**Project Deliverable H**
**Video and User Manual**

**GNG2101 [D]**
**Introduction to Product Development and Management for Engineers and Computer Scientists**

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**Table 1. Acronyms**

| Acronym | Definition |
|---|---|
| **CAD** | Computer aided design |
| **PVC** | Polyvinyl Chloride |

**Table 2. Glossary**

| Term | Acronym | Definition |
|---|---|---|
| **Center of Disease Control** | **CDC** | **CDC is the the national public health agency of the United States** |
| **Medium density fibreboard** | MDF | **MDF is a wood material** |
| **Polylactic Acid** | PLA | **3D printing material** |

# 1 Introduction

This document is an overview of all necessary steps and tasks in order to successfully build and use our design. This document will initially provide all information needed to build our aerobic exercise device. The main focus of our device is to assist and support people who can’t do symmetric exercises; such as push-ups, planks, and mountain climbers. The document begins with a brief overview of the building process and importance of our device. The next step highlighted is the starting configuration of our design and its setup process. The document will then go over how to simply use our design and its limitations/issues that may appear when using it frequently. This is achieved by following all sub-systems of our design and all product documentation used throughout the design and the building phase. The document also reviews all the problems the user may encounter and how to troubleshoot these issues if they arise. Finally, it goes through all of our prototypes in detail and how each prototype was built, what materials were used, and lessons that were learned from it. Our devices feature no login or confidential information input, thus security and privacy is no issue or concern.

# 2 Overview

According to the CDC, adults should partake in 150 minutes of physical activity and 2 days of muscle conditioning activities every week [1]. For those with physical limitations, this can be quite difficult. Our team was tasked with creating a device which can help those with arm mobility limitations complete symmetrical aerobic exercises like push-ups and planks. This accessibility problem is an important problem to solve because no one should have to be limited or be restricted from participating in any activity due to any physical limitation. Our client has a need for a compact and light device to simulate a locking motion in his left elbow while ensuring proper support under continuous load, throughout symmetrical and static movements. Currently, on the market, numerous exercise devices are available. Unfortunately, many of these existing devices are not meant for use by those with accessibility needs. These devices exist to increase the resistance in exercises, not make it easier. Other devices such as exo-skeletal arms do exist but these are impractical to the average consumer due to the very high cost and bulkiness associated with the product. Our product seen below in Figure 1, is a device which was created to do exactly what the existing device can’t do. Make exercises easier and provide support during these exercises. Our device stores the user’s potential energy into a spring and converts this energy to help the user complete various different exercises. Our device includes a padded platform to secure and help the user's shoulder to increase control and a raised handle to ensure anyone with issues fully extending their arms are still capable of using this device. Our device is constructed out of a 6” PVC pipe which is used as a case to hold the inner spring which is connected to the pipe by an 8” bolt through a slot in the pipe to control the spring's vertical movement. The spring is also connected to the shoulder platform by a 2” pipe which is bolted to a 6” MDF disk and the platform uses 2 stainless curtain rod joints. The MDF disk is then connected to the spring using a custom-printed connection piece.

Figure 1: Final Prototype

# 3 Getting started

## 3.1 Configuration Considerations

The design for the aerobic workout device is quite simple and easy to understand. Our design used basic components/equipment with no presence of electrical or communication devices. The main component is a 6” water main pipe which holds a pre-bought mechanical spring at its center. Other components used are bolts and nuts which enable various pieces to be assembled together. Likewise, numerous pieces of 2x4 wood are assembled together with screws to simulate a handle on which the non-dominant hand will rest. The pieces assembled together with bolts are pre-bought metal flanged pieces, a 2” diameter PVC pipe, a 3D printed custom mounting piece and a laser cut 6” disk. Finally, the platform on which the chest will sit is made from plywood with a few layers of foam added on and finished off with a layer of vinyl to

Our device requires no complex software or automated systems with a few tools required for its assembly. A pair of pliers are recommended to ensure all bolts are securely tight on the device along with an easy ability to take apart and assemble the device.

## 3.2 User Access Considerations

Our design is focused on various users that are interested in successfully accomplishing dynamic and static exercise movements without limitations. The design can be oriented towards rehab facilities with people who suffer from weakness or injury to one arm. The resistance aspect and the ability to interchange the spring with different strengths allow for the rehabilitation of one's strength and stability from injury. In addition, anyone who might struggle to complete dynamic upper body exercises like a pushup from muscle imbalances may benefit from this design.

Our system does require a bit of custom components to ensure it can be used properly. Measurements must be first taken of the client in order to ensure the length/height of the device is in line with his other arm/side. The proper measurements will ensure dynamic exercise movements can be done in a symmetric motion. Another limited aspect is the choice of spring. The spring used in the device is limited by the client's weight and strength, thus initial testing must be accomplished before use.

