                        |
|                                                                                                                                                                                                                            | CHECKED  |                        |                        |                        |                     |                        |
|                                                                                                                                                                                                                            | APPROVED |                        |                        |                        |                     |                        |
|                                                                                                                                                                                                                            |          |                        |                        | SIZE<br><b>A</b>       | DWG NO.<br><b>3</b> | REV.<br><b>A</b>       |
|                                                                                                                                                                                                                            |          | MATERIAL<br><b>PLA</b> | FINISH<br><b>Rough</b> | SCALE<br><b>1:1</b>    | WEIGHT              | SHEET<br><b>1 of 1</b> |

2

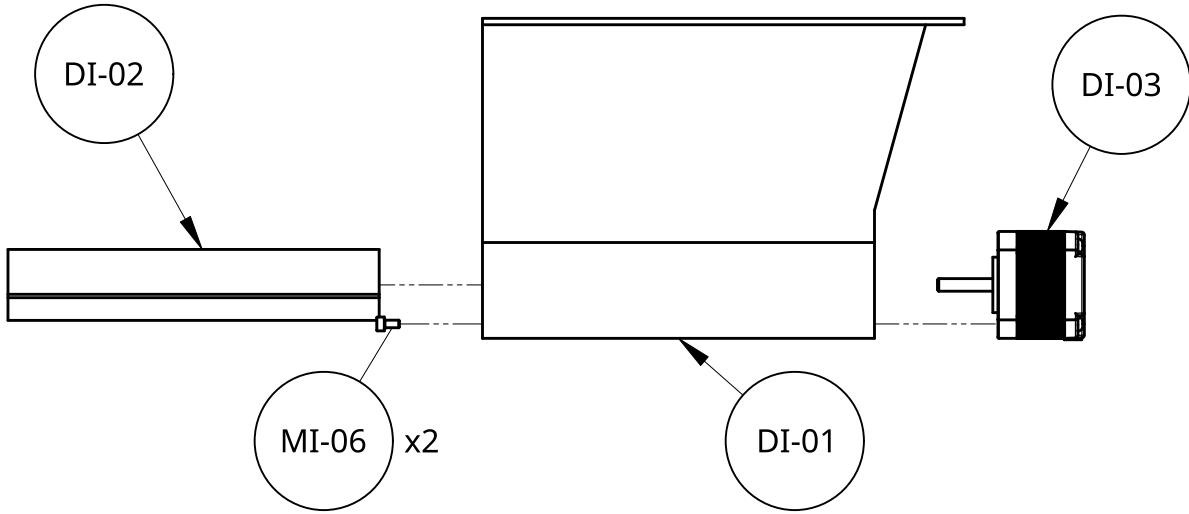
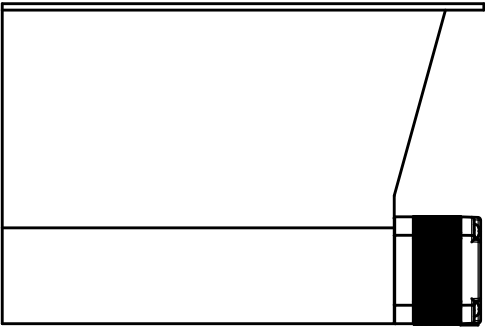
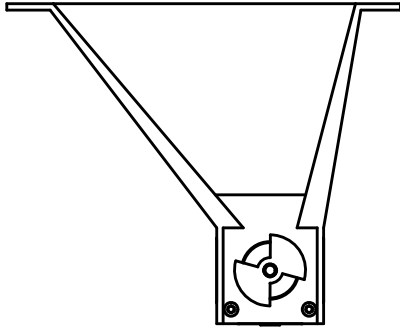
1

B

A

B

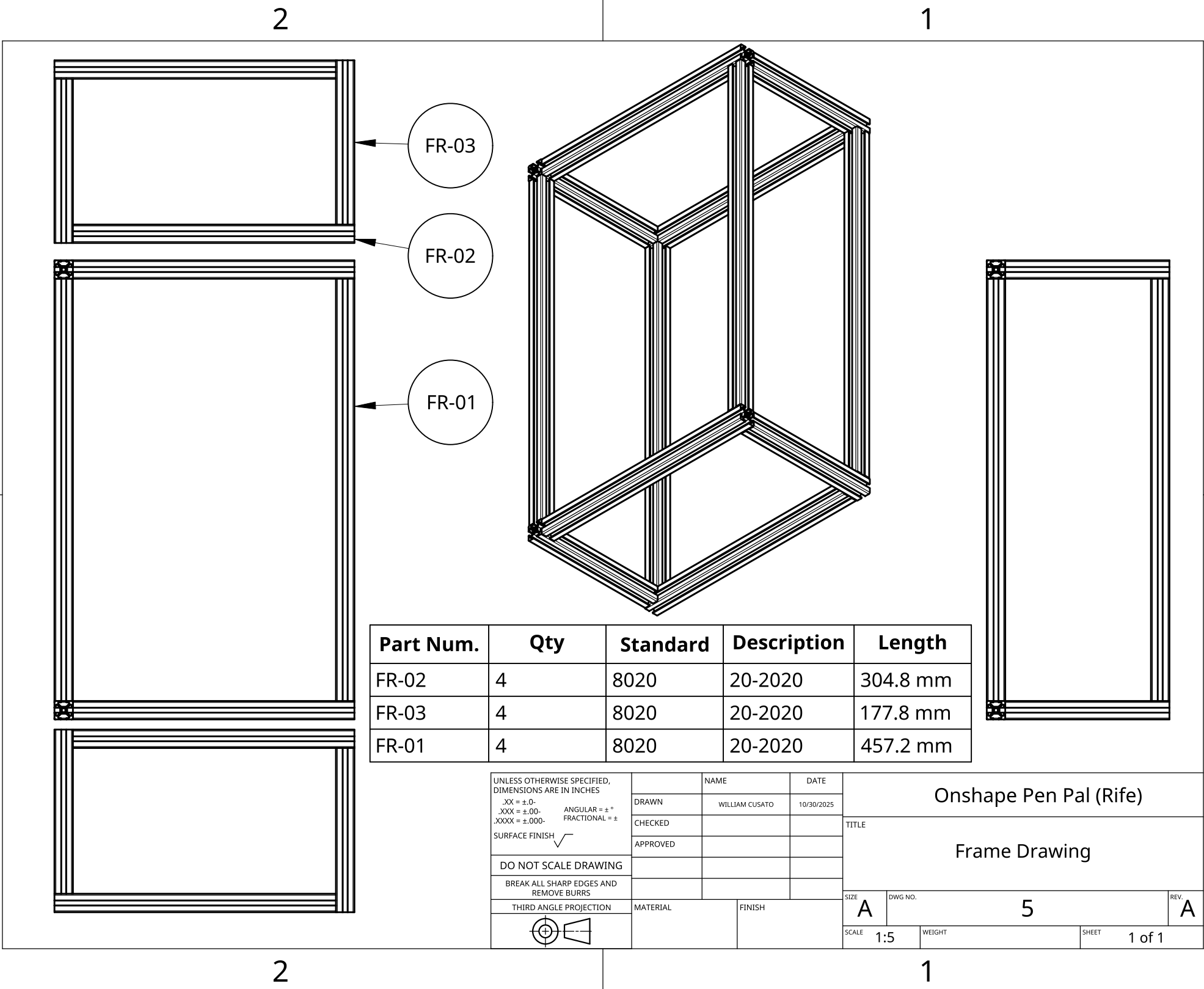
A



|                                                                                                                           |                      |                |            |                                      |                     |                        |
|---------------------------------------------------------------------------------------------------------------------------|----------------------|----------------|------------|--------------------------------------|---------------------|------------------------|
| UNLESS OTHERWISE SPECIFIED,<br>DIMENSIONS ARE IN INCHES<br>.XX = ±.0-<br>.XXX = ±.00-<br>.XXXX = ±.000-<br>SURFACE FINISH |                      | NAME           | DATE       | Onshape Pen Pal (Rife)               |                     |                        |
|                                                                                                                           | DRAWN                | WILLIAM CUSATO | 12/14/2025 | TITLE<br><br>Hopper Assembly Drawing |                     |                        |
|                                                                                                                           | CHECKED              |                |            |                                      |                     |                        |
|                                                                                                                           | APPROVED             |                |            |                                      |                     |                        |
|                                                                                                                           | DO NOT SCALE DRAWING |                |            |                                      |                     |                        |
| BREAK ALL SHARP EDGES AND<br>REMOVE BURRS                                                                                 |                      |                |            | SIZE<br><b>A</b>                     | DWG NO.<br><b>4</b> | REV.<br><b>A</b>       |
| THIRD ANGLE PROJECTION<br>                                                                                                | MATERIAL             | FINISH         |            | SCALE<br><b>1:3</b>                  | WEIGHT              | SHEET<br><b>1 of 1</b> |

