GNG2101

**Design Project User and Product Manual**

# Cup Daddy

## Secure Cup Holder


Submitted by:

**Group Z13**

François-Nasr Kharrat 300315604

Nusaibah Rashid 300334452

Justin Saikali 300072671

Jieying Yang 300103978

Jessica Young Spice 300160284


Sunday, July 23


University of Ottawa

# Table of Contents

# List of Figures

# List of Tables

# List of Acronyms and Glossary

**Table 1. Acronyms**

| Acronym | Definition |
|---|---|
| ABS | Acrylonitrile Butadiene Styrene |
| CAD | Computer Aided Design |
| PLA | Polylactic Acid |

# 1 Introduction

Thank you for choosing our secure cup holder product! This User and Product Manual has been created to provide you with all the necessary information on how to effectively use our cup holder. This manual will guide you through the installation process, usage instructions, and important safety considerations.

We assume that you have a basic understanding of how to handle tools and perform simple installations. We also assume that you have access to a suitable surface that can be clamped upon, and that you have received all the necessary components included with the cup holder.

This document is organized into several sections to help you navigate through the information easily. For more information visit the table of contents which gives an overview of the sections.

The purpose of this document is to provide comprehensive instructions and guidelines for users to effectively install, use, and maintain the cup holder product. It aims to ensure a safe and satisfactory experience while utilizing our cup holder.

This document covers all aspects related to the installation, usage, safety considerations, and maintenance of the cup holder product. It serves as a reference guide for users, enabling them to understand the product's functionality and make the most out of its features.

This User and Product Manual is intended for end users of the cup holder product, and future teams planning on improving the product. It is intended to provide detailed instructions on

its installation, usage, and maintenance. A wide variety of users could enjoy the purpose of this secure cup holder. Whether boat users, gamers or disabled individuals get this product it will be beneficial and will answer some of their needs.

While using the cup holder, it is important to ensure that it is mounted securely onto a clampable surface. Please follow the installation instructions carefully to avoid any potential accidents or damage. Additionally, make sure to handle the cup holder and its components with care to prevent injuries.

# 2 Overview

The client that the product was originally designed for has cerebral palsy and has limited control of her limbs. Due to uncontrolled movements, she often knocks her cup off of her wheelchair tray. This causes spills and prevents the user from enjoying her drink, as she does not have constant aid. This means that she may not be able to get someone to bring her a new drink and clean up the spill for a prolonged period. The user wants to prevent the spilling of her drink, as well as gain more independence to be left alone or enjoy her drink by herself. This design will not only help the client to keep her independence and prevent drink spills, but it will lower the number of times that those in charge of helping her will have to check in and clean up any mess.

The user has a few important needs. She needs to keep the cup and straw that she currently owns; she does not have enough suction force to use a straw that is any longer than her current one and the cup and straw system that she has in place is ideal for her. Due to this, the user requires that the cup remains in the same place on her wheelchair tray that she already has. Before the design of our cup holder system, the user would attach her cup to her wheelchair tray using a piece of Velcro. This solution was subpar, and the cup holder will drastically improve the stability of the cup when in place. Other needs that the user had and preferred was the cupholder can be used on multiple trays or thicknesses of trays. This is because the user has two wheelchairs and would like to use the cupholder on both. This also provides the user with the ability to buy or change wheelchairs in the future and still be able to use the cupholder.

Our product is different than other products that can be found online or in-stores due to the personalization that can be done, the ease of use, and the rugged construction. The Cup Daddy

plastic component can be personalized to be manufactured in different shapes and sizes to accommodate different cups or items, as well as different colours for additional personalization. The clamp sub system can also be used for purposes other than cup stabilization, since a new component can be designed and slotted onto the clamp. This means that the cup holder system can be used for multiple different purposes. It is also very sturdy and can withstand a lot of use due to its rugged design. Most other products and designs are made of a flimsy plastic that will bend and deform over time. They are often not able to be disassembled, meaning that if one part fails, all parts fail. Our design can be dissembled and is made of metal and plastic, meaning that repairs and reprints are easy and quick to do, saving the user both time and money.

Figure 1. Virtual Rendering of the Design (Left) and The Final Prototype (Right)

The key features of our design are the removable cup holder and hand tightening clamp system. To use Cup Daddy, you simply find a wheelchair tray or flat surface that is smaller than an inch wide, place the clamp onto the table and hand tighten the thumbscrew attached to the base. Make sure that the clamp is not too tight; finger tight is great. Once the clamp is attached to the table, simply slide the cup holder component onto the slot and then insert your drink. If installed correctly, the user should be able to hit and knock the cup holder without the cup spilling or falling out.

The construction of the Cup Daddy involves a C-channel and flat bar made of aluminum, some screws as permanent joints, a PLA 3D printed cup holder component, and a thumbscrew with a swivel head. To make the clamp subsystem, the C-channel was attached to the flat bar using three screws. The flat bar was placed against the back of the C-channel, forming the elongated bar that the cup holder component slots onto. A hole at the base of the C-channel was created and threaded to allow for the thumbscrew to be used. The swivel head is then attached to the thumbscrew. Rubber pads were added to the bottom of the top section of the C-channel as well as the swivel head to allow for more grip. The cup holder component was designed using SolidWorks and was then 3D printed using PLA plastic. The cup was designed to perfectly slot onto the clamp subsystem.