## 3.3 Accessing/setting-up the System

Our design prides itself on easy accessibility and use when starting. Assuming the device is taken apart as noted below for easy transportation from locations, then the setting up process is very simple. The first step is to simply attach the top piece (the bottom of the yellow 3D printed piece as seen in Figure 2) to the spring which is already sitting in the main pipe (as seen in Figure 3). Once the top piece is securely sitting on the spring, the 8" bolt is used to go through the pre-made hole in the yellow customs 3D printed part and through the slot on the main 6" pipe (as seen in Figure 4). This bolt ensures all components are connected together and can securely slide through the slot without any issues. Once the bolt is secured through, simply add a nut at the end of the bolt which is securely added but not too tight in order to not limit motion throughout the slot.

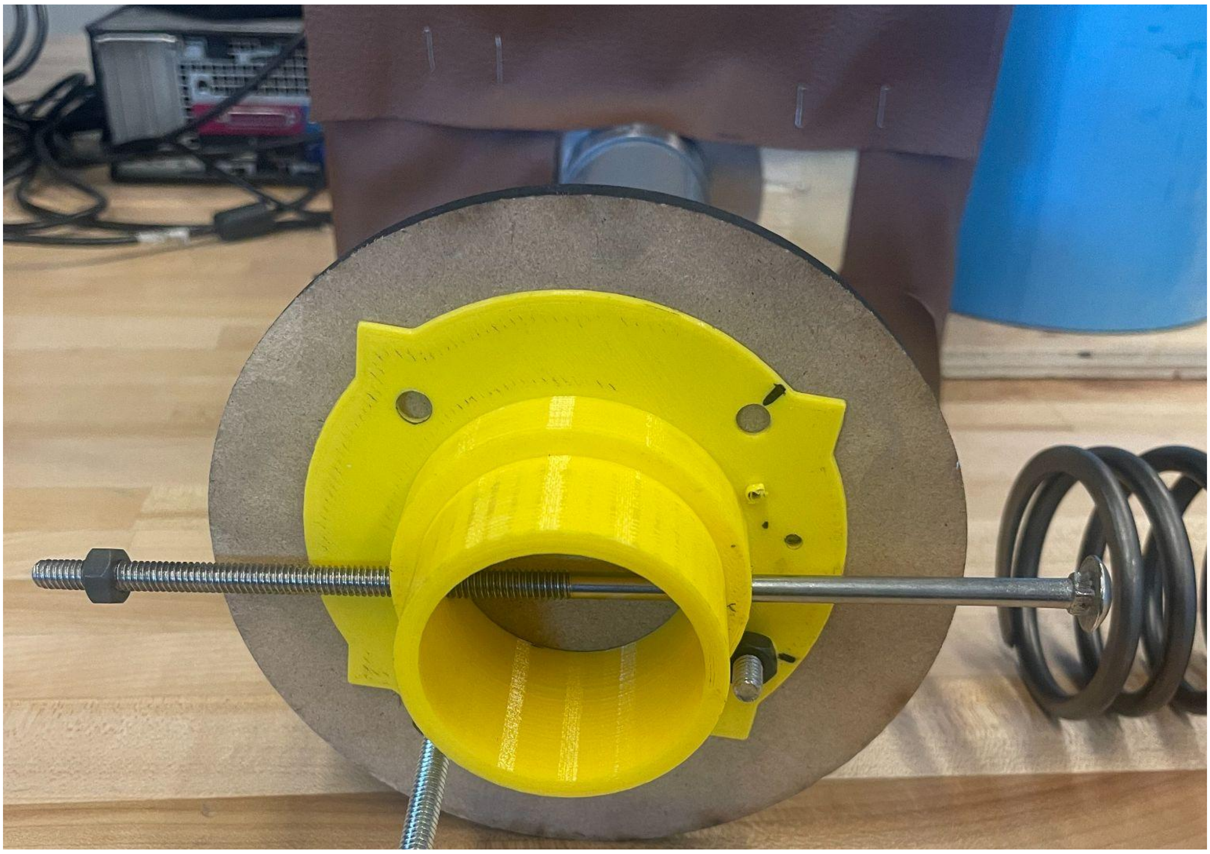

Figure 2: 3D-printed piece which will connect to top of spring

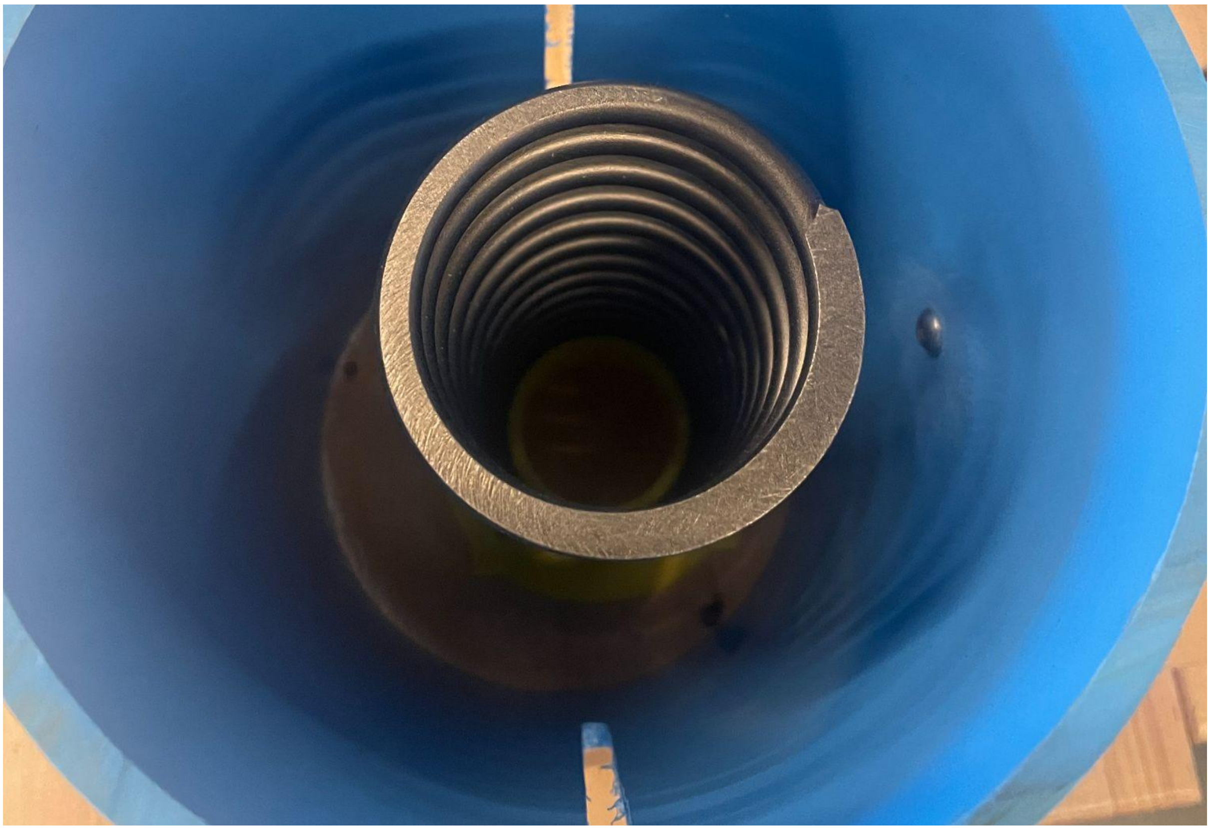

Figure 3: Illustration of spring sitting inside main pipe component

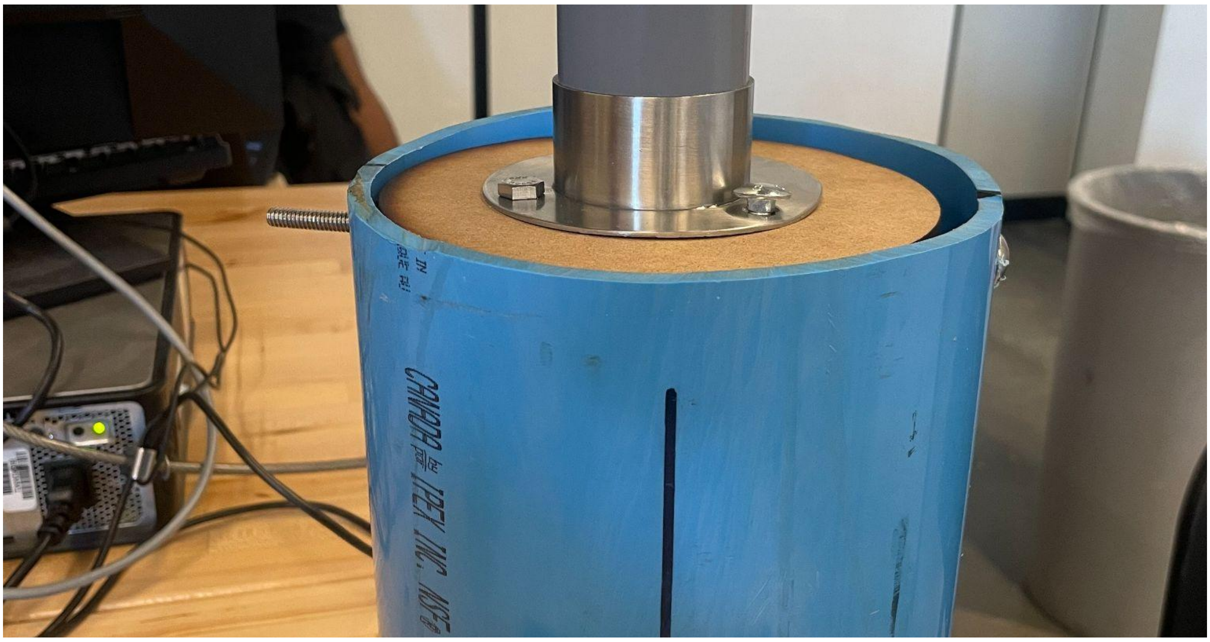

Figure 4: Side view of 8” bolt going through all components and pre-made slot

## 3.4 Exiting the System

In order to put away the system, it is a simple process, which is the reverse order of how to put together our system. First remove the nut on the 8” bolt, once the nut is removed, simply pull the bolt out of the system. Once the nut is removed, simply take off the top portion of our design and leave the bottom portion intact, with the spring still sitting in the 6” pipe. We recommend not disassembling the device any further and simply putting both main pieces in a bag for transportation to the required location. However, if other steps are required for disassembly, the wooden pieces can simply be pulled off and stored elsewhere.