2

1



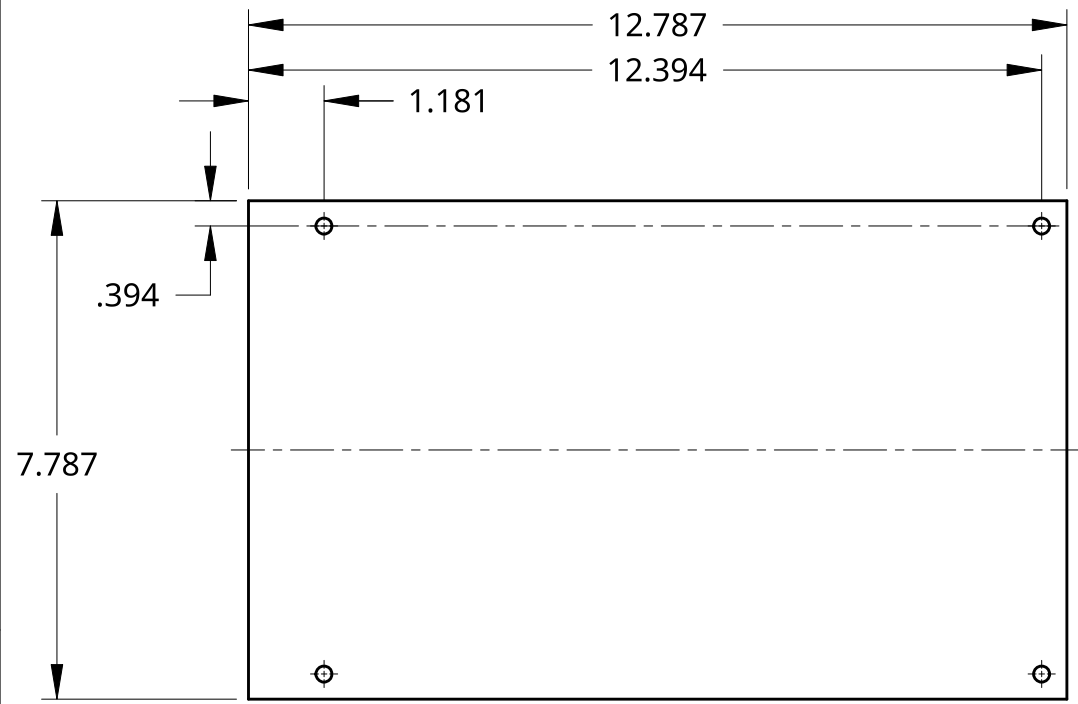


B

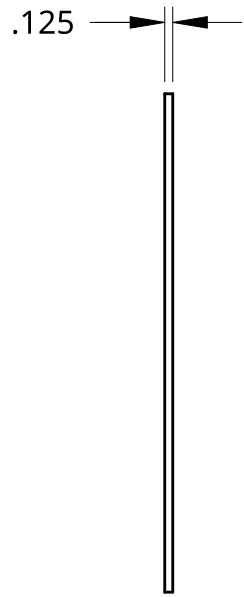
A

B

A



All Corner Mounting Holes  
are symmetrical through  
the centerline



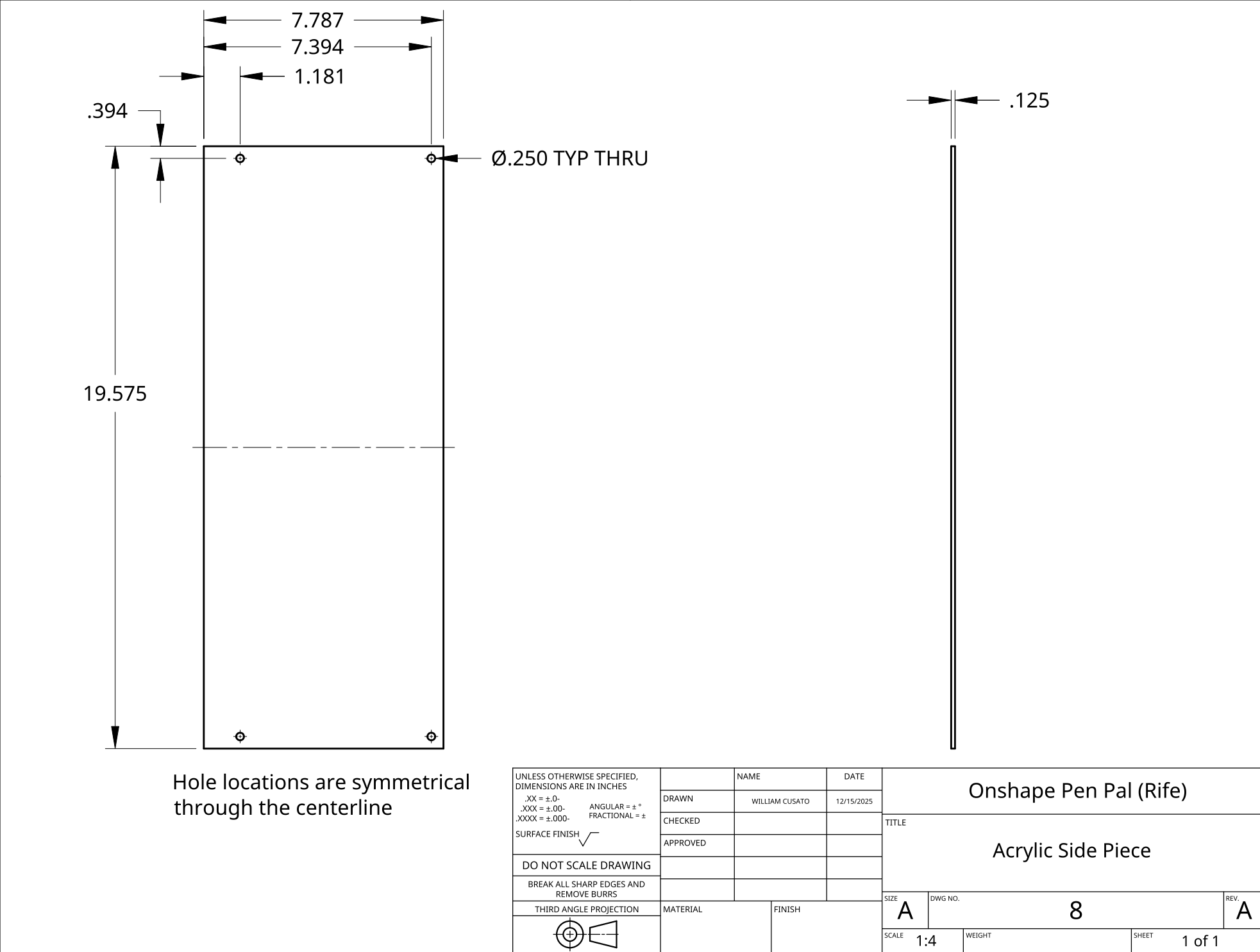
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |          |  |                |                                                                   |  |        |  |            |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|----------|--|----------------|-------------------------------------------------------------------|--|--------|--|------------|
| <div>UNLESS OTHERWISE SPECIFIED,<br/>DIMENSIONS ARE IN INCHES</div> <div><div>.XX = ±.0-<br/>.XXX = ±.00-<br/>.XXXX = ±.000-</div><div>ANGULAR = ± °<br/>FRACTIONAL = ±</div></div> <div>SURFACE FINISH </div> <div>DO NOT SCALE DRAWING</div> <div>BREAK ALL SHARP EDGES AND<br/>REMOVE BURRS</div> <div>THIRD ANGLE PROJECTION</div> <div></div> |  | NAME     |  | DATE           | <div>Onshape Pen Pal (Rife)</div> <div>Plywood Bottom Piece</div> |  |        |  |            |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |  | DRAWN    |  | WILLIAM CUSATO |                                                                   |  |        |  | 12/16/2025 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |  | CHECKED  |  |                |                                                                   |  |        |  |            |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |  | APPROVED |  |                |                                                                   |  |        |  |            |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |          |  |                |                                                                   |  |        |  |            |
| MATERIAL                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |  | FINISH   |  | SIZE           | DWG NO.                                                           |  | REV.   |  |            |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |          |  | A              | 7                                                                 |  | A      |  |            |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |          |  | SCALE          | WEIGHT                                                            |  | SHEET  |  |            |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |          |  | 1:3            |                                                                   |  | 1 of 1 |  |            |

B

A

B

A

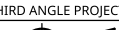


2

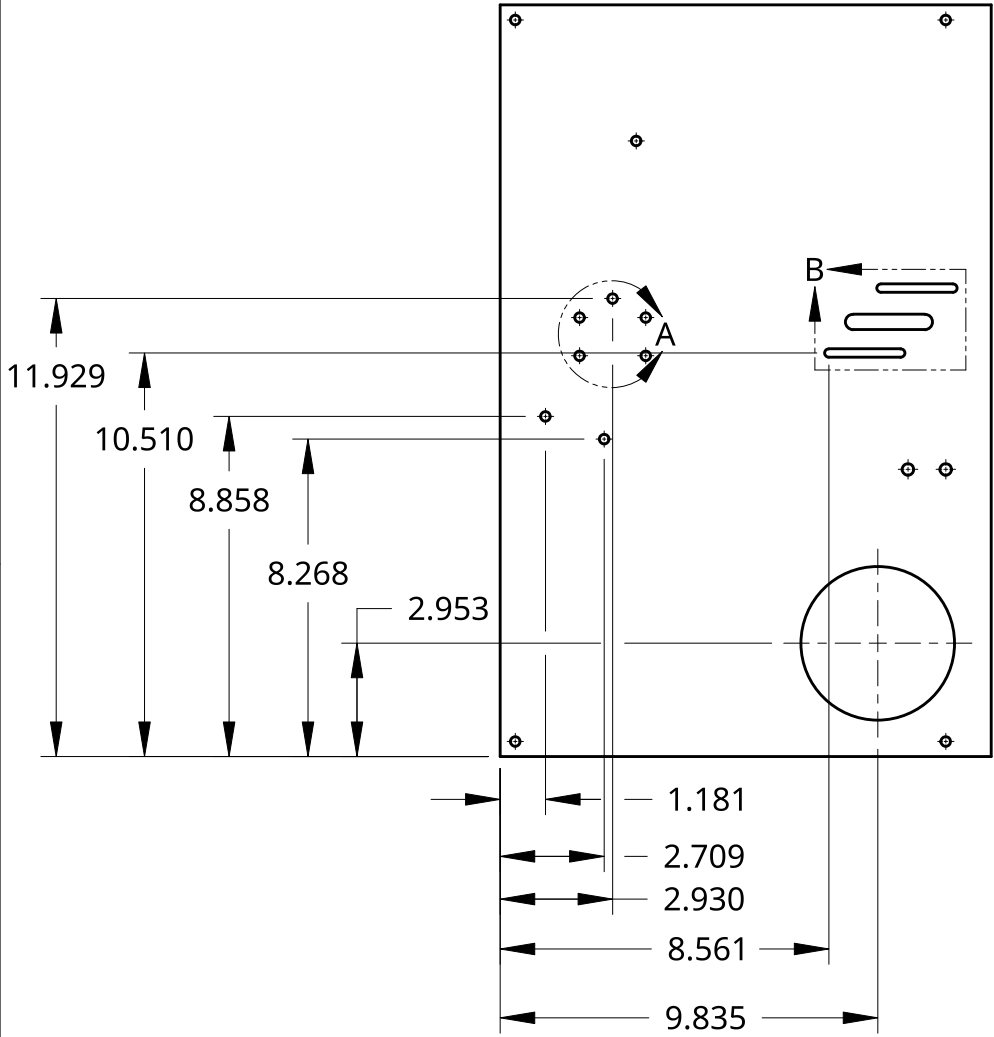
1

1



|                                                                                                                                                                                                                                                          |                      |                |            |  |                                 |         |  |        |        |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|----------------|------------|--|---------------------------------|---------|--|--------|--------|
| UNLESS OTHERWISE SPECIFIED,<br>DIMENSIONS ARE IN INCHES<br><br>.XX = ±.0-<br>.XXX = ±.00-<br>.XXXX = ±.000-<br>ANGULAR = ±°<br>FRACTIONAL = ±<br><br>SURFACE FINISH  | NAME                 |                | DATE       |  | Onshape Pen Pal (Rife)          |         |  |        |        |
|                                                                                                                                                                                                                                                          | DRAWN                | WILLIAM CUSATO | 12/15/2025 |  |                                 |         |  |        |        |
|                                                                                                                                                                                                                                                          | CHECKED              |                |            |  | TITLE<br><br>Plywood Back Piece |         |  |        |        |
|                                                                                                                                                                                                                                                          | APPROVED             |                |            |  |                                 |         |  |        |        |
|                                                                                                                                                                                                                                                          | DO NOT SCALE DRAWING |                |            |  |                                 |         |  |        |        |
| BREAK ALL SHARP EDGES AND REMOVE BURRS                                                                                                                                                                                                                   |                      |                |            |  |                                 |         |  |        |        |
| THIRD ANGLE PROJECTION                                                                                                                                                                                                                                   | MATERIAL             |                | FINISH     |  | SIZE                            | DWG NO. |  |        | REV.   |
|                                                                                                                                                                      |                      |                |            |  | A                               | 9       |  |        | A      |
|                                                                                                                                                                                                                                                          |                      |                |            |  | SCALE                           | 1:5     |  | WEIGHT | SHEET  |
|                                                                                                                                                                                                                                                          |                      |                |            |  |                                 |         |  |        | 1 of 2 |

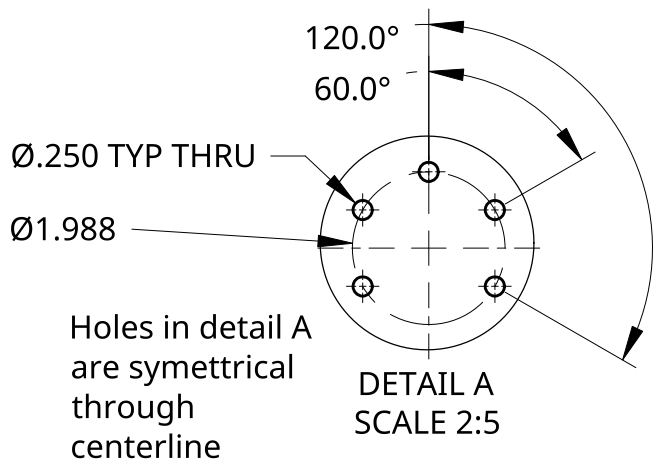
B



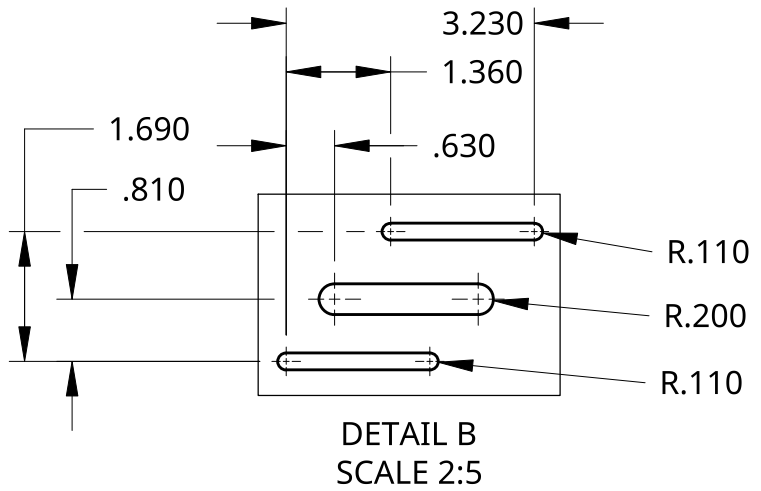
A

2

1



B

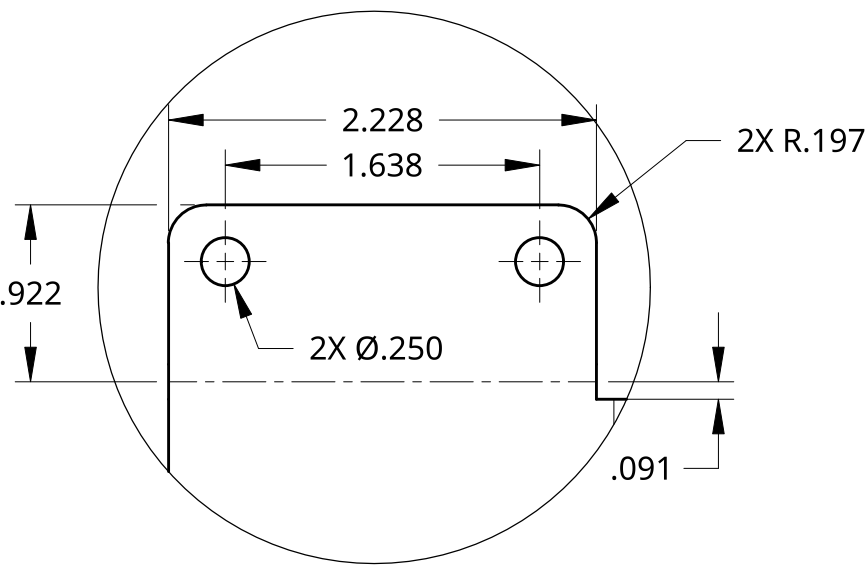
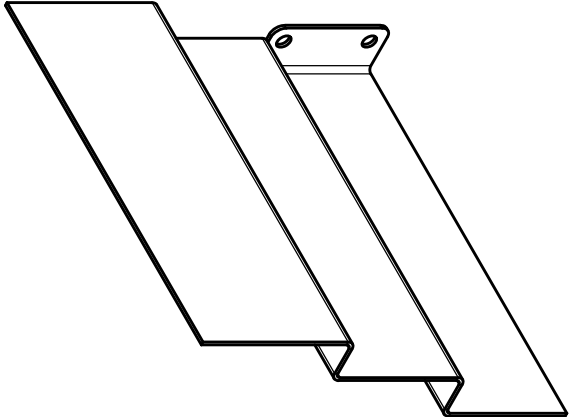
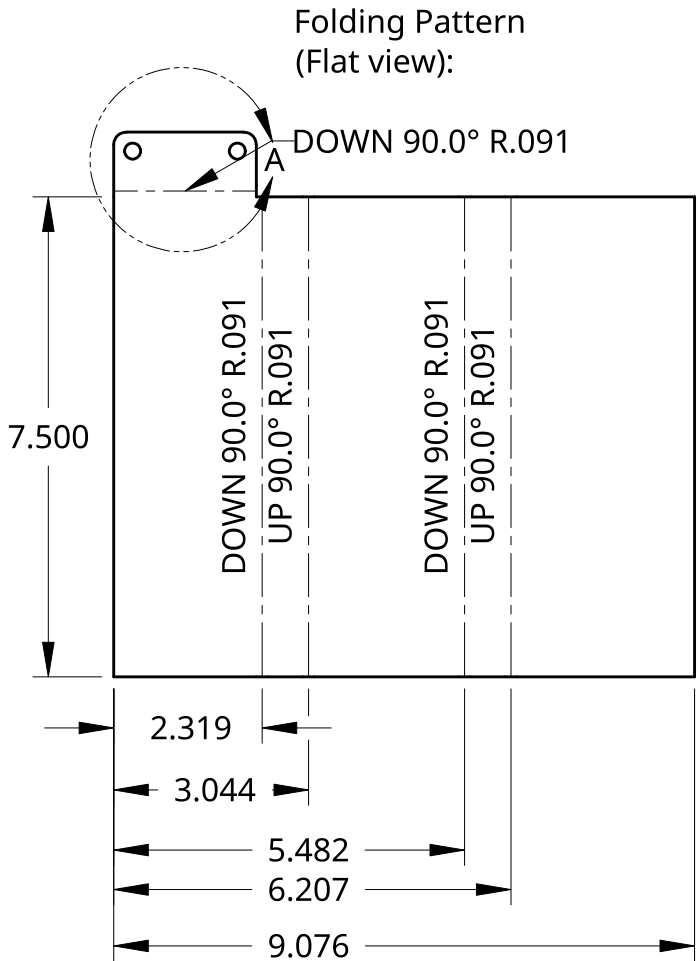