Extra consideration to have when using or installing this component, is that it is designed for an able-bodied person to install the device, which can then be left for the user or others to use or insert the cup into the cupholder. The cup holder component was designed with a wide outer edge that streamlines and becomes smaller to fit the cup at the base. This will allow for the user to simply place the cup in the cupholder without having to worry about exact placement.

## 2.1 Conventions

Conventions within this manual that the user should be aware of, is when giving instructions about how to use or install the device, the manual will tell the user to follow the steps below. There will then be numbered steps that the user must follow. The instructions are spilt up into sections for certain actions, so the user may have to look through another set of instructions if there is some confusion. At the end of each instruction section, there is a small paragraph about the product or about the intended use for the given instructions.

## 2.2 Cautions & Warnings

Before using the clamp, the user should be aware that the clamp can be taken apart for repairs or cleanings. This means that the user should be careful when storing the clamp in a loose container or when disassembling in order to prevent loss or damage of the pieces. The user should also be aware that the clamp sub-part is made of metal that does have ridges and elongated pieces that stick out, such as the flat bar. This means that when traveling or transporting a wheelchair or item with the clamp attached, care should be taken to ensure that no one or no items get snagged or hit by the elongated parts. The parts have been smoothed out, but this does not perfectly prevent accidents.

# 3 Getting started

To ensure a smooth setup and usage experience with our cup holder, please follow the steps outlined below. This section will guide you through the assembly process and provide instructions for configuring and accessing the system.

## 3.1 Configuration Considerations

Our cup holder system consists of several components that need to be assembled. The only tools required for assembly are M3 sized Allen keys to be able to screw the flat bar to the c-channel.

Figure 2. Allen keys **[1]**

## 3.2 User Access Considerations

Our cup holder system is designed for general users who wish to securely hold cups on a clampable surface. Primarily, it was designed for people with disabilities. Disabled users who have good function in the hands can easily use the product, while users who have limited hand mobility might need assistance to properly use the product. Otherwise, there are no other limitations on accessibility.

## 3.3 Accessing/setting up the System

1. Begin by unpacking the contents of the package. You should have the following components:

- Plastic Cup holder
- Flat bar with 3 counterbore holes

- C-Channel with 3 tapped holes on the vertical part and one tapped hole in the middle of the lower horizontal part
- 3 M3 socket head screws
- Thumb grip
- ¼-20” socket head screw
- Swivel Head

2. Using the proper size Allen key, screw the C-Channel to the flat bar using the 3 M3 socket head screws. Tighten until secure or flush with flat bar.

3. Press fit the thumb grip onto the ¼-20” screw head

4. Take the ¼-20” screw with the now press fitted thumb grip and thread it into the lower horizontal part of the C-Channel.

5. Attach the swivel head to the end of the thumb screw. This will help mount the cup to uneven surfaces.

6. Now, you can slot the cup holder onto the protruding end of the flat bar attached to the C-Channel. Ensure a snug fit.

Now you’re all set to use the secure cup holder. Find a clampable surface, slide the clamp in, and screw the thumb screw until the swivel head is in tight contact with the clampable surface!

Figure 3. Exploded view of the product

## 3.4 System Organization & Navigation

Cup Daddy consists of the following main components:

- Plastic Cup holder: This is the main part where you can place your cup or beverage container.
- Flat bar with 3 counterbore tapped holes: It serves as the connecting piece between the C-Channel and the cup holder.
- C-Channel with 3 tapped holes on the vertical part and one tapped hole in the middle of the lower horizontal part: This is the clamp that securely attaches the cup holder to a clampable surface.
- Thumb screw: It allows you to rotate the screw that is used for the clamping system.

- Swivel Head: This component is attached to the thumb screw and is there to guarantee good contact between the screw with the clampable surface. Since it swivels, it can adapt to non-flat surfaces.

Each of these components plays a specific role in the overall functionality of the cup holder system.

# 4 Using the System

The following section provides detailed, step-by-step instructions on how to use the various functions or features of the secure cup holder for the wheelchair tray.

## 4.1 Placing the Cup in the Secure Cup Holder

Cup Daddy is designed to securely hold cups and bottles of all sizes on the wheelchair tray, preventing spills and ensuring user comfort. The process of putting the mug into the holder is very simple.

To put a cup into the safety cup holder, the user needs to follow the steps below:

1. Slide the clamp onto the tray or table you wish to use.

2. Tighten the clamp to the tray using the thumb screw.

3. Gently place your cup or bottle cup into the cup holder until it is firmly seated in the designated space.

Once the cup is properly placed, users can visually confirm that the cup is securely held within the holder. The design and material of the cup holders ensure stability and keep the cups in place even when the wheelchair moves or tilts.

## 4.2 Adjust the position of the cup holder

The secure cup holder devices we provided are adjustable to accommodate different tray sizes and user preferences. Users can easily adjust the position of the cup holders for the most convenient setup.

To adjust the cup holder position, users need to follow the steps below:

1. Locate the thumb screw at the bottom of the cup holder assembly.
2. Turn the thumb screw to increase the gap between the clamps.
3. Adjust and determine the proper cup holder position.
4. Once the position is confirmed, tighten the thumb screw to lock the cup holder in place.

The adjustability of the cup holder allows users to find the most comfortable and accessible position for their cup.