# 4 Using the System

## 4.1 User Function

The spring plays a big role in our product since it is the main thing that keeps the system functioning. The point of the spring is to stabilize and help the injured arm in not carrying lots of weight. The user needs to have a customized spring since the user needs to get a spring that can support their weight and allow the spring to be compressed. When the user is trying to get a customized spring all the things that are needed from them are their weight and how long their arm is. After giving that information they are guaranteed to get a spring that will help them do push-ups with proper form.

### 4.1.1 Platform System

The platform is another system in which the user can choose how it should look and the user’s arm length is needed for this part of our system. The user can choose what kind of cushioning they want the platform to have and they can also request for the platform to be customized to their liking. The platform is where the shoulder/chest rest and the purpose of the platform are to stabilize the shoulder and help the user to do push-ups with a proper form.

# 5 Troubleshooting & Support

## 5.1 Possible Errors and Troubleshooting

Although a good physical prototype allows for fewer mistakes, some common errors can still arise. In the case of this aerobics product, user and product setup errors are mainly harmless and can be easily fixed.

### 5.1.1 Setup Phase

The most common error for the utilization of this product comes in the setup phase. While setting up the product, the user must ensure that the supportive base is placed onto a rigid flat surface (i.e hardwood, concrete, tiles) to provide maximum stability. Any uneven surfaces should be avoided to prevent a lack of control. After the base is firmly secured, the next component to set up involves the shoulder platform. Users can have potential setup errors with this platform via the following ways: unstable platform, loosely connected platform, and securing the platform with an incorrect bolt. These issues can be easily resolved by double-checking the fastening of the threaded nut onto the steel bolt.