A

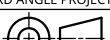
1

B

A



DETAIL A  
SCALE 1:1

|                                                                                                                                                                                                                                                                                                                                                                                                                                                        |  |          |  |                |  |                                                                                |  |         |  |            |  |       |  |        |  |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|----------|--|----------------|--|--------------------------------------------------------------------------------|--|---------|--|------------|--|-------|--|--------|--|
| <div>UNLESS OTHERWISE SPECIFIED,<br/>DIMENSIONS ARE IN INCHES<br/>.XX = ±.0-<br/>.XXX = ±.00-<br/>.XXXX = ±.000-<br/>SURFACE FINISH </div> <div>DO NOT SCALE DRAWING</div> <div>BREAK ALL SHARP EDGES AND<br/>REMOVE BURRS</div> <div>THIRD ANGLE PROJECTION</div> <div></div> |  | NAME     |  | DATE           |  | <div>Onshape Pen Pal (Rife)</div> <div>TITLE</div> <div>Sheetmetal Slide</div> |  |         |  |            |  |       |  |        |  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                        |  | DRAWN    |  | QUINN HAMPSON  |  |                                                                                |  |         |  | 11/04/2025 |  |       |  |        |  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                        |  | CHECKED  |  | William Cusato |  |                                                                                |  |         |  | 12/16/2025 |  |       |  |        |  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                        |  | APPROVED |  |                |  |                                                                                |  |         |  |            |  |       |  |        |  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                        |  |          |  |                |  | SIZE                                                                           |  | DWG NO. |  | 10         |  | REV.  |  | A      |  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                        |  | MATERIAL |  | FINISH         |  | SCALE                                                                          |  | 1:3     |  | WEIGHT     |  | SHEET |  | 1 of 1 |  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                        |  | Aluminum |  |                |  |                                                                                |  |         |  |            |  |       |  |        |  |

B

A

2

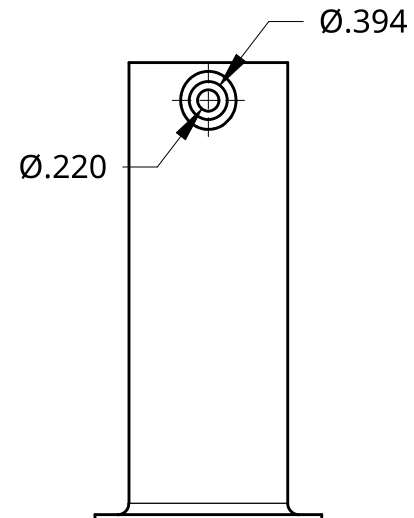
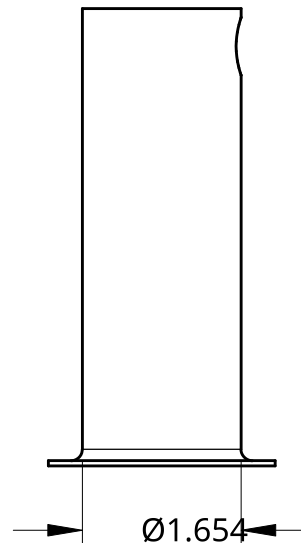
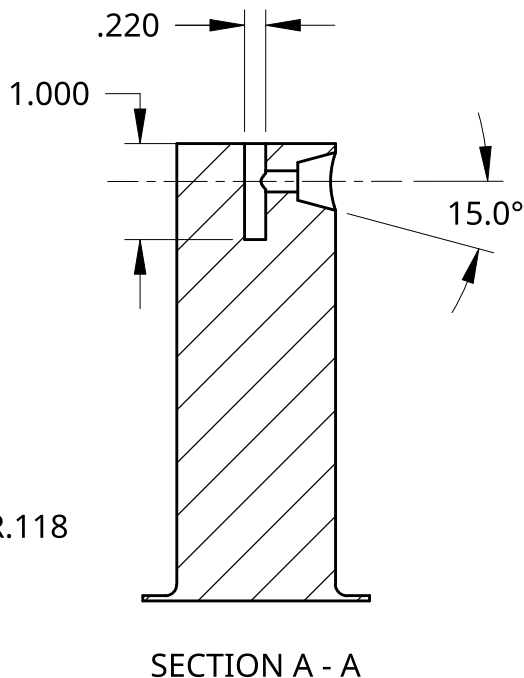
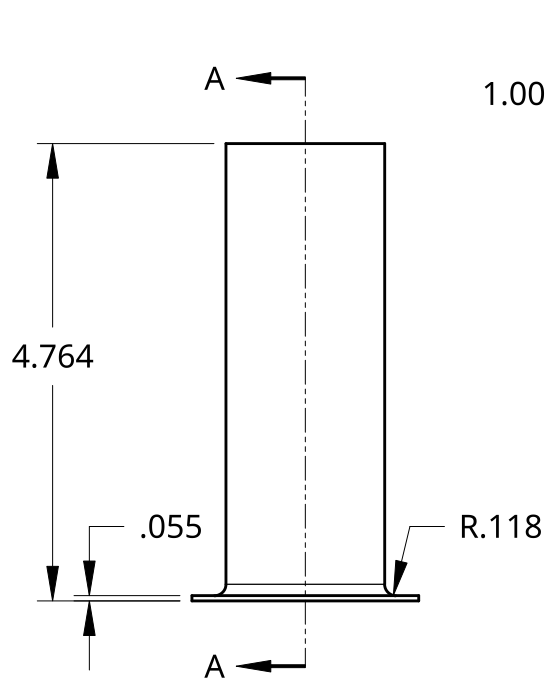
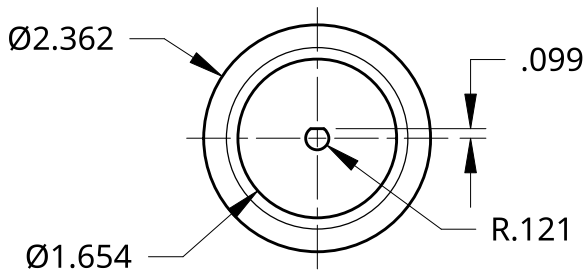
1

B

A

B

A



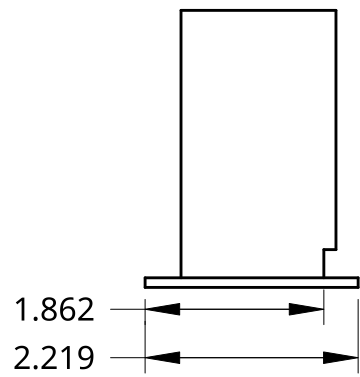
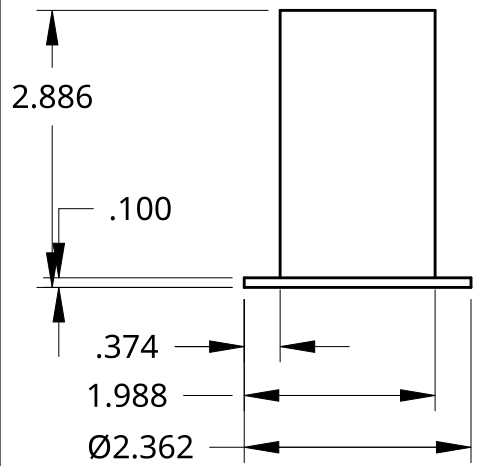
Draft Angle from 0.394 in hole is 15 degrees

0.220 in hole goes halfway though part and intersects motor shaft entry

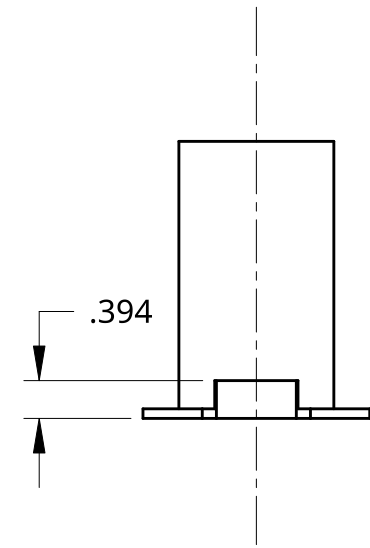
|                                                                                                                                                                                                               |  |                               |  |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|-------------------------------|--|
| UNLESS OTHERWISE SPECIFIED,<br>DIMENSIONS ARE IN INCHES<br>.XX = ±.0-<br>.XXX = ±.00-<br>.XXXX = ±.000-<br>SURFACE FINISH  |  | ANGULAR = ±<br>FRACTIONAL = ± |  |
| DO NOT SCALE DRAWING                                                                                                                                                                                          |  |                               |  |
| BREAK ALL SHARP EDGES AND<br>REMOVE BURRS                                                                                                                                                                     |  |                               |  |
| THIRD ANGLE PROJECTION                                                                                                    |  |                               |  |

|                                        |  |                |                        |                     |                      |
|----------------------------------------|--|----------------|------------------------|---------------------|----------------------|
| NAME                                   |  | DATE           | Onshape Pen Pal (Rife) |                     |                      |
| DRAWN                                  |  | WILLIAM CUSATO |                        |                     |                      |
| CHECKED                                |  |                | TITLE                  |                     |                      |
| APPROVED                               |  |                |                        |                     |                      |
| DO NOT SCALE DRAWING                   |  |                | Conveyor Driven Spool  |                     |                      |
| BREAK ALL SHARP EDGES AND REMOVE BURRS |  |                |                        |                     |                      |
| THIRD ANGLE PROJECTION                 |  | MATERIAL       | FINISH                 | SIZE<br><b>A</b>    | DWG NO.<br><b>11</b> |
|                                        |  |                |                        | SCALE<br><b>1:2</b> | WEIGHT               |
|                                        |  |                |                        | SHEET               | 1 of 1               |

B

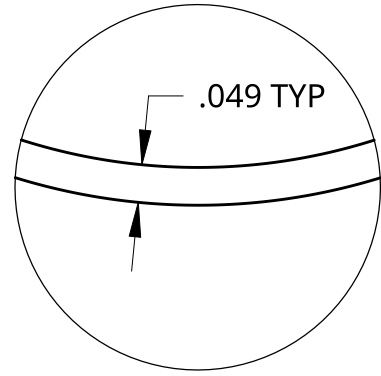
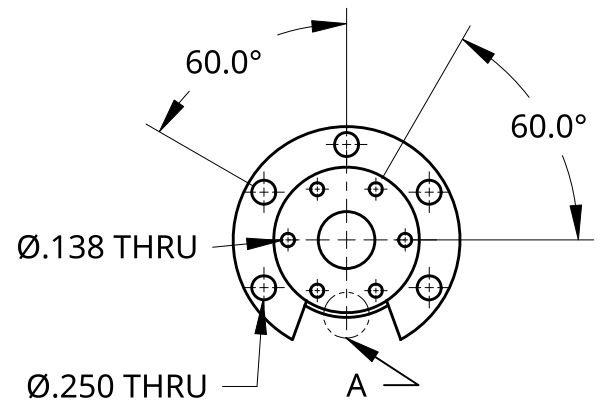