## 4.3 Removing the cup from the secure cup holder

When users want to clean the cups or change to another cup holder, they can easily remove the cup holder from the clamp system. To remove the cup holder from the entire secure cup holder device, the users need to follow the steps below:

1. Hold the cup holder firmly with one hand.
2. Stabilize the clamp system with another hand from the top or bottom.
3. Lift the cup holder vertically to remove it from the clamp system.
4. If another cup holder needs to be set, please follow the instructions in section 4.1.

To maintain the stability of the cup holder, there are magnetic devices on the bottom of the cup holder and the top of the clamp. There will be some resistance when separating the cup holder.

### 4.4 180 Degree Cup Rotation

The 180-degree cup rotation feature allows the user to adjust whether the cup holder is positioned on or beside the table as desired. This feature enhances user convenience by providing the flexibility to reposition the cup in the appropriate orientation for easy access to the cup.

To rotate the direction of the cup holder, users need to follow the steps below:

1. Follow instructions in section 4.3 to separate the cup holder from the clamp system.
2. Rotate the cup holder 180 degrees and connect the cup holders to the clamp system.
3. Follow instructions in section 4.1 to replace the cup with the cup holder device.

This feature is primarily intended for the user to be able to change the orientation of the cup holder based on existing usage. This prevents the wheelchair from widening due to the cup holders when maneuvering through narrower spaces. Or if the cup holder reduces the usable surface area of the table during daily use.

## 5 Troubleshooting & Support

### 5.1 Malfunctions

If the cup holder is not being secured properly, the users are advised to re-secure the cup holder to the tray by following the secure tray installation procedure described in section 4. In case of any other malfunction or unexpected behavior, you can contact our customer support department.

## 5.2 Special Considerations

1. Avoid exposing the cup holder to extreme temperatures as this may affect its usability and strength.
2. If the screws are loose, try to tighten them again with the Allen key. If any part of the unit has a loose connection, you may contact our technical support department.

## 5.3 Maintenance

1. Regular Cleaning: Clean the cup holder regularly with mild soap and water to remove spills or residue. Make sure it is thoroughly dry before use.
2. Occasionally check the thumb screw threads to ensure smooth twisting of the thumb screw.

## 5.4 Support

Our team is available 24/7 to assist with any issues that may arise. The following individuals are responsible for system support:

François-Nasr Kharrat, fkhar009@uottawa.ca

Nusaibah Rashid, nrash057@uottawa.ca

Justin Saikali, jsaik076@uottawa.ca

Jieying Yang, jyang202@uottawa.ca

Jessica Young Spice, jyoun120@uottawa.ca

In case of emergencies or urgent technical issues, contact the support team immediately by dialing (613-CUP-DADD).

Please contact the Support Team via email or phone to report any issues or defects with the secure cup holder, include a detailed description of the problem encountered and any malfunctions.

# 6 Product Documentation

The final prototype was built from 3 subsystems: the cup holder, the clamp, and the thumb screw. The cup holder is one single component of 3D-printed PLA plastic. This material was chosen as it was the main material we had access to. However, we did not feel the need to source other materials as PLA is strong enough for the application and typical for 3D printed products. Strength tests of a 3D printed cup holder prototype can be seen in section 6.4. Other materials such as ABS plastic are also a good option that can be both 3D printed or injection molded like PLA.

Figure 4. 3D-Printed PLA Cup Holder

The clamp is made up of aluminum extrusions, screws, and rubber grip. The aluminum extrusions are a flat bar and a c-channel initially made from a structural square tube. A structural tube was chosen as no prefabricated c-channels were available in the sizes we required. We therefore cut one side of the structural tube to end up with a c-channel. Holes for the thumb screw subsystem and for the flat bar connecting screws were drilled and tapped (threaded) into the c-channel. For future consideration, a prefabricated c-channel could be ideal if the right size were to be available. Aluminum was selected as the material as it would be corrosion resistant, and aesthetically pleasing. For the application, it is very strong and will withstand extensive daily use (See section 6.2 for strength and deformation simulation). However, for an even more rugged construction, stainless steel could be an option which offers corrosion resistance, aesthetic design, but provides more strength than aluminum. Three socket head screws were used to connect the flat bar to the c-channel. The flat bar holes were counterbored to ensure no protrusion of the screw head. This design was chosen as it was easy to recess the screws in the holes and would provide strong

connection. The rubber grip was glued to the top of the c-channel to provide additional friction to the clamp when it is in use. This selection of rubber strip was the perfect choice for the product.