### 5.1.2 User Errors

Another case where issues can prominently arise is user errors. This can be seen with the incorrect use of the product, incorrect positioning of the product, and errors with general knowledge about the product. To resolve these issues, the user must ensure they have thoroughly understood the product as well as read the user manual file to familiarize themselves with the proper method of using it.

## 5.2 Maintenance

To properly maintain this device, there are some guidelines to be followed. Firstly, the device must be stored in a dry and safe space to avoid any degeneration of materials and/or potential decomposition onto any parts. To maintain the shoulder support platform, extra care must be taken onto the vinyl wrap placed on top of the platform. Ensuring any sharp or pointed objects are kept away to prevent scratching or tearing of the fabric-like material.

Next, the maintenance of the compression spring in the device is quite important. For example, over an extended period of time, the spring may become susceptible to permanent defiguration that changes the force allowed to reach compression. In this case, however, this could be a helpful phenomenon to allow the user to properly compress the spring fully.

## 5.4 Support

If the need for system support arises for a user, they must follow the guidelines below to get assistance. Firstly, the team at Aerobics R' Us can be directly contacted through the email: aerobicsrus@uottawa.ca. In this case, a detailed email providing information on the support needed, as well as preferably pictures of the issue should be included. This would allow the team who constructed this product to directly communicate with the user in need of support. Another method of receiving support would be to read this user manual under whichever section support is needed for. A meeting can also be set up; an in-person help session with one or more of the team members can be scheduled to get hands-on assistance.

# 6 Product Documentation

## 6.1 Device Information

### 6.1.1 BOM (Bill of Materials)

In the following section, a bill of materials for all required materials is provided including links to purchase said materials.