DETAIL A  
SCALE 4:1

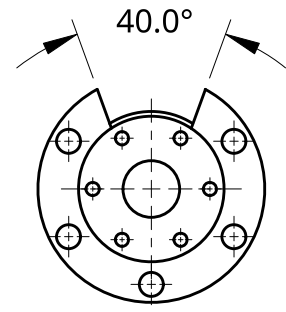


B

A



Wall thickness typical at 0.49 in



Cut made at 40 degree angle  
symmetrical through centerline  
and through wall

A

All mounting holes symmetrical  
through the center lines

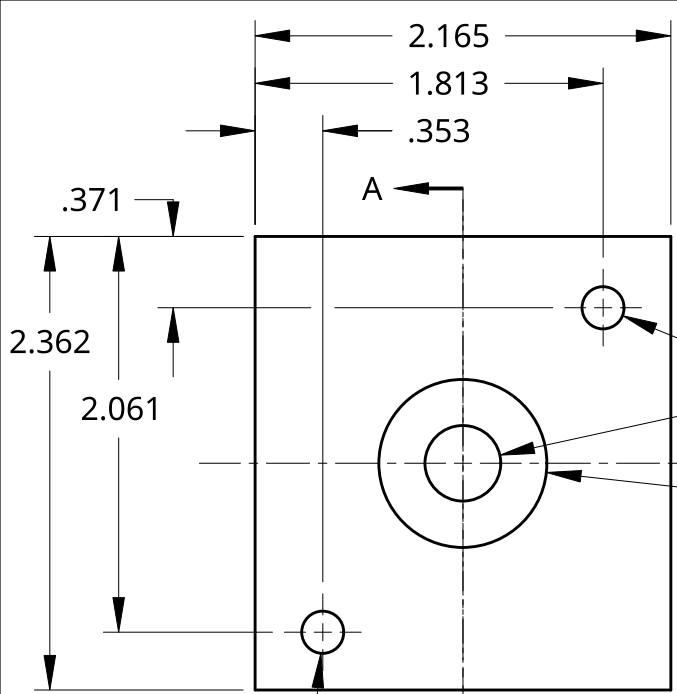
|                                                                                                                                                                                                                                                                                                                                                                                                      |                 |                    |            |                                   |               |                 |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|--------------------|------------|-----------------------------------|---------------|-----------------|
| UNLESS OTHERWISE SPECIFIED,<br>DIMENSIONS ARE IN INCHES<br>.XX = ±.0-<br>.XXX = ±.00-<br>.XXXX = ±.000-<br>SURFACE FINISH <br>DO NOT SCALE DRAWING<br>BREAK ALL SHARP EDGES AND<br>REMOVE BURRS<br>THIRD ANGLE PROJECTION<br> |                 | NAME               | DATE       | Onshape Pen Pal (Rife)            |               |                 |
|                                                                                                                                                                                                                                                                                                                                                                                                      | DRAWN           | WILLIAM CUSATO     | 12/06/2025 | TITLE<br><br>Conveyor Motor Mount |               |                 |
|                                                                                                                                                                                                                                                                                                                                                                                                      | CHECKED         |                    |            |                                   |               |                 |
|                                                                                                                                                                                                                                                                                                                                                                                                      | APPROVED        |                    |            |                                   |               |                 |
|                                                                                                                                                                                                                                                                                                                                                                                                      |                 |                    |            | SIZE<br>A                         | DWG NO.<br>12 | REV.<br>A       |
|                                                                                                                                                                                                                                                                                                                                                                                                      | MATERIAL<br>PLA | FINISH<br>3D Print |            | SCALE<br>1:2                      | WEIGHT        | SHEET<br>1 of 1 |

2

1

B

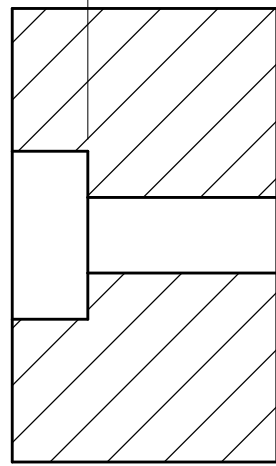
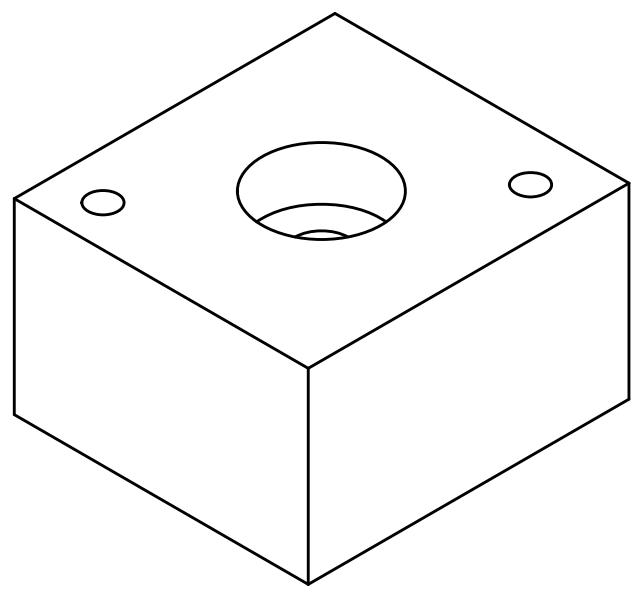
A



Ø.220 THRU  
Ø.394 THRU  
Ø.875

Location of second mounting hole  
reflected about both centerlines

All design features located on top  
face



SECTION A - A

1

B

A



2

1

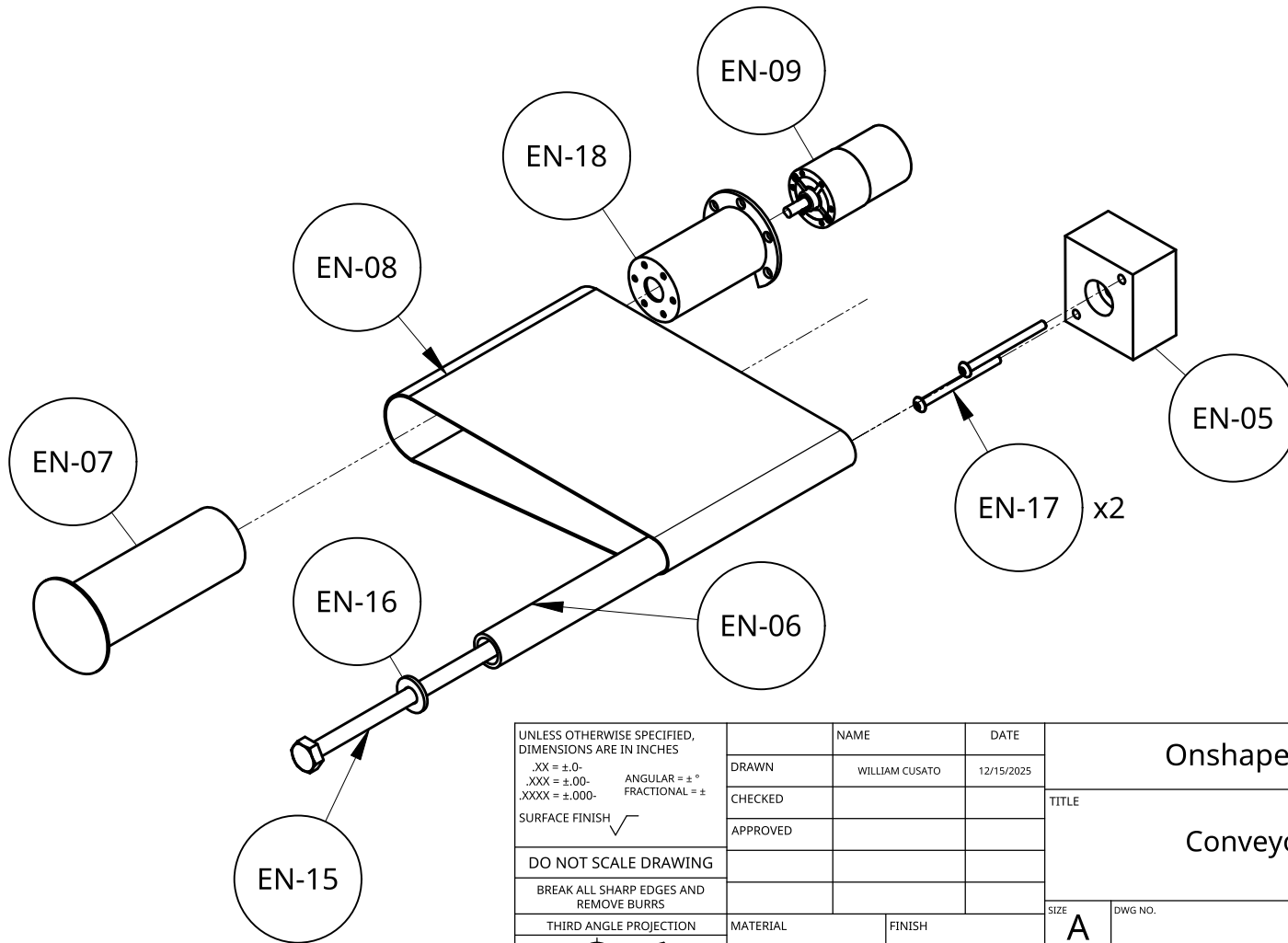
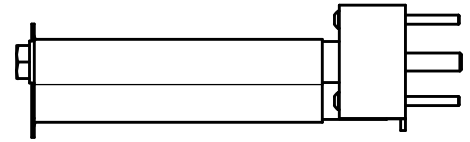
|                                                                                                                                                                                                                                                                                                                                                                                                      |          |                |            |                                   |                  |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|----------------|------------|-----------------------------------|------------------|
| UNLESS OTHERWISE SPECIFIED,<br>DIMENSIONS ARE IN INCHES<br>.XX = ±.0-<br>.XXX = ±.00-<br>.XXXX = ±.000-<br>SURFACE FINISH <br>DO NOT SCALE DRAWING<br>BREAK ALL SHARP EDGES AND<br>REMOVE BURRS<br>THIRD ANGLE PROJECTION<br> |          | NAME           | DATE       | Onshape Pen Pal (Rife)            |                  |
|                                                                                                                                                                                                                                                                                                                                                                                                      | DRAWN    | WILLIAM CUSATO | 12/15/2025 | TITLE<br><br>Conveyor Idler Mount |                  |
|                                                                                                                                                                                                                                                                                                                                                                                                      | CHECKED  |                |            |                                   |                  |
|                                                                                                                                                                                                                                                                                                                                                                                                      | APPROVED |                |            |                                   |                  |
|                                                                                                                                                                                                                                                                                                                                                                                                      |          |                |            | SIZE<br><b>A</b>                  | REV.<br><b>A</b> |
|                                                                                                                                                                                                                                                                                                                                                                                                      | MATERIAL | FINISH         |            | DWG NO.<br><b>13</b>              | SHEET<br>1 of 1  |
|                                                                                                                                                                                                                                                                                                                                                                                                      |          |                |            | SCALE<br><b>1:1</b>               | WEIGHT           |

B

A

B

A



|                                                         |                                 |          |                |                        |                                |                  |                        |
|---------------------------------------------------------|---------------------------------|----------|----------------|------------------------|--------------------------------|------------------|------------------------|
| UNLESS OTHERWISE SPECIFIED,<br>DIMENSIONS ARE IN INCHES |                                 |          |                | Onshape Pen Pal (Rife) |                                |                  |                        |
| .XX = ±.0-                                              | ANGULAR = ± °<br>FRACTIONAL = ± | DRAWN    | WILLIAM CUSATO | 12/15/2025             | TITLE<br><br>Conveyor Assembly |                  |                        |
| .XXX = ±.00-                                            |                                 | CHECKED  |                |                        |                                |                  |                        |
| .XXXX = ±.000-                                          |                                 | APPROVED |                |                        |                                |                  |                        |
| SURFACE FINISH                                          |                                 |          |                |                        |                                |                  |                        |
| DO NOT SCALE DRAWING                                    |                                 |          |                |                        | SIZE<br><b>A</b>               |                  |                        |
| BREAK ALL SHARP EDGES AND<br>REMOVE BURRS               |                                 |          |                |                        | DWG NO.<br><b>14</b>           |                  |                        |
| THIRD ANGLE PROJECTION                                  |                                 | MATERIAL |                | FINISH                 |                                | REV.<br><b>A</b> |                        |
|                                                         |                                 |          |                |                        | SCALE<br><b>1:4</b>            | WEIGHT           | SHEET<br><b>1 of 1</b> |

2

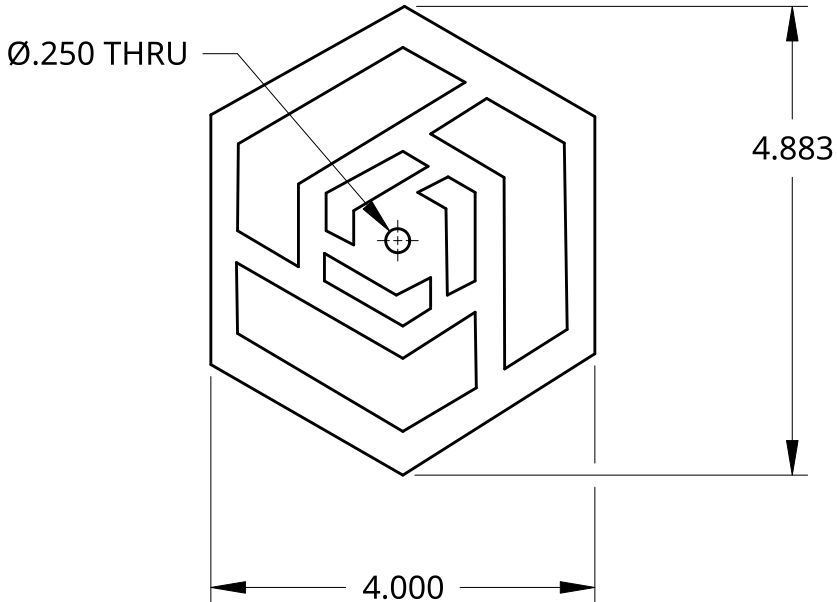
1

B

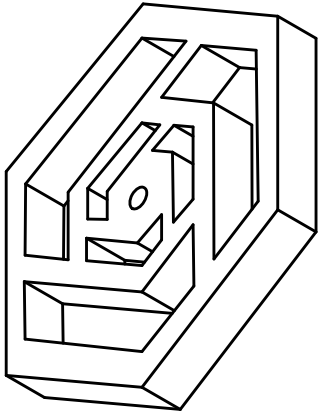
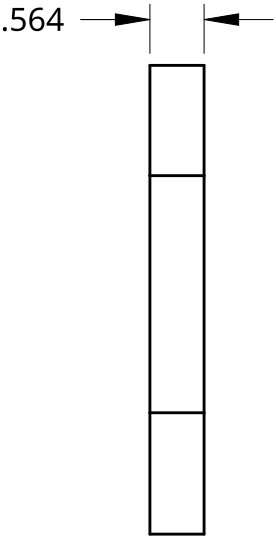
A