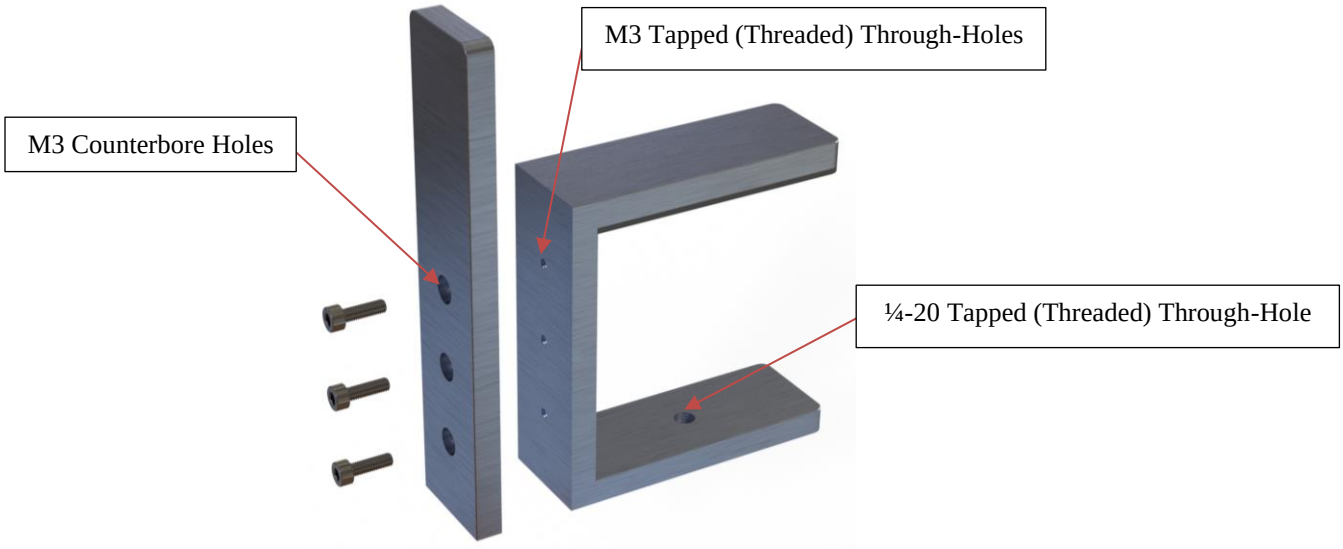


Figure 5. Main Clamp Features

The thumb screw is made up of 4 parts: a socket head screw, a thumb grip, a threaded swivel head, and a rubber tip. The socket head screw is a good and simple choice for the threading mechanism of this product. The swivel head with a rubber tip is also a great choice for this product as it can adjust to uneven surfaces and adds additional grip to the clamp. The thumb grip works well for the application but is slightly more difficult to use then a circular thumb screw grip for example. Therefore, for future consideration, instead of a 4-part subsystem, the thumbscrew subsystem can be modified to be 2 parts. My recommendation would be to have an integral rubber pad to the swivel head to eliminate the need for gluing the rubber pad separately, and eliminate the need for a press fitted thumb grip by replacing the bolt and thumb grip by a single thumb screw as seen below.


Figure 6. Current thumb screw on left (4 parts), suggested thumb screw on right (2 parts)

## 6.1 Subsystem 1 : 3D-Printed Cup Holder

### 6.1.1 BOM (Bill of Materials)

**Table 2. BOM for Subsystem 1**

| Material/Item | Description | Unit Cost | Quantity | Total Cost | Link |
|---|---|---|---|---|---|
| PLA Plastic | 3D printing filament | $25.95/kg | 107 g | $2.77 | 3D Printing Canada |

### 6.1.2 Equipment list

To build this system, the equipment needed is a 3D printer, a CAD software (such as SolidWorks) that enables you to design the part, and a slicer (such as Cura) to be able to turn your 3D CAD model into a version that can be read by the 3D printer. As long as you have these three components, you will be able to design and print whatever you design.

### 6.1.3 Instructions

The first step in building this prototype is to design the cup-holder in a CAD software. This will require the use of many CAD functions. The first of such functions is sketching. Sketching is

used to draw the perimeter of the part you will want to design. In this case, the first sketch to complete is the base of the cup holder. Once the sketch is complete, you can extrude it at the desired height. If a less conventional cup holder shape is desired, the loft function can be used as well, but this will require sketches on different planes. Once the extrusion or loft is complete, the shell function can be used to make the solid cup holder shape into a constant thickness cup holder shell. Once this is complete. The sketch of the slot can be drawn and extruded. This can be done in one step to allow the slot to be integrated into the sketch of the extrusion, or in 2 steps where the extrusion is solid, and a cut extrude function is used to make the slot. At the end, ensure to use the fillet function to avoid sharp edges in your model. The CAD model should now be complete.