Table 3: Bill of Materials

| Parts | Quantity | Unit | Cost | Link |
|---|---|---|---|---|
| 1 foot 6” PVC Pipe | 1 | EA | $0 | Repurposed Scrap |
| 2” PVC Pipe | 1 | EA | $5.49+($9.97 Shipping) | Lowes |
| Compression Springs 10” Long, 2.906” OD | 1 | EA | $27.75 USD | McMaster |
| 8” Stainless Steel Bolt | 1 | EA | $5.84 USD | McMaster |
| ¼”-20 Thread size Bolt | 4 | EA | $6.00 USD/100 Bolts | McMaster |
| 4” Stainless Steel Bolt | 3 | EA | $8.31 USD /10 | McMaster |
| Pipe Fitting (curtain rod holders) | 2 | EA | $25.66 ($51.31/2) | Amazon |
| Pipe Fitting | 1 | EA | $0 | To Be Laser Cut |
| Base Plate | 1 | EA | $0 | To Be Laser Cut |
| Shoulder Platform | 3 | EA | $0 | To Be Printed |
| MDF Cost | | | $0.55 * | |
| PLA Cost | | | $5.40* (Assuming 0.05$/g) | |
| Price | | | $169.11 | |
| Price (Include HST) | | | $191.09 | |

### 6.1.2 Equipment list

For our final conceptual design, various skills and resources are required to complete and manufacture each working part. A few of the various resources/skills available that will help with our design can be seen below:

- Manual Mill: The manual mill at the Brunsfield centre will be used in order to create the 10” x 0.25”  slot on each side of the main 6” pipe for our device. This slot is necessary in order to allow for proper movement of the connecting bolt. Proper knowledge and skill will be required to precisely cut a slot on both sides of a cylindrical shape.
- Laser cutter: The laser cutter in the Makerspace will be used for parts in our design. We will laser cut the main 6” diameter plate with a maximum laser thickness capacity of ⅜”. The 6” disk will be cut to use for the pipe fitting-spring connection piece.
- 3D printers: The 3D printers in the Makerspace will be used for our design. Due to the need for specific 3D parts, we will not be able to laser-cut certain parts. We will be 3D printing a makeshift rod clevis which will connect the bolt into the slot on the 6” pipe to the platforms.
- Drill Press: The drill press at the Brunsfield Center will be used to drill numerous holes into our pipes to allow for bolts to be installed to safely fix our parts together. A ¼” hole will be drilled into the 6” section to install the bolt for the handle. Four separate ¼” holes will be drilled into the 2” pipe so we can bolt both ends of the pipe to the shoulder platform and to the custom pipe fitting. Finally, two more ¼” holes will be drilled into our custom pipe fitting to connect to the 2” pipe using a nut and bolt.

### 6.1.3 Instructions

In this section, all part drawings will be shown with appropriate dimensions and an isometric view. Each subsection will show its corresponding part. All parts purchased from McMaster Carr have their respective drawings from the website shown below and all links to the source can be found below in the Bill of Materials. All documents below are in IPS.

#### 6.1.3.1 Shoulder Platform

To manufacture this part, we will be laser cutting the shoulder platform due to its flat geometry and to avoid the risk of warpage seen in the large flat plates during 3D printing. We will then be 3D printing the 2” pipe fitting (same pipe fitting as the pipe fitting-spring connection part) which will be printed due to its 3-dimensional shape and flaps will be added to ensure we can screw the fitting securely to the disk.