B

A



Bounding Box Dimensions Given.  
For other pertinent dimensions, please  
consult the PTC Brand Guide



|                                                                                                                                                                                                                                |          |                      |            |                                    |                      |                 |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|----------------------|------------|------------------------------------|----------------------|-----------------|
| UNLESS OTHERWISE SPECIFIED,<br>DIMENSIONS ARE IN INCHES<br>.XX = ±.0-<br>.XXX = ±.00-<br>.XXXX = ±.000-<br>SURFACE FINISH ✓<br>DO NOT SCALE DRAWING<br>BREAK ALL SHARP EDGES AND<br>REMOVE BURRS<br>THIRD ANGLE PROJECTION<br> |          | NAME                 | DATE       | Onshape Pen Pal (Rife)             |                      |                 |
|                                                                                                                                                                                                                                | DRAWN    | WILLIAM CUSATO       | 12/16/2025 | TITLE<br><br>Machined Onshape Logo |                      |                 |
|                                                                                                                                                                                                                                | CHECKED  |                      |            |                                    |                      |                 |
|                                                                                                                                                                                                                                | APPROVED |                      |            |                                    |                      |                 |
|                                                                                                                                                                                                                                |          |                      |            | SIZE<br><b>A</b>                   | DWG NO.<br><b>15</b> | REV<br><b>B</b> |
|                                                                                                                                                                                                                                |          | MATERIAL<br>Aluminum | FINISH     | SCALE<br>1:2                       | WEIGHT               | SHEET<br>1 of 1 |

2

1

B

A

B

A

Ø.594 THRU

3.172

2.708

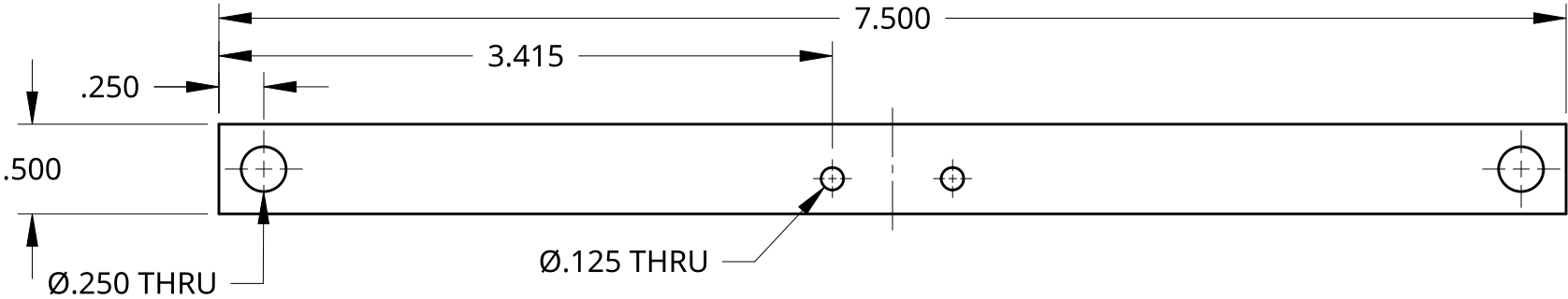
.787

Bounding Box Dimensions Provided.  
Part Based on Onshape Logo. Other  
pertinant design features and dimensions  
can be found through the PTC Brand Guide

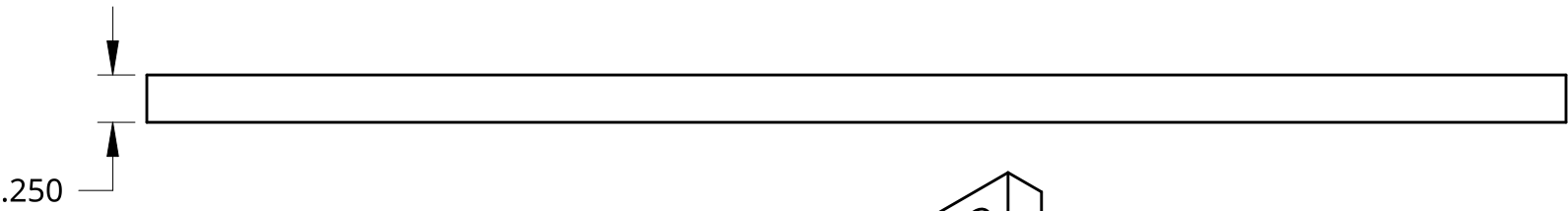
|                                                                                                                                                                                                                                                                                                                                                                                                      |          |                |            |                        |                      |                        |
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| UNLESS OTHERWISE SPECIFIED,<br>DIMENSIONS ARE IN INCHES<br>.XX = ±.0-<br>.XXX = ±.00-<br>.XXXX = ±.000-<br>SURFACE FINISH <br>DO NOT SCALE DRAWING<br>BREAK ALL SHARP EDGES AND<br>REMOVE BURRS<br>THIRD ANGLE PROJECTION<br> |          | NAME           | DATE       | Onshape Pen Pal (Rife) |                      |                        |
|                                                                                                                                                                                                                                                                                                                                                                                                      | DRAWN    | WILLIAM CUSATO | 12/16/2025 | TITLE<br><br>Obstacle  |                      |                        |
|                                                                                                                                                                                                                                                                                                                                                                                                      | CHECKED  |                |            |                        |                      |                        |
|                                                                                                                                                                                                                                                                                                                                                                                                      | APPROVED |                |            |                        |                      |                        |
|                                                                                                                                                                                                                                                                                                                                                                                                      |          |                |            | SIZE<br><b>A</b>       | DWG NO.<br><b>16</b> | REV.<br><b>A</b>       |
|                                                                                                                                                                                                                                                                                                                                                                                                      |          | MATERIAL       | FINISH     | SCALE<br><b>1:1</b>    | WEIGHT               | SHEET<br><b>1 of 1</b> |

B

B

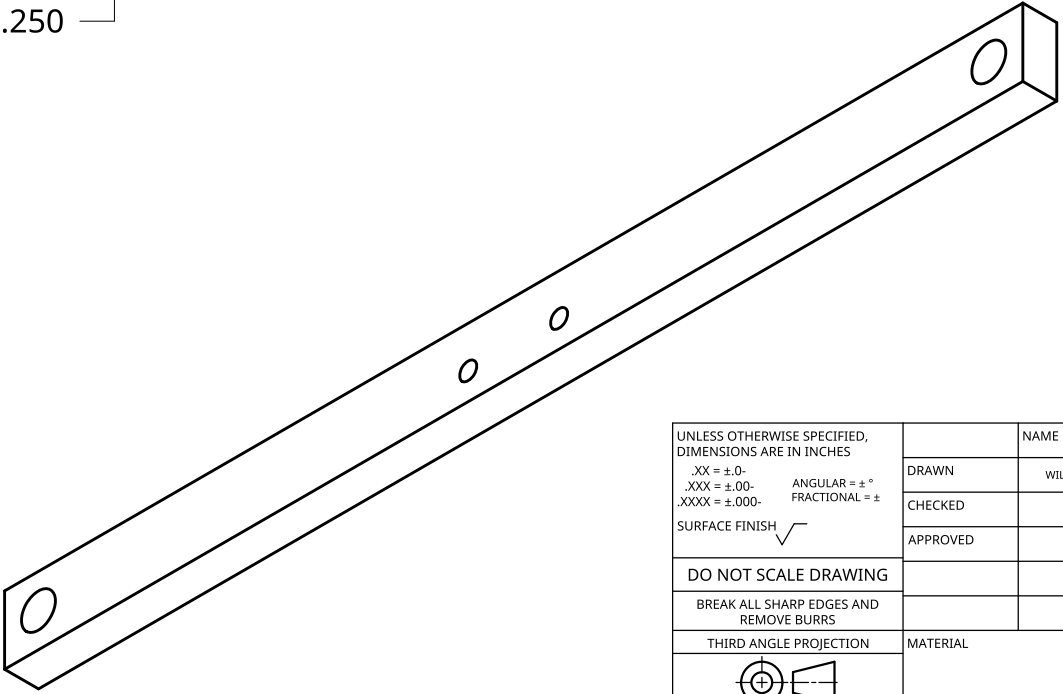


Hole locations are symmetrical through the centerline



A

A



|                                                                                                                                                                                                                                 |          |                |            |                         |               |                 |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|----------------|------------|-------------------------|---------------|-----------------|
| UNLESS OTHERWISE SPECIFIED,<br>DIMENSIONS ARE IN INCHES<br>.XX = ±.0-<br>.XXX = ±.00-<br>.XXXX = ±.000-<br>SURFACE FINISH ✓<br>DO NOT SCALE DRAWING<br>BREAK ALL SHARP EDGES AND<br>REMOVE BURRS<br>THIRD ANGLE PROJECTION<br>⊕ |          | NAME           | DATE       | Onshape Pen Pal (Rife)  |               |                 |
|                                                                                                                                                                                                                                 | DRAWN    | WILLIAM CUSATO | 12/15/2025 | TITLE<br>Obstacle Mount |               |                 |
|                                                                                                                                                                                                                                 | CHECKED  |                |            |                         |               |                 |
|                                                                                                                                                                                                                                 | APPROVED |                |            |                         |               |                 |
|                                                                                                                                                                                                                                 |          |                |            | SIZE<br>A               | DWG NO.<br>17 | REV.<br>A       |
|                                                                                                                                                                                                                                 |          |                |            | SCALE<br>1:1            | WEIGHT        | SHEET<br>1 of 1 |

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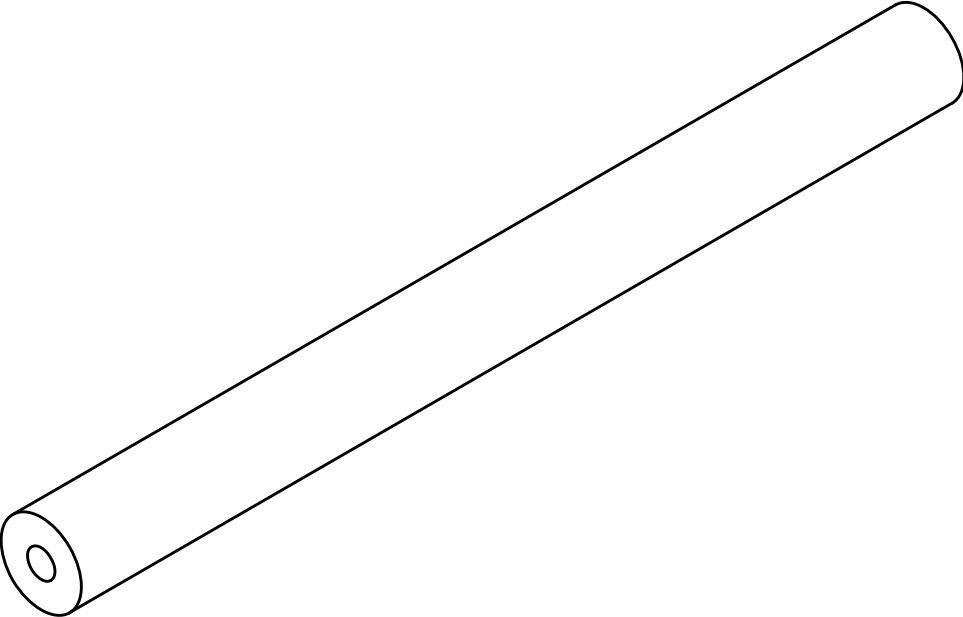
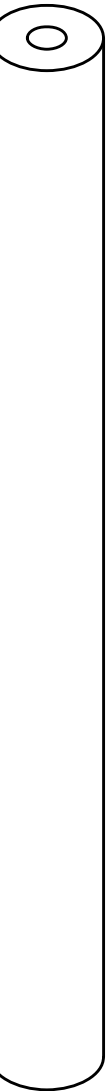
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Ø.591

Ø.203 THRU

6.500



|                                                                                                                                                                                                               |                      |                |            |                             |                      |                        |
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| UNLESS OTHERWISE SPECIFIED,<br>DIMENSIONS ARE IN INCHES<br>.XX = ±.0-<br>.XXX = ±.00-<br>.XXXX = ±.000-<br>SURFACE FINISH  |                      | NAME           | DATE       | Onshape Pen Pal (Rife)      |                      |                        |
|                                                                                                                                                                                                               | DRAWN                | WILLIAM CUSATO | 12/17/2025 | TITLE<br><br>Obstacle Shaft |                      |                        |
|                                                                                                                                                                                                               | CHECKED              |                |            |                             |                      |                        |
|                                                                                                                                                                                                               | APPROVED             |                |            |                             |                      |                        |
|                                                                                                                                                                                                               | DO NOT SCALE DRAWING |                |            |                             |                      |                        |
| BREAK ALL SHARP EDGES AND<br>REMOVE BURRS                                                                                                                                                                     |                      |                |            | SIZE<br><b>A</b>            | DWG NO.<br><b>18</b> | REV.<br><b>A</b>       |
| THIRD ANGLE PROJECTION<br>                                                                                                | MATERIAL             | FINISH         |            | SCALE<br><b>1:1</b>         | WEIGHT               | SHEET<br><b>1 of 1</b> |