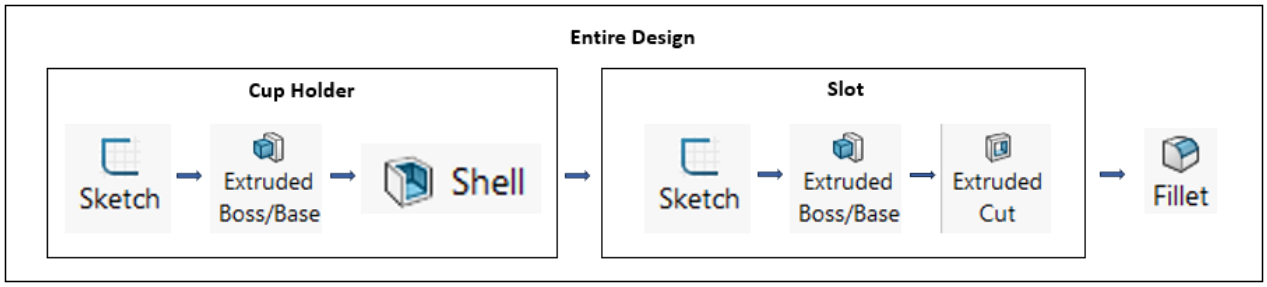


Figure 7. Simple Diagram on Designing Cup Holder

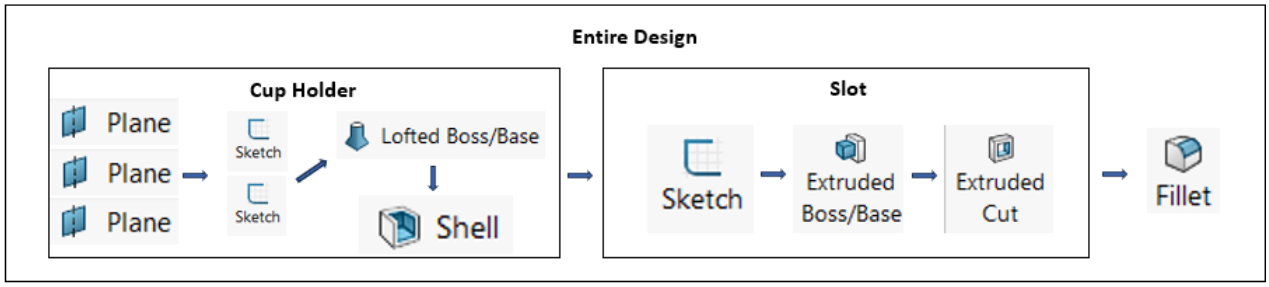


Figure 8. Complex Diagram on Designing Cup Holder

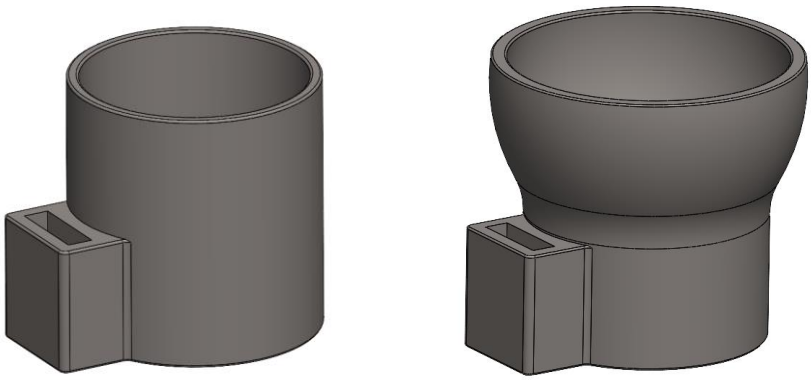

Figure 9. Simple Cup Holder Design (left) and Complex Cup Holder Design (right)

The next step is simply to save your CAD model as a STL file, and import it into a slicer for 3D printing (Cura in our case). Once this is done, you can select your cup holder's print orientation and infill, and you're off to the printer.

Figure 10. Image of STL File

## 6.2 Subsystem 2 : Aluminum Clamp

### 6.2.1 BOM (Bill of Materials)

**Table 3. BOM for Subsystem 2**

| Material/Item | Description | Unit Cost | Quantity | Total Cost | Link |
|---|---|---|---|---|---|
| Aluminum Flat Bar | 0.25 x 1” x 4.75” 6061 aluminum flat bar | $1.02 | 1 | $4.02 (with cutting from *Metal Pros*) | Metal Pros |
| Aluminum Structural Tube | 3” x 3” x 0.25” | $2.71 | 1 | $6.71 (with cutting from *Metal Pros*) | Metal Pros |
| M3 Screws | M3 x 0.5 mm, 10 mm Long, Alloy Steel Socket Head Screw | $9.54 (Pack of 100) | 3 | $0.30 | McMaster-Carr |
| Rubber Strip | 1" x 3.3' x 1/8" | $10.49 | 1 | $0.79 | Amazon |
| Adhesive | Clear Gorilla Glue | $10.99 | 1 | $0.25 | Walmart |

### 6.2.2 Equipment list

The equipment used to manufacture this subsystem included a mill, a band saw, a Dremel tool, and tapping tools. Another noteworthy addition is a CAD software to ensure the manufacturability of the subsystem is adequate, and to ensure that every machining operation has an end goal (such as milling a part to the right dimensions, drilling holes at the right locations, etc).




Figure 11. Mill - Band Saw - Dremel Tool - Tapping Tools **[2] [3] [4] [5]**

### 6.2.3 Instructions

The first step of manufacturing is to cut the aluminum flat bar to the desired length with the band saw (or chop saw if available). Ensure that the cut is as straight as possible to avoid the need to flatten the surface with a mill, adding manufacturing processes to the product.

Figure 12. Aluminum Flat Bar Manufacturing Step

The second step is cut the structural aluminum tube into a c-channel (note: if a c-channel is acquired instead of a structural aluminum tube as mentioned previously, this step can be omitted). Select one side of the aluminum tube to cut of and use the band saw to make straight cuts through the one side (at the green arrows in the figure below). Be careful not to hold the aluminum piece for very long as the band saw will make it very hot; use a pushing support instead.

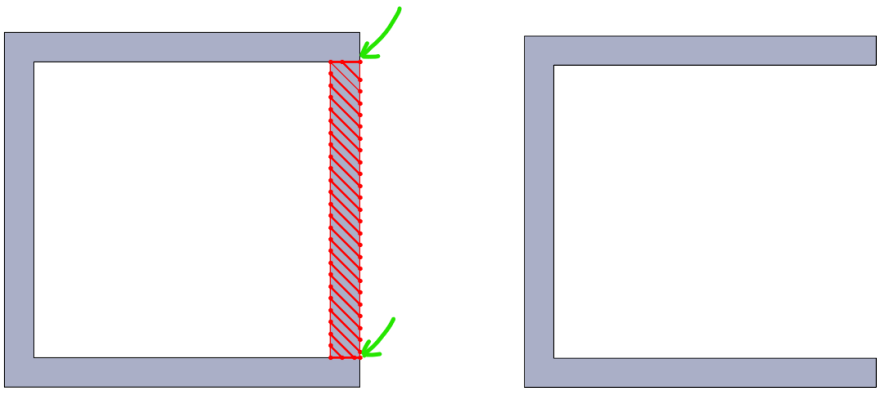

Figure 13. Aluminum C-Channel Manufacturing Steps

The third step is to drill the holes in the flat bar using the mill. Drill 3 counterbored holes to fit M3 screws at the desired locations. The counterbores should be half the depth of the ¼ inch thick bar for the screws to sit flush.