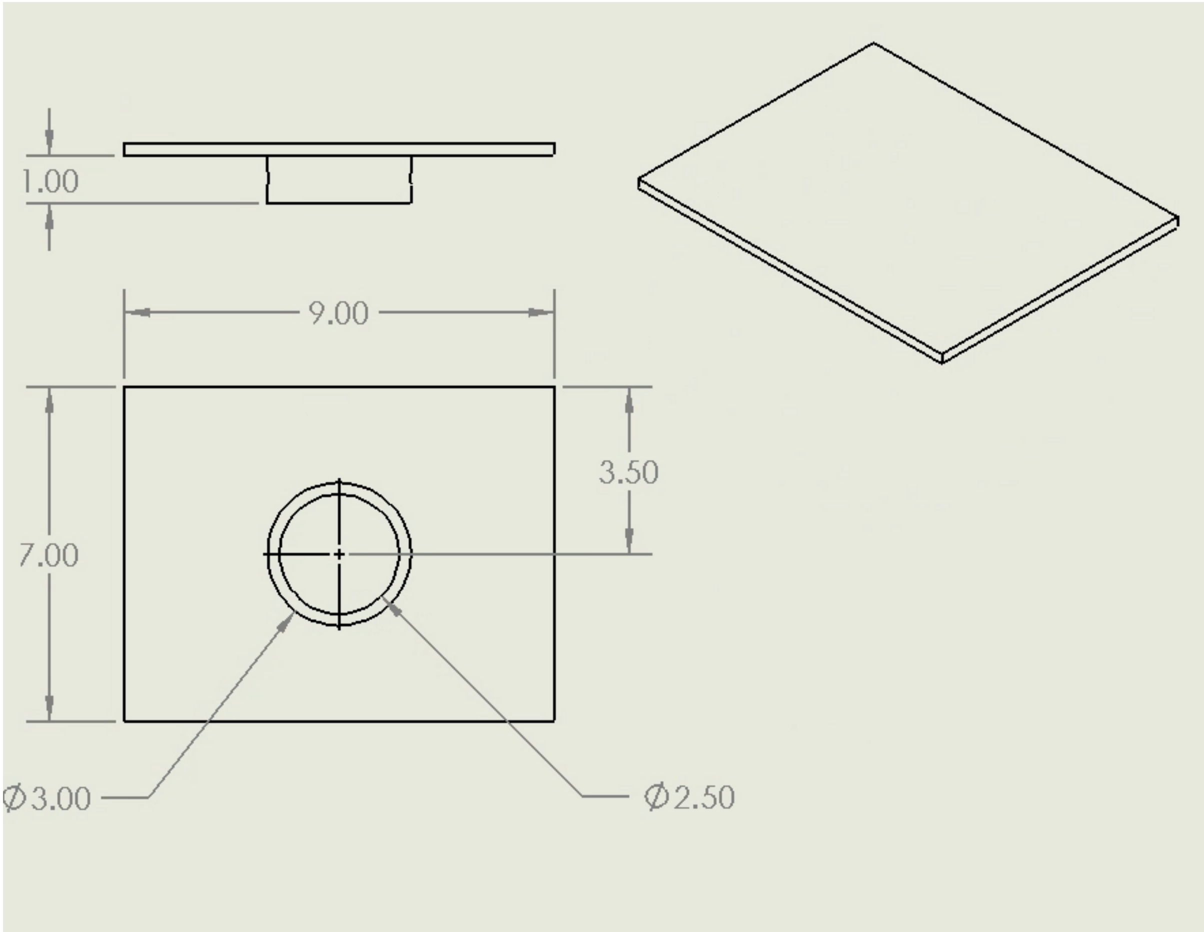


Figure 5: Custom Shoulder Platform Engineering Drawing

#### 6.1.3.2 2” Pipe

To manufacture this part, we will be cutting the 2” pipe (4’ in length) to our desired length of 10”. Once our pipe has been cut, we will be drilling 4 holes using the drill press into the side of the pipe as seen below 0.5” from the edges which will be where the bolts secure the pipe to the rest of the assembly.