2

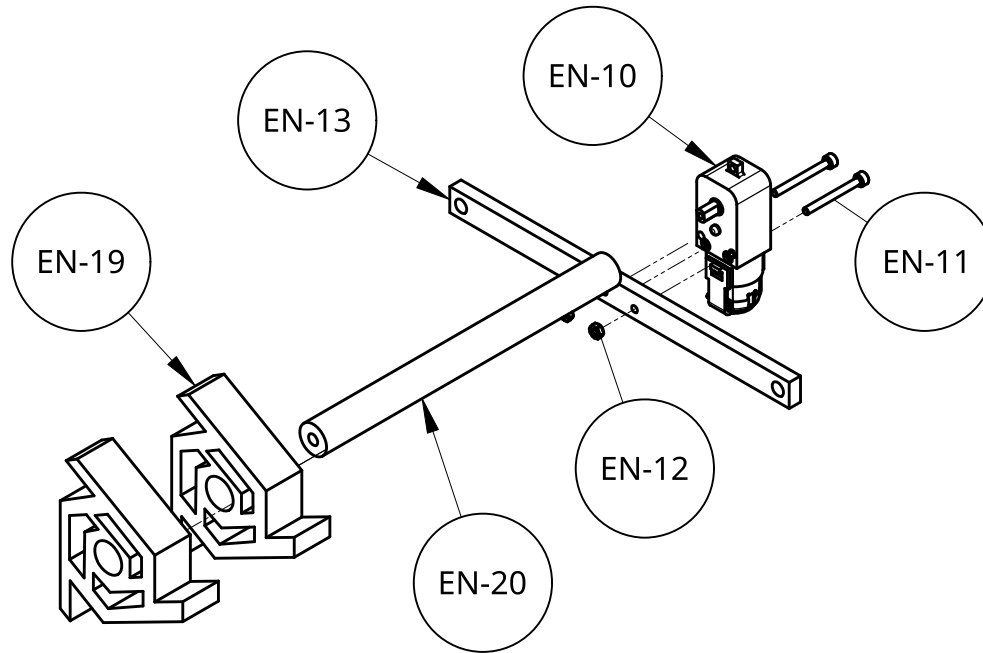
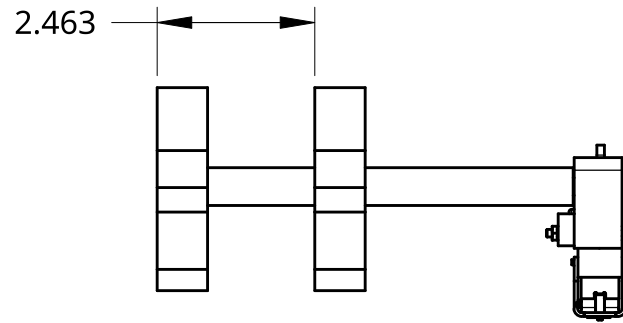
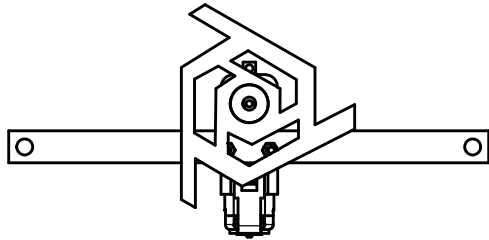
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| UNLESS OTHERWISE SPECIFIED,<br>DIMENSIONS ARE IN INCHES<br>.XX = ±.0-<br>.XXX = ±.00-<br>.XXXX = ±.000-<br>SURFACE FINISH <br>DO NOT SCALE DRAWING<br>BREAK ALL SHARP EDGES AND<br>REMOVE BURRS<br>THIRD ANGLE PROJECTION<br> |          | NAME           | DATE       | Onshape Pen Pal (Rife)         |                      |                        |
|                                                                                                                                                                                                                                                                                                                                                                                                      | DRAWN    | WILLIAM CUSATO | 12/15/2025 | TITLE<br><br>Obstacle Assembly |                      |                        |
|                                                                                                                                                                                                                                                                                                                                                                                                      | CHECKED  |                |            |                                |                      |                        |
|                                                                                                                                                                                                                                                                                                                                                                                                      | APPROVED |                |            |                                |                      |                        |
|                                                                                                                                                                                                                                                                                                                                                                                                      |          |                |            | SIZE<br><b>A</b>               | DWG NO.<br><b>19</b> | REV.<br><b>A</b>       |
|                                                                                                                                                                                                                                                                                                                                                                                                      |          | MATERIAL       | FINISH     | SCALE<br><b>1:3</b>            | WEIGHT               | SHEET<br><b>1 of 1</b> |

2

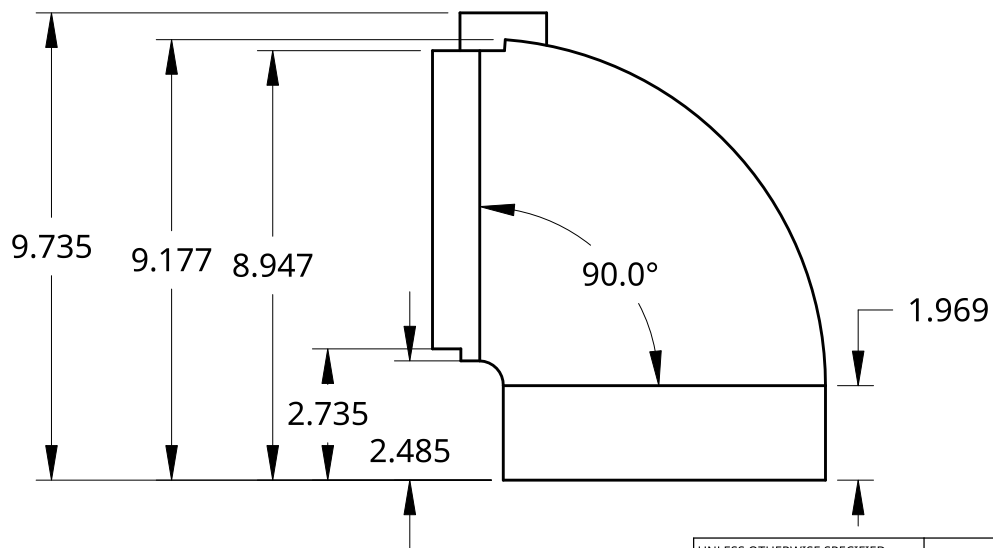
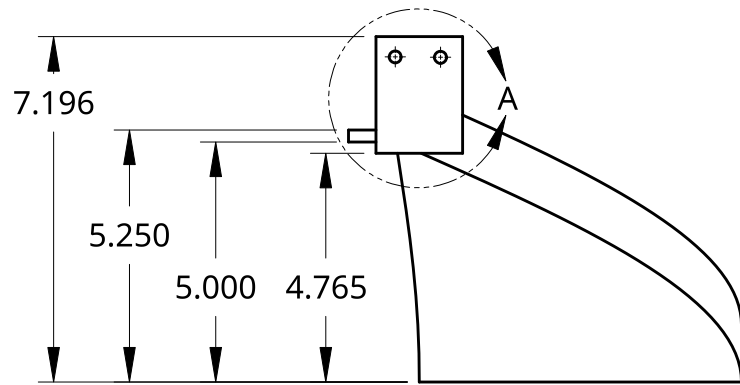
1

B

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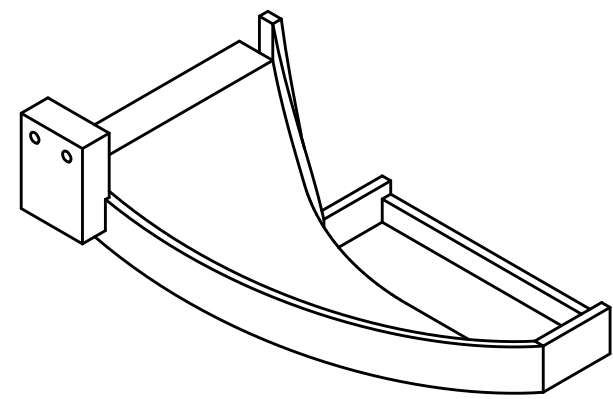
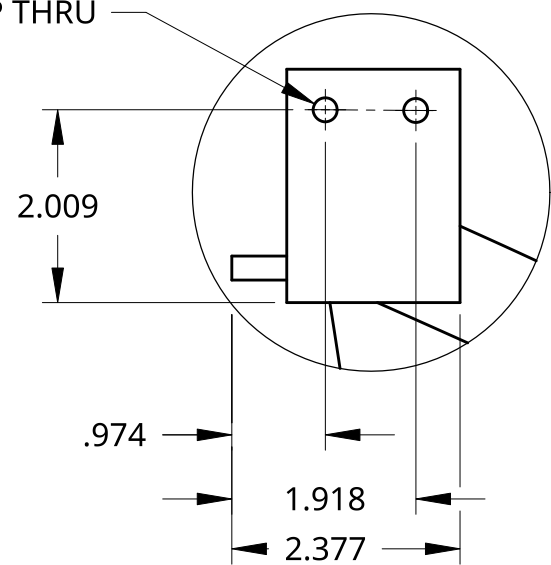
B

A



Ø.250 TYP THRU

DETAIL A  
SCALE 1:2



|                                                                                                                                                                                                                                                                                                                                                                                                   |          |               |            |                        |              |               |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|---------------|------------|------------------------|--------------|---------------|
| UNLESS OTHERWISE SPECIFIED,<br>DIMENSIONS ARE IN INCHES<br>.XX = ±.0-<br>.XXX = ±.00-<br>.XXXX = ±.000-<br>SURFACE FINISH <br>DO NOT SCALE DRAWING<br>BREAK ALL SHARP EDGES AND<br>REMOVE BURRS<br>THIRD ANGLE PROJECTION  |          | NAME          | DATE       | Onshape Pen Pal (Rife) |              |               |
|                                                                                                                                                                                                                                                                                                                                                                                                   | DRAWN    | CAROLINE BAUR | 12/17/2025 | Slide                  |              |               |
|                                                                                                                                                                                                                                                                                                                                                                                                   | CHECKED  |               |            |                        |              |               |
|                                                                                                                                                                                                                                                                                                                                                                                                   | APPROVED |               |            |                        |              |               |
|                                                                                                                                                                                                                                                                                                                                                                                                   |          |               |            |                        |              |               |
|                                                                                                                                                                                                                                                                                                                                                                                                   | MATERIAL | PLA           | FINISH     | Rough                  | SIZE<br>A    | DWG NO.<br>20 |
|                                                                                                                                                                                                                                                                                                                                                                                                   |          |               |            |                        | SCALE<br>1:4 | WEIGHT        |
|                                                                                                                                                                                                                                                                                                                                                                                                   |          |               |            |                        | SHEET        | 1 of 2        |
|                                                                                                                                                                                                                                                                                                                                                                                                   |          |               |            |                        | REV.<br>A    |               |

2

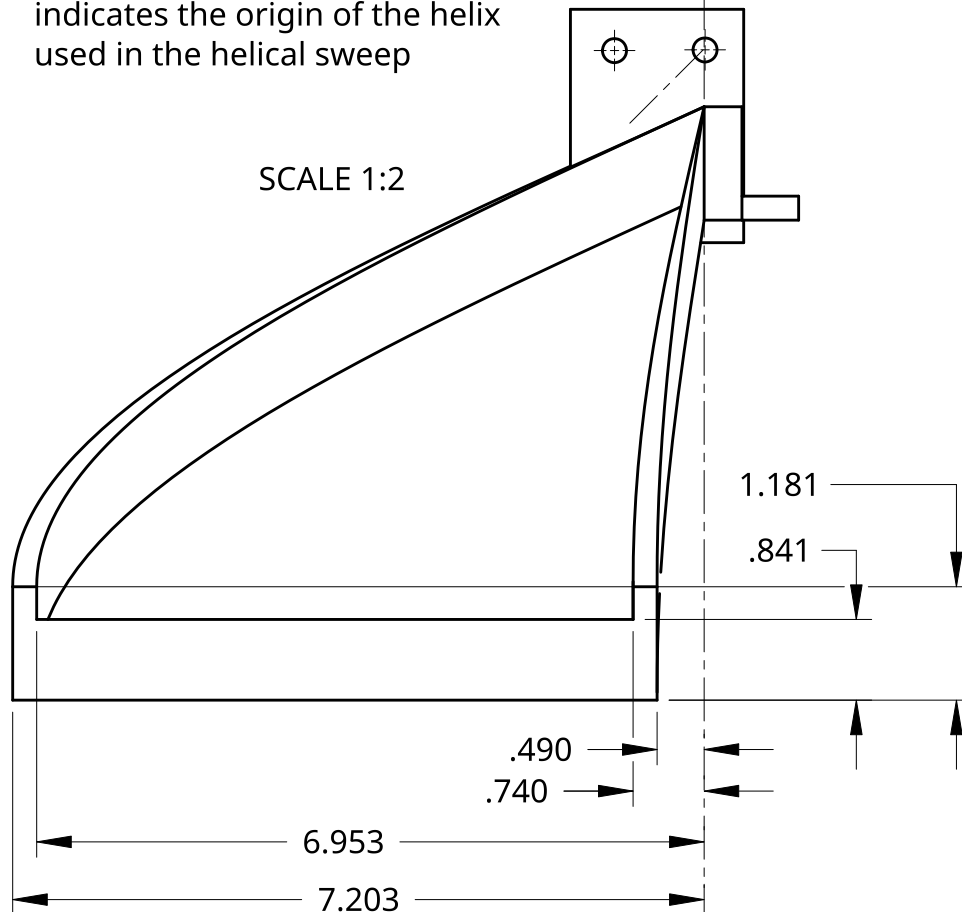
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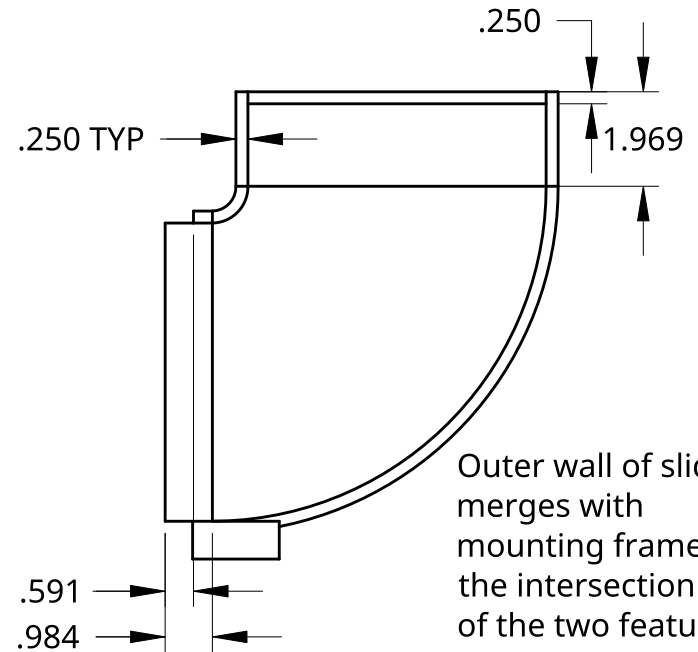
1