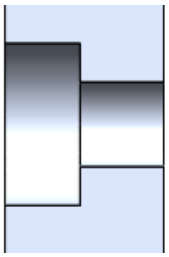

Figure 14. Counterbore Hole in Flat Bar

The fourth step is to drill the holes for the aluminum c-channel using the mill. On the side opposite to the cut-out section of the c-channel will be 3 M3 tapped holes to connect the flat bar to the c-channel using M3 screws. Drill 3 M3 holes at the same location as the flat bar to ensure proper fit. After these holes are drilled, use a tapping tool to thread M3 threads into the c-channel holes. Once that is complete, use the appropriate drill bit for a ¼-20 inch hole in the bottom of the c-channel, then thread the hole. This will be used by the thumb screw to tighten the clamp to a tray or table.

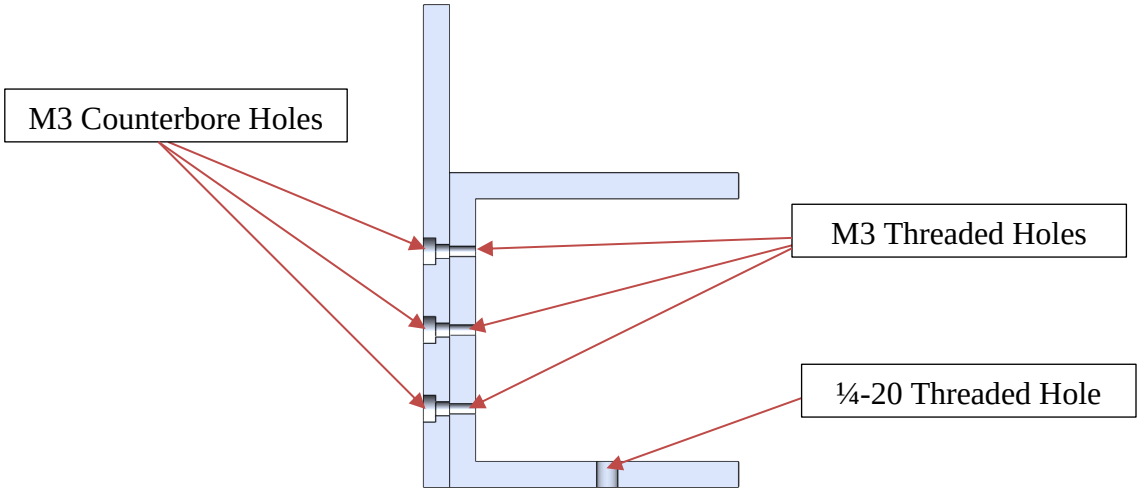


Figure 15. Holes in Clamp

Once ensured that the holes align, the edges must be deburred and rounded to remove sharp edges. Using the Dremel tool with a round ceramic tool head, round 6 corners (4 corners on the c-channel and 2 corners on the flat bar)

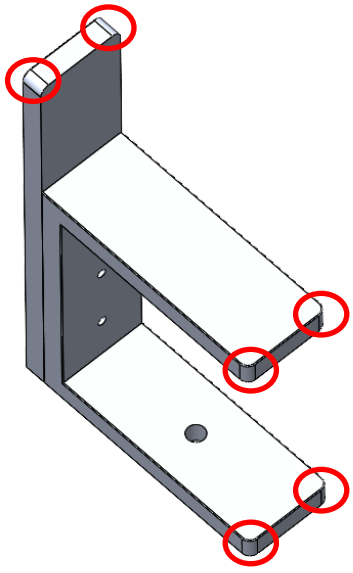

Figure 16. Edges to Fillet

The fifth step is to screw the flat bar to the c-channel. Using M3 socket head screws and an Allen key, screw the M3 screws into the c-channel through the flat bar. Tighten until the screw sits flush with the flat bar, or until it becomes too difficult to tighten, as we want to avoid stripping the threads.

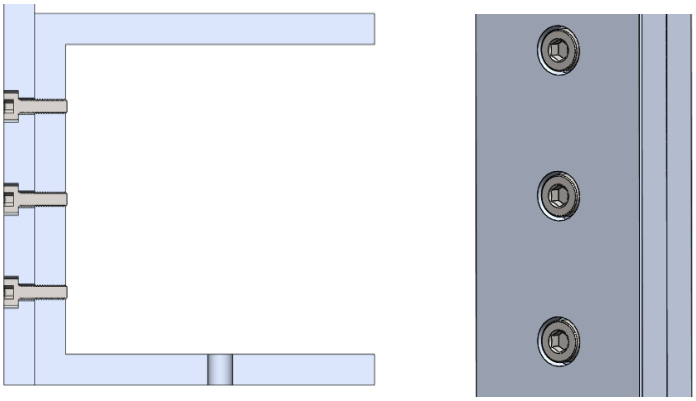

Figure 17. Flat Bar Screwed to C-Channel

The last steps are to polish the aluminum with a scrubbing sponge to give it the brushed aluminum look and glue the rubber strip to the clamp. Cut the rubber strip to the appropriate length, cover one side of the rubber strip with sufficient gorilla glue and place it at the bottom of the top c-channel arm. Once placed, clamp the two pieces together and let is harden for at least 2 hours (although allow 24 hours for it to fully cure).