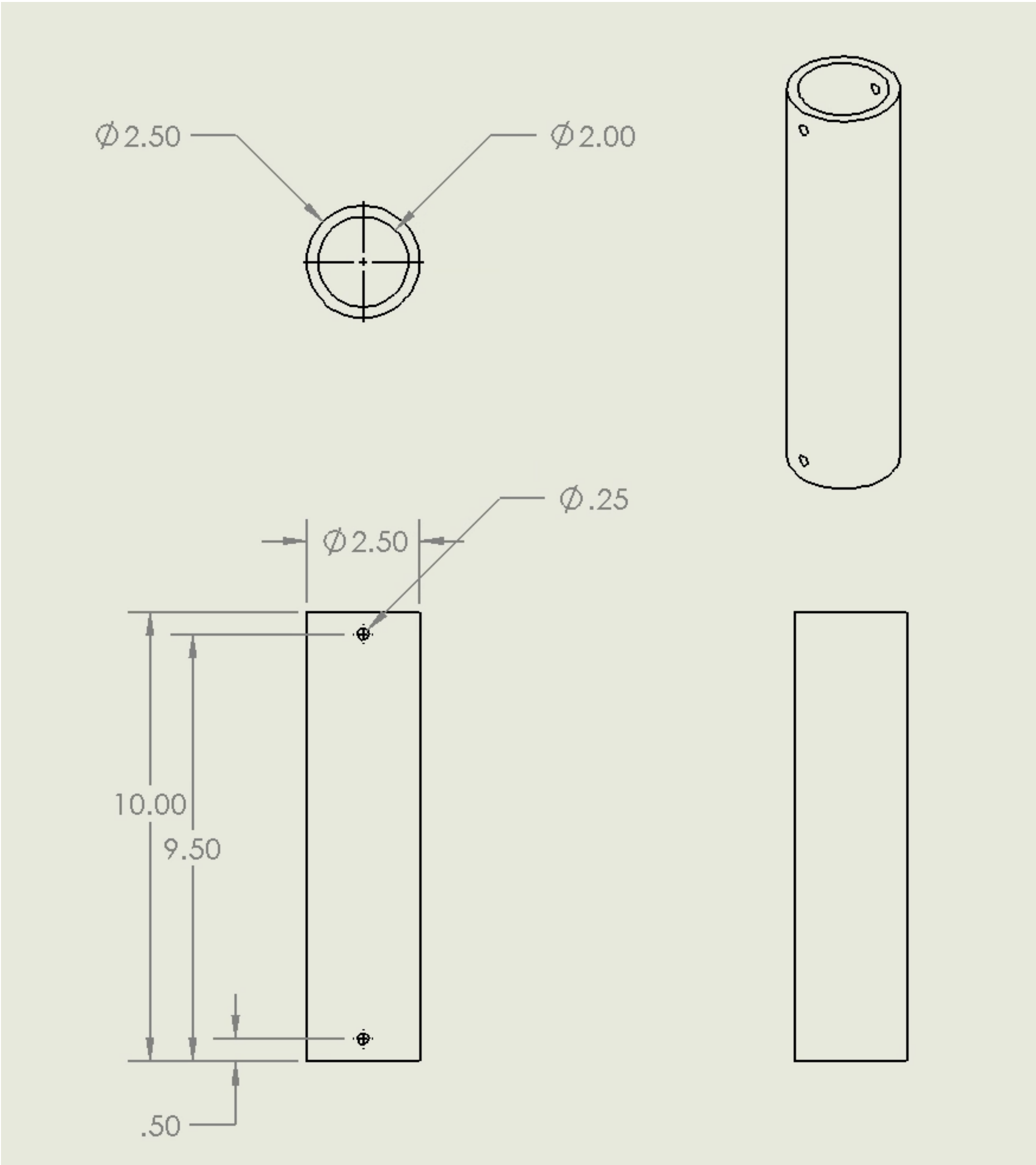


Figure 6: 2” Custom Pipe Engineering Drawing

### 6.1.3.3 Pipe Fitting-Spring Connecting

To manufacture this part, we will be laser cutting the 6” disk since it will be much easier to get such a big and flat surface area cut instead of running the risk of warpage incurred when 3D printing parts of similar shape. We will then be 3D printing the 2” pipe fitting (same pipe fitting as the shoulder platform) and the pin clevis on the bottom of the disk due to their more complex geometry but we will be adding flanges to the bottom of these two parts to screw it on securely to the laser cut disk.