Slide curvature made through a helical sweep. Centerline indicates the origin of the helix used in the helical sweep

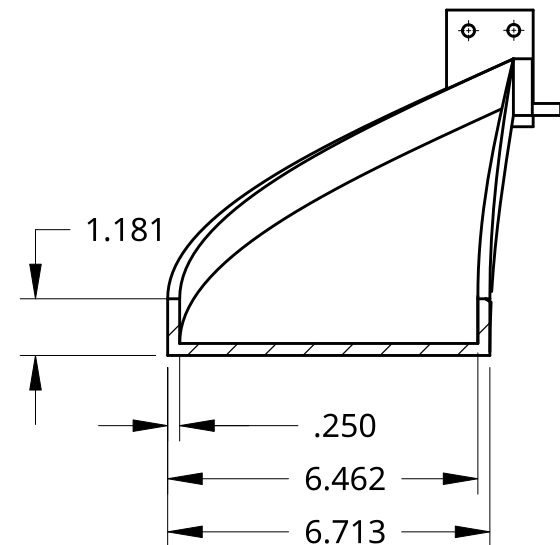
SCALE 1:2



Slide Curvature made through helical sweep. With the sweep profile shown in broken out section (bottom right view).



Outer wall of slide merges with mounting frame at the intersection of the two features



2

1

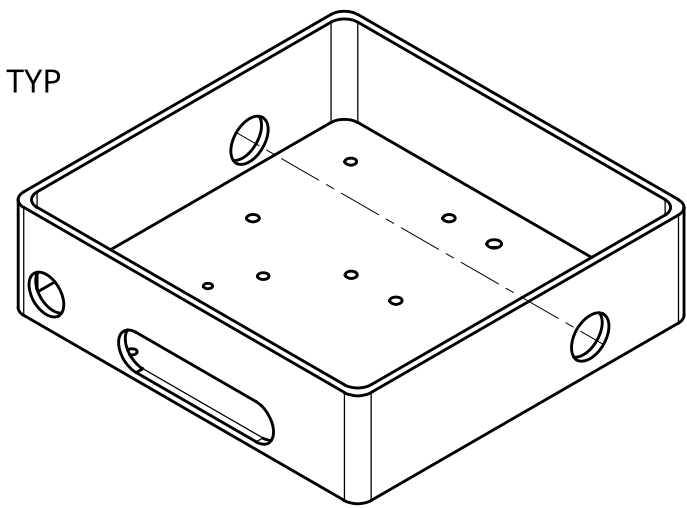
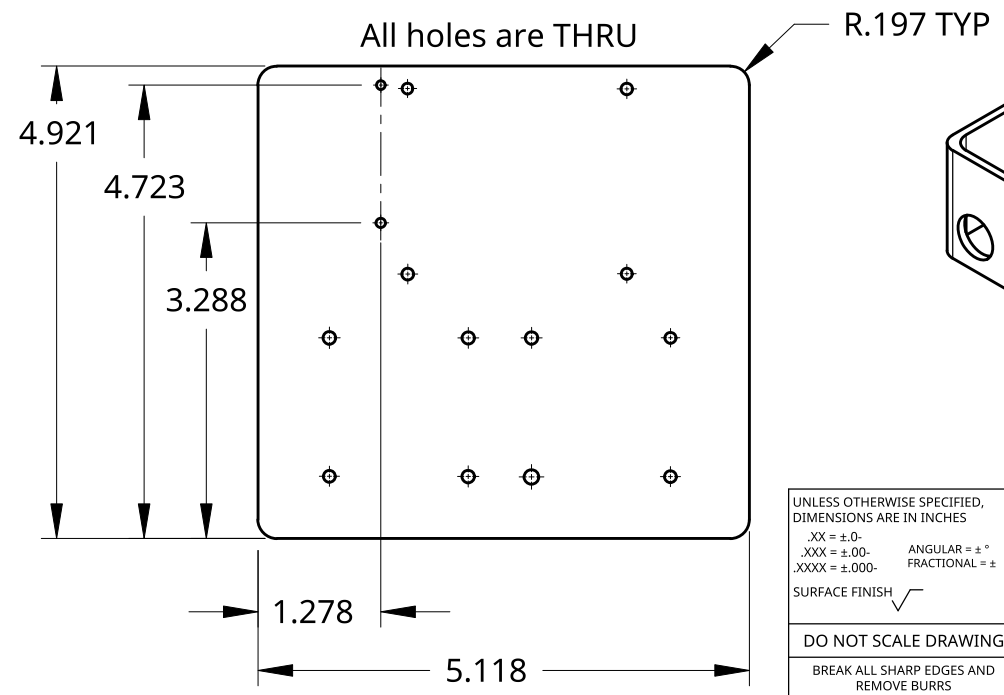
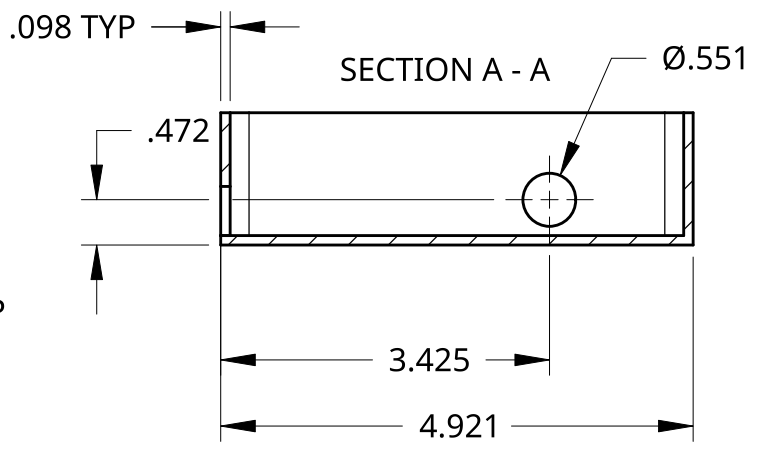
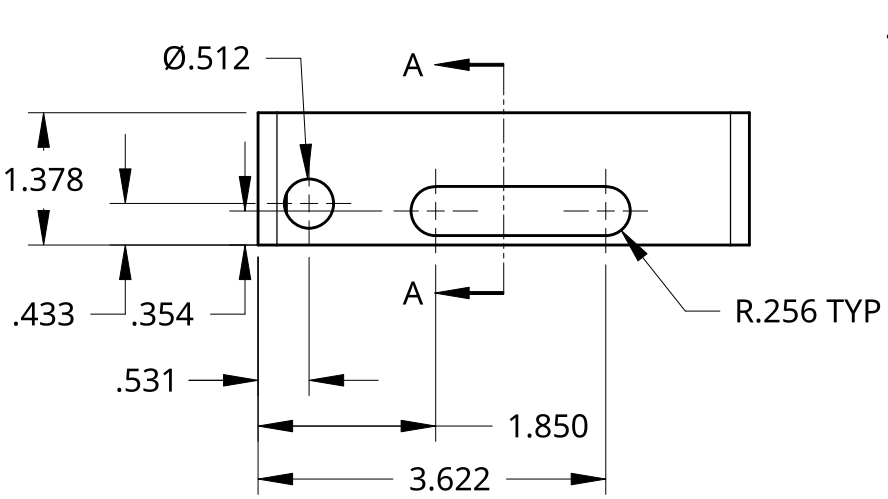
B

A

B

A

0.551 in hole symmetric on other side of enclosure (see isometric view)



|                                                                                                                                                                                                                            |  |  |  |                        |                    |                                     |  |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|--|------------------------|--------------------|-------------------------------------|--|
| UNLESS OTHERWISE SPECIFIED,<br>DIMENSIONS ARE IN INCHES<br>.XX = ±.0-<br>.XXX = ±.00-<br>.XXXX = ±.000-<br>SURFACE FINISH ✓<br>DO NOT SCALE DRAWING<br>BREAK ALL SHARP EDGES AND<br>REMOVE BURRS<br>THIRD ANGLE PROJECTION |  |  |  | NAME<br>WILLIAM CUSATO | DATE<br>12/17/2025 | Onshape Pen Pal (Rife)              |  |
|                                                                                                                                                                                                                            |  |  |  | DRAWN                  |                    | TITLE<br>Electronics Enclosure Base |  |
|                                                                                                                                                                                                                            |  |  |  | CHECKED                |                    | SIZE<br>A                           |  |
|                                                                                                                                                                                                                            |  |  |  | APPROVED               |                    | DWG NO.<br>21                       |  |
|                                                                                                                                                                                                                            |  |  |  | MATERIAL               |                    | FINISH                              |  |
|                                                                                                                                                                                                                            |  |  |  |                        |                    | SHEET<br>1 of 2                     |  |
|                                                                                                                                                                                                                            |  |  |  |                        |                    | REV.<br>A                           |  |

2

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B

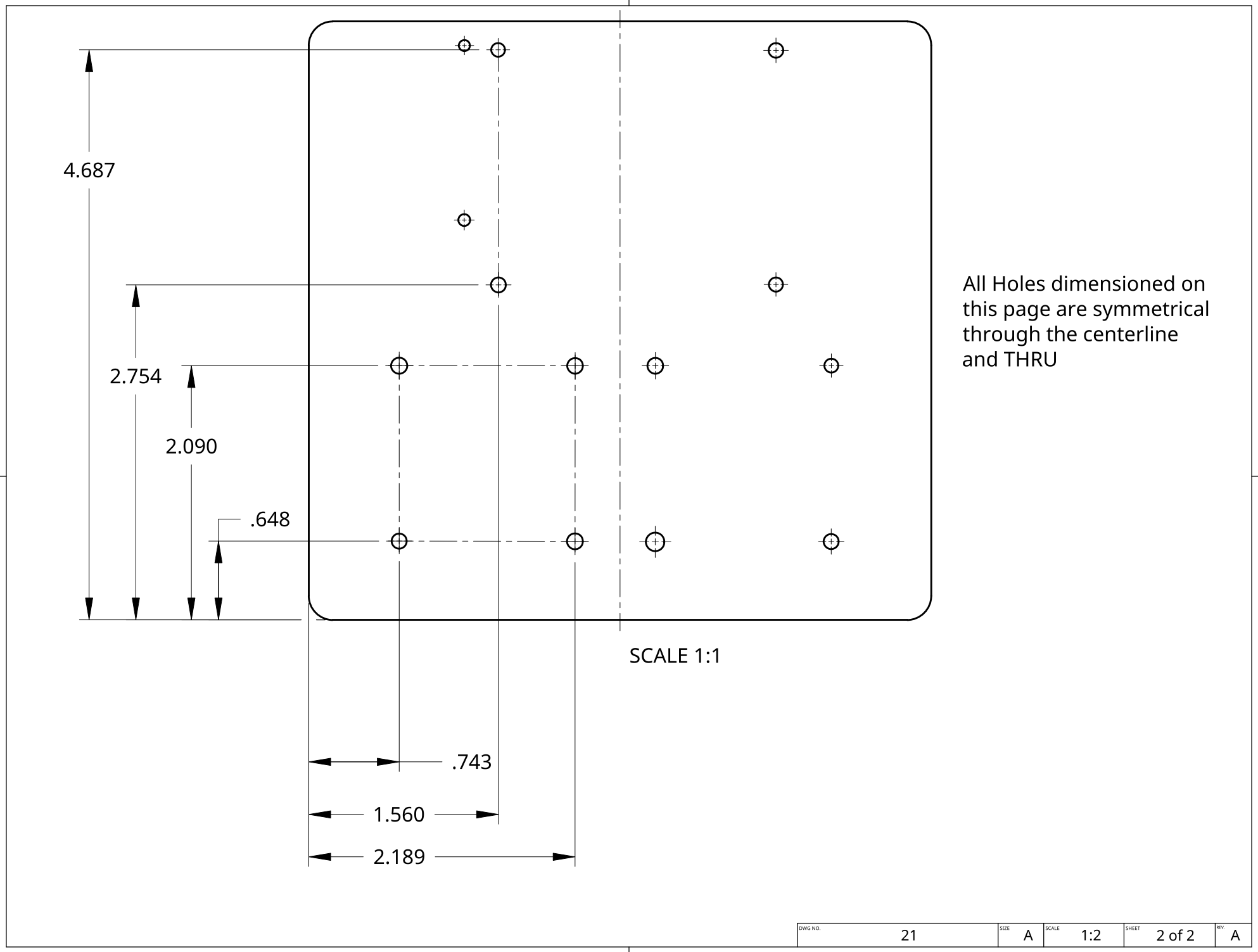
B

All Holes dimensioned on  
this page are symmetrical  
through the centerline  
and THRU