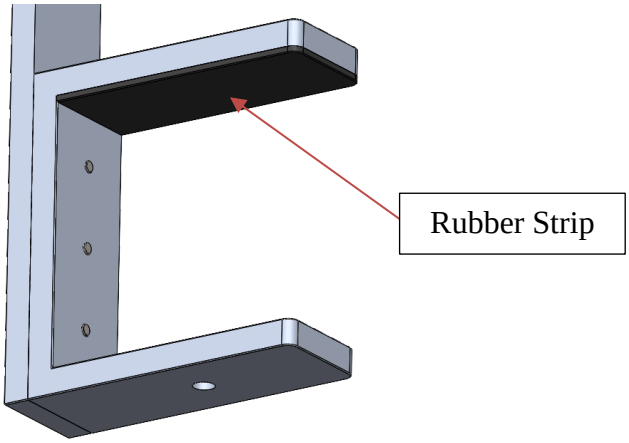


Figure 18. Rubber Strip Glued to Clamp

## 6.3 Subsystem 3 : Thumb Screw

### 6.3.1 BOM (Bill of Materials)

**Table 4. BOM for Subsystem 3**

| Material/Item | Description | Unit Cost | Quantity | Total Cost | Link |
|---|---|---|---|---|---|
| Threaded Swivel Head | Swivel Leveling Mount, Plastic with 1/4"-20 Threaded Hole | $4.08 | 1 | $4.08 | McMaster-Carr |
| Socket Head Screw | Alloy Steel Socket Head Screw, 1/4"-20 Thread Size, 2-1/2" Long, Fully Threaded | $15.53 (pack of 25) | 1 | $0.62 | McMaster-Carr |
| Rubber Strip | 1" x 3.3' x 1/8" | $10.49 | 1 | $0.20 | Amazon |
| Thumb Grip | Two Arm Grip, Acetal, for 1/4" Screw Size | $10.47 (pack of 50) | 1 | $0.21 | McMaster-Carr |

### 6.3.2 Equipment list

For this subsystem, no equipment is required. It may however be useful to use a vise to more easily press fit the thumb grip onto the socket head screw.

### 6.3.3 Instructions

The thumb screw consists of four components: a threaded swivel head, a socket head screw, a thumb screw grip, and a rubber pad. The first step to assemble this subsystem is to glue a round rubber pad the top of the swivel head. Using the same type of rubber as for the clamp's rubber strip, cut a circular piece of rubber and glue it to the top of the swivel head.

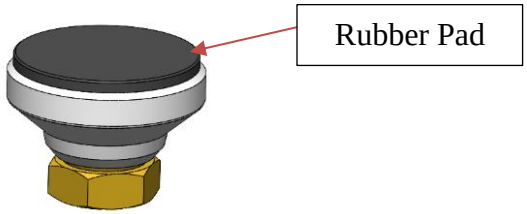


Figure 19. Rubber Pad Glued to Swivel Head

The second step is to press fit the thumb grip into the end of the socket head screw. The best way to do this is to hand press the thumb grip onto the screw head, then fully press it in with a vise. Ensure the screw and thumb grip are aligned correctly before press fitting.

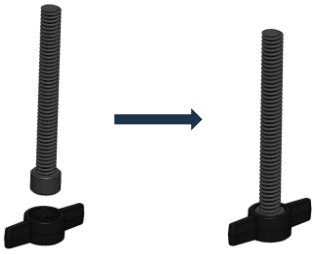

Figure 20. Press Fitted Thumb Grip

The last step is to thread the swivel head onto the screw. Thread the screw through the bottom hole of the aluminum clamp first, then once enough of the screw is protruding, thread the swivel head onto the screw.

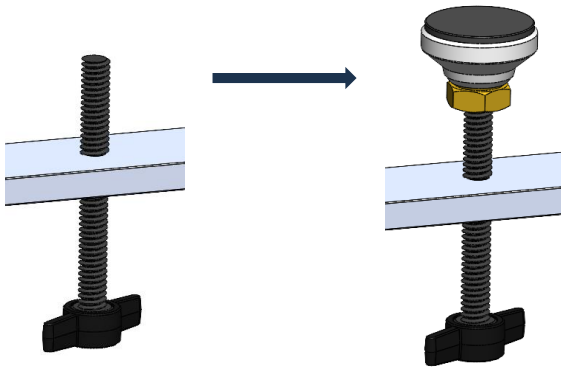

Figure 21. Swivel Head Threaded onto Thumb Screw

## 6.4 Testing & Validation

For validation of the cup holder prototype, we conducted physical tests to ensure it met our target specifications and endured expected use. We tested the weight to ensure it was not too heavy. We tested the print time of the cup holder to ensure it was a reasonable time. We tested the water resistance of the cup to ensure it could handle any spills. We tested the tolerances on the 3D printed to evaluate how our design matches the final product. Lastly, we performed strength tests to ensure that the cup holder is strong enough to withstand force. The results of our tests are presented below.