A

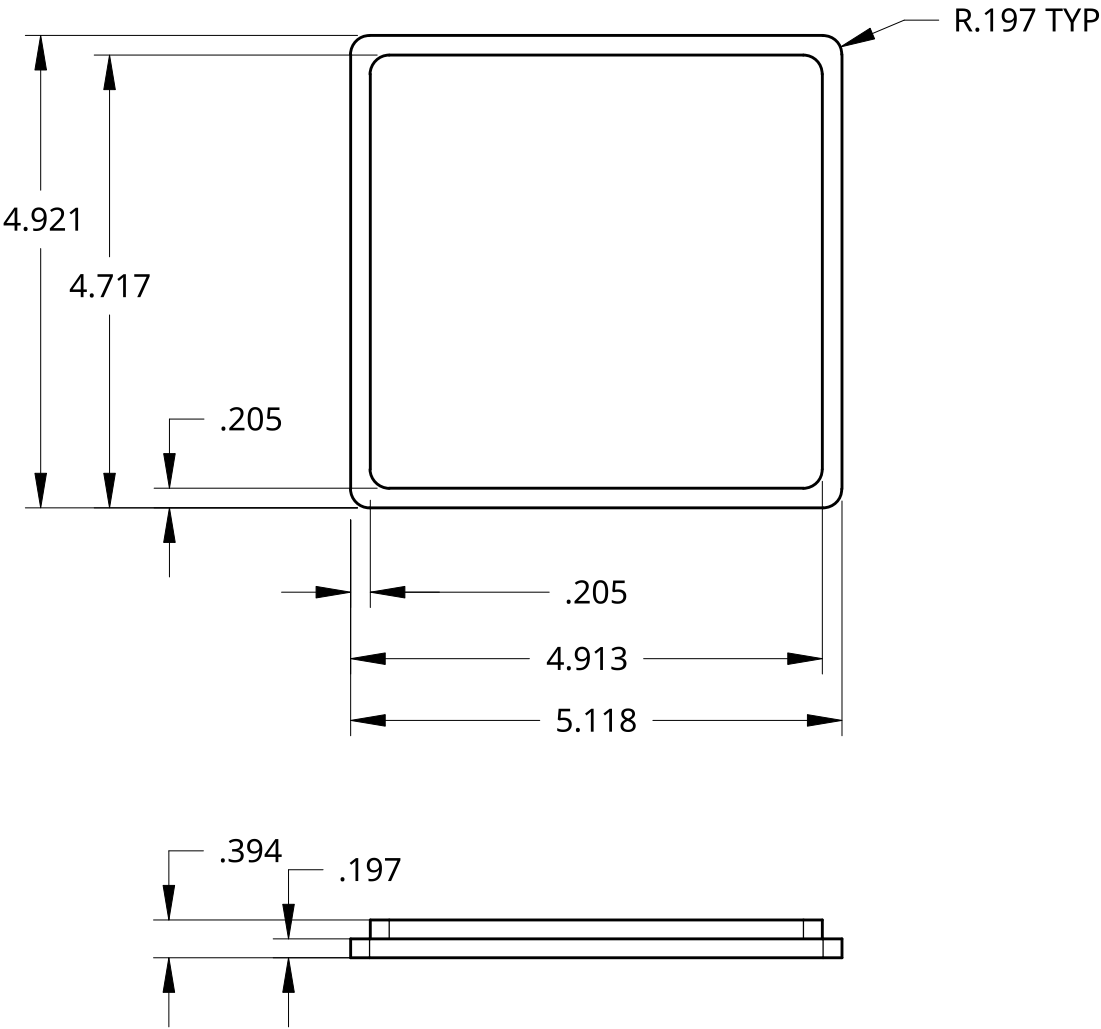
A

SCALE 1:1



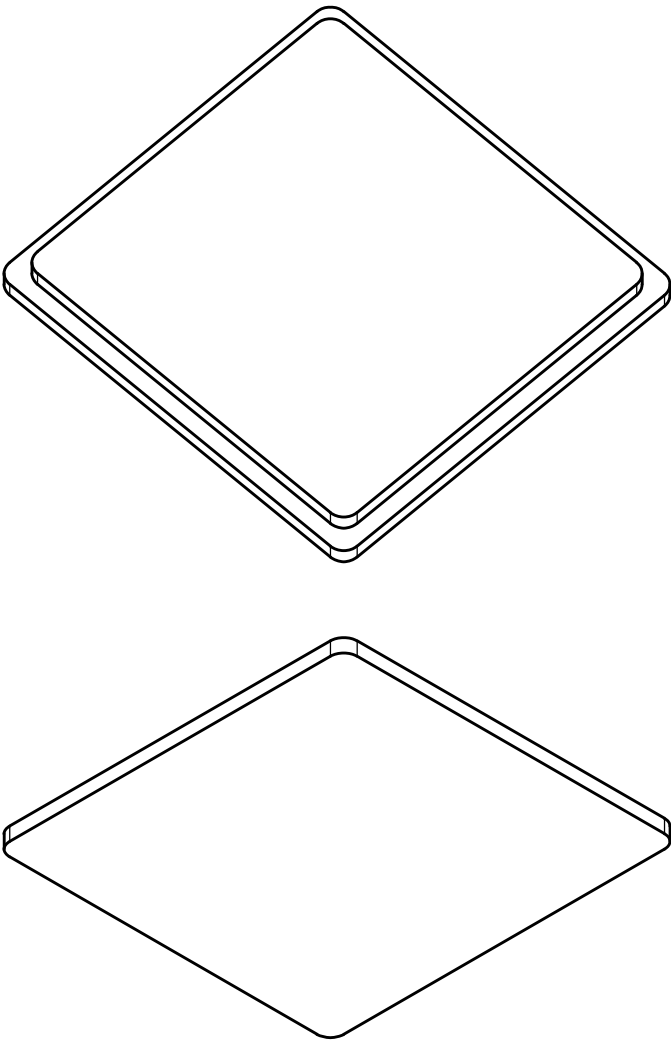
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|                                                                                                                                                                                                                                 |          |                |            |                                        |               |                 |
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| UNLESS OTHERWISE SPECIFIED,<br>DIMENSIONS ARE IN INCHES<br>.XX = ±.0-<br>.XXX = ±.00-<br>.XXXX = ±.000-<br>SURFACE FINISH ✓<br>DO NOT SCALE DRAWING<br>BREAK ALL SHARP EDGES AND<br>REMOVE BURRS<br>THIRD ANGLE PROJECTION<br>⊕ |          | NAME           | DATE       | Onshape Pen Pal (Rife)                 |               |                 |
|                                                                                                                                                                                                                                 | DRAWN    | WILLIAM CUSATO | 12/17/2025 | TITLE<br><br>Electronics Enclosure Lid |               |                 |
|                                                                                                                                                                                                                                 | CHECKED  |                |            |                                        |               |                 |
|                                                                                                                                                                                                                                 | APPROVED |                |            |                                        |               |                 |
|                                                                                                                                                                                                                                 |          |                |            | SIZE<br>A                              | DWG NO.<br>22 | REV.<br>A       |
|                                                                                                                                                                                                                                 |          | MATERIAL       | FINISH     | SCALE<br>1:2                           | WEIGHT        | SHEET<br>1 of 1 |

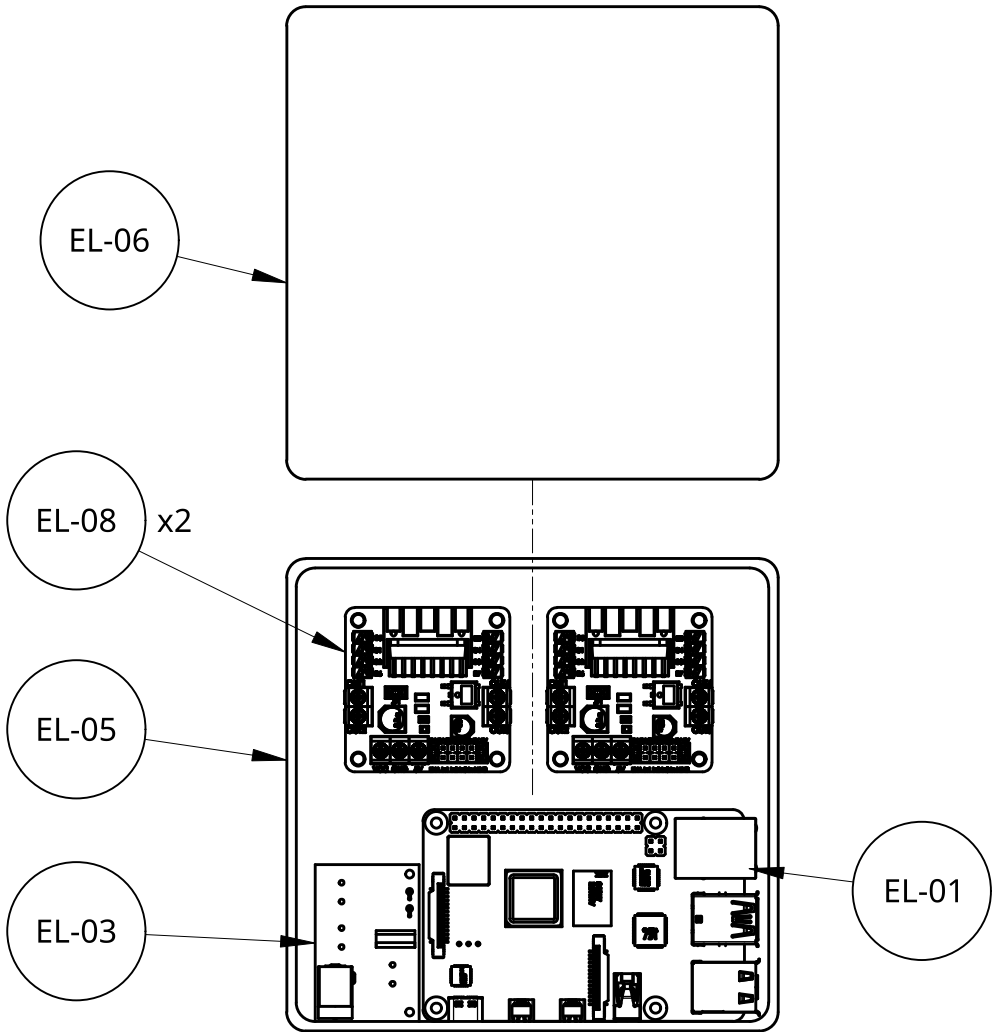
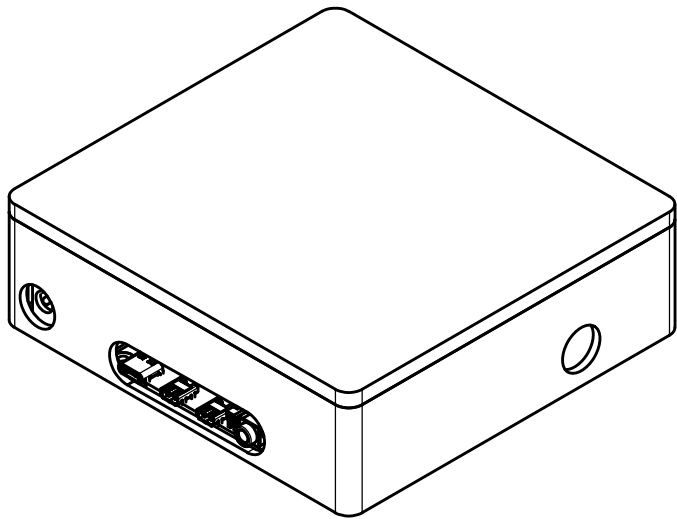
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|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|----------|--|----------------|--|-------------------------------------------------------------------|--|---------|--|------------|--|
| <div>UNLESS OTHERWISE SPECIFIED,<br/>DIMENSIONS ARE IN INCHES</div> <div>.XX = ±.0-<br/>.XXX = ±.00-<br/>.XXXX = ±.000-</div> <div>ANGULAR = ±°<br/>FRACTIONAL = ±</div> <div>SURFACE FINISH ✓</div> <div>DO NOT SCALE DRAWING</div> <div>BREAK ALL SHARP EDGES AND<br/>REMOVE BURRS</div> <div>THIRD ANGLE PROJECTION</div> <div></div> |  | NAME     |  | DATE           |  | <div>Onshape Pen Pal (Rife)</div> <div>Electronics Assembly</div> |  |         |  |            |  |
|                                                                                                                                                                                                                                                                                                                                                                                                                              |  | DRAWN    |  | WILLIAM CUSATO |  |                                                                   |  |         |  | 12/16/2025 |  |
|                                                                                                                                                                                                                                                                                                                                                                                                                              |  | CHECKED  |  |                |  |                                                                   |  |         |  |            |  |
|                                                                                                                                                                                                                                                                                                                                                                                                                              |  | APPROVED |  |                |  |                                                                   |  |         |  |            |  |
|                                                                                                                                                                                                                                                                                                                                                                                                                              |  |          |  |                |  |                                                                   |  |         |  |            |  |
|                                                                                                                                                                                                                                                                                                                                                                                                                              |  |          |  |                |  | TITLE                                                             |  |         |  |            |  |
|                                                                                                                                                                                                                                                                                                                                                                                                                              |  |          |  |                |  | SIZE                                                              |  | DWG NO. |  |            |  |
|                                                                                                                                                                                                                                                                                                                                                                                                                              |  |          |  |                |  | A                                                                 |  | 23      |  |            |  |
|                                                                                                                                                                                                                                                                                                                                                                                                                              |  |          |  |                |  | SCALE                                                             |  | WEIGHT  |  |            |  |
|                                                                                                                                                                                                                                                                                                                                                                                                                              |  |          |  |                |  | 1:2                                                               |  | 1 of 1  |  |            |  |
|                                                                                                                                                                                                                                                                                                                                                                                                                              |  |          |  |                |  | SHEET                                                             |  | 1 of 1  |  |            |  |
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