**Table 5. Cup Holder Tests**

| Type of test | Description | Target Specification | Result |
|---|---|---|---|
| Print Time | Measuring the time needed to complete 3D printing | < 6 hrs | 5 hours 26 minutes |
| Weight Test | Measuring the weight of the 3D printed cup holder | < 150 g | 107 g |
| Dimension Tolerance Test | Measuring the dimensions of the cup to test how accurate the 3D printer is compared to the CAD model | + 0.5 mm | Slot : - 0.4 mm<br>ø : +/- 0.2 mm |
| Strength Test | Measuring the force the cup holder can withstand in longitudinal and diametral compression | < 5 lbs (22.25 N) | Withstands 5 lbs of force |

Figure 22. Longitudinal Compression Test (Left), Diametral Compression Test (Right)

For the clamp subsystem, SolidWorks simulations were conducted to ensure minimal deformation of the clamp under load. A force of 15 pounds was set at the edges of the c-channel for one simulation, and the same amount of force was set to the edge of the flat bar for the second

simulation. The results are presented below, and as is shown, the maximum deflection is 0.265 mm for the c-channel and 0.067 mm for the flat bar. These are very minimal deflections and the design was deemed very strong for the application.

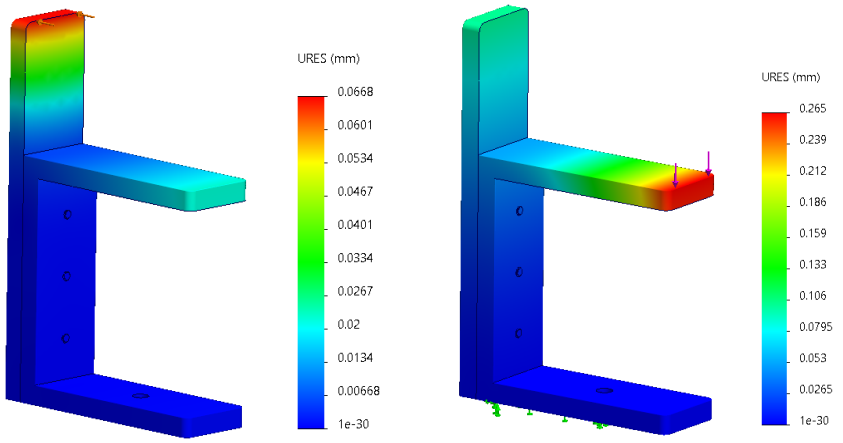


Figure 23. 15-Pound-Force Deformation Simulation for Flat Bar (Left) and C-Channel (Right)

For sustained use, it is not recommended to consistently apply large amounts of force to the clamp nor the cup holder. Although our physical and virtual tests demonstrated strong components, over time, material fatigue can set in and make the components weaker if consistently stressed. However, in normal everyday use and relative care, the entire product should last many years.

# 7 Conclusions and Recommendations for Future Work

During our work, multiple things were learned. For instance, time management is extremely important when you have deadlines. Having client meetings coming up or presentations means we need to arrive ready. Sometimes we would notice our deadlines approaching and we wouldn't have for example our prototype ready or other things to submit. Furthermore, we had initial ideas for our product that couldn't be accomplished due to missing knowledge or training. Initially, we had plans to weld our clamp sub-system. Unfortunately, none of us are qualified for this task. This being the case, our idea had to be flushed but this was beneficial since we found a better solution and an easier one which was to screw a C-channel with a flat bar.

If we had a few more month to work on our project, it would've most definitely been more complete. Our plans were to get a snugger fit between our cup holder and clamp when attached together. In addition, developing more then one cup holder was a priority of ours if time would've allowed it. By doing this we have a multitude of attachments for different uses, some being more ergonomic others for mugs with a handle, some of different colors or sizes. Finally, nothing was really abandoned due to time constraints. Our team simply would've had bigger plans if time would've allowed it. Overall, we are satisfied with the product and we hope you are too!

# 8 Bibliography

[1] Hex Key, Wikipedia, https://en.wikipedia.org/wiki/Hex_key (visited: 7/18/2023)

[2] OTMT 2V 3 HP Knee Type Vertical Milling Machine, Travers, https://www.traverscanada.com/product/otmt-2v-knee-type-vertical-milling-machine-87-114-194 (visited: 7/19/2023)

[3] Band Saw (Wood Working), OAV Equipment and Tools, Inc., https://www.oavequipment.com/en/product-129502/Band-Saw-SBW-3501B.html (visited: 7/19/2023)
[4] Dremel 7350, Amazon, https://www.amazon.ca/Dremel-7350-Pet-3-6v-Pet-Grooming/dp/B08YKFJ3FR (visited: 7/19/2023)

[5] Cergrey 7pcs Metric Thread Steel Tap Tapping Tool, Walmart, https://www.walmart.ca/en/ip/Cergrey-7pcs-Metric-Thread-Steel-Tap-Tapping-Tool-M3-M4-M5-M6-M8-M10-M12-Screw-Taps-Tool-Set-Thread-Tap/PRD6HJ4XRX1ENNT (visited: 7/19/2023)

# APPENDICES

## APPENDIX I: Design Files

All CAD files, deliverables, pictures, etc, can be found at the URL in Table 7.

**Table 6. Referenced Documents**

| Document Name | Document Location and/or URL | Issuance Date |
|---|---|---|
| Project Files | https://makerepo.com/JessicaYoungSpice/1675.secure-cup-holder | July 7 2023 |