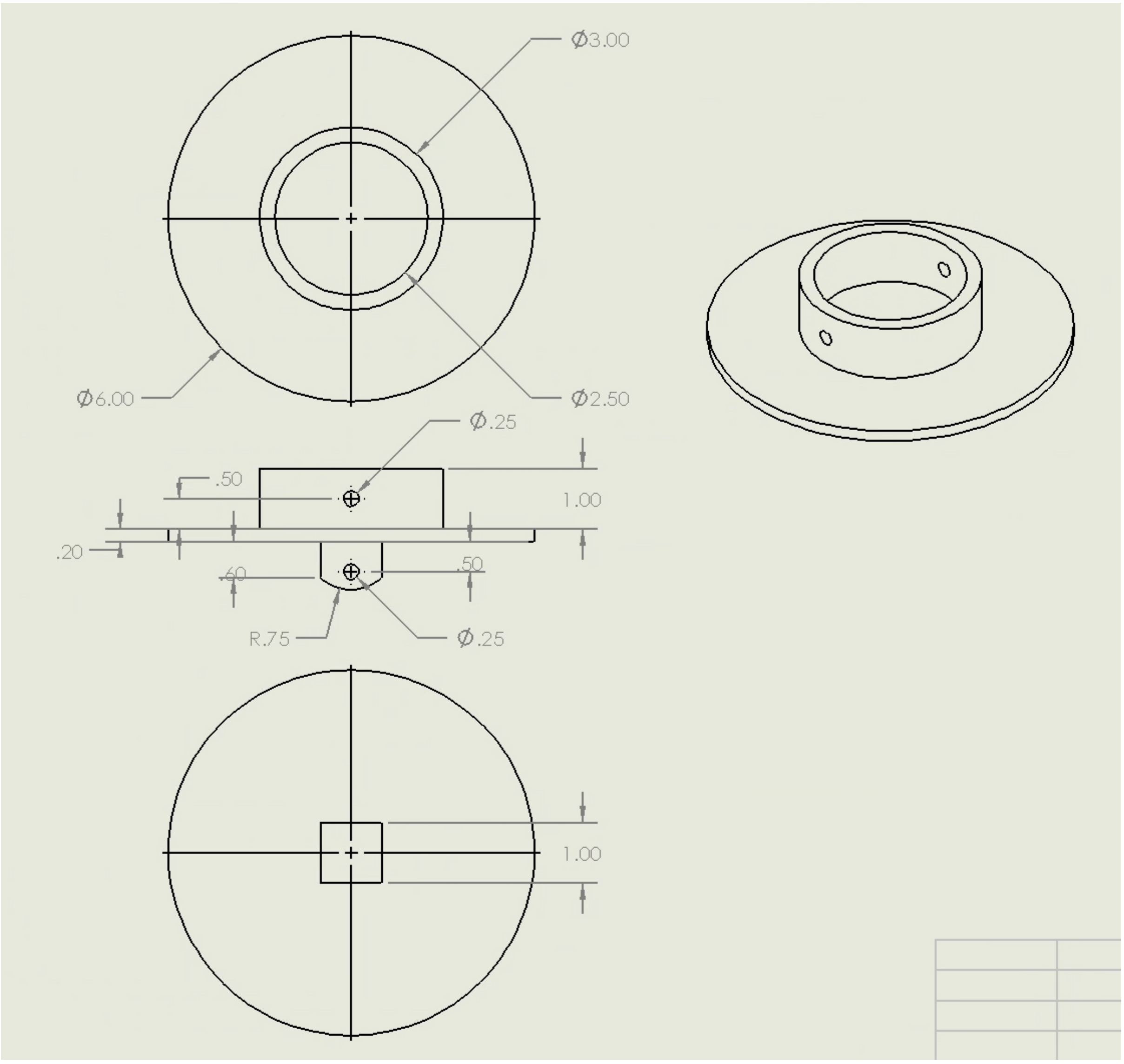


Figure 7: Custom Connection Part Engineering Drawing

#### 6.1.3.4 6” Pipe

To manufacture this part, we will be taking our 6” PVC scrap pipe and we will be first milling two slots (0.25” x 10”) into the sides of the pipe which will be used as the mechanism to control the vertical movement of the platform and spring. Once these two slots have been milled, we will drill the hole for the handle 6.5” from the bottom of the pipe.

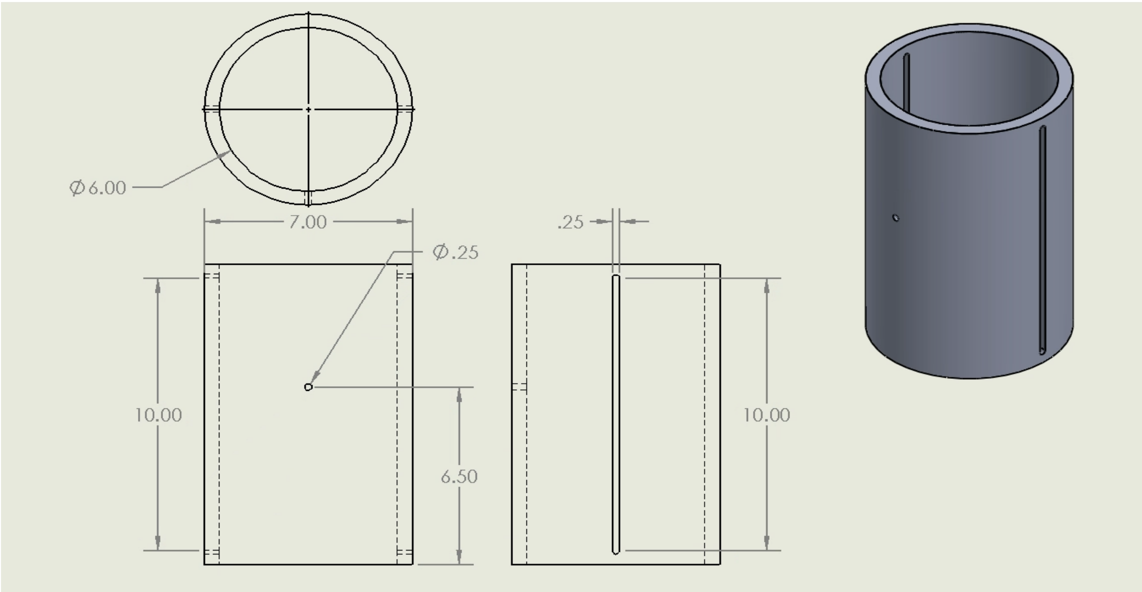


Figure 8: Custom Pipe Engineering Drawing

#### 6.1.3.5 Compression Spring

This part will be purchased from McMaster-Carr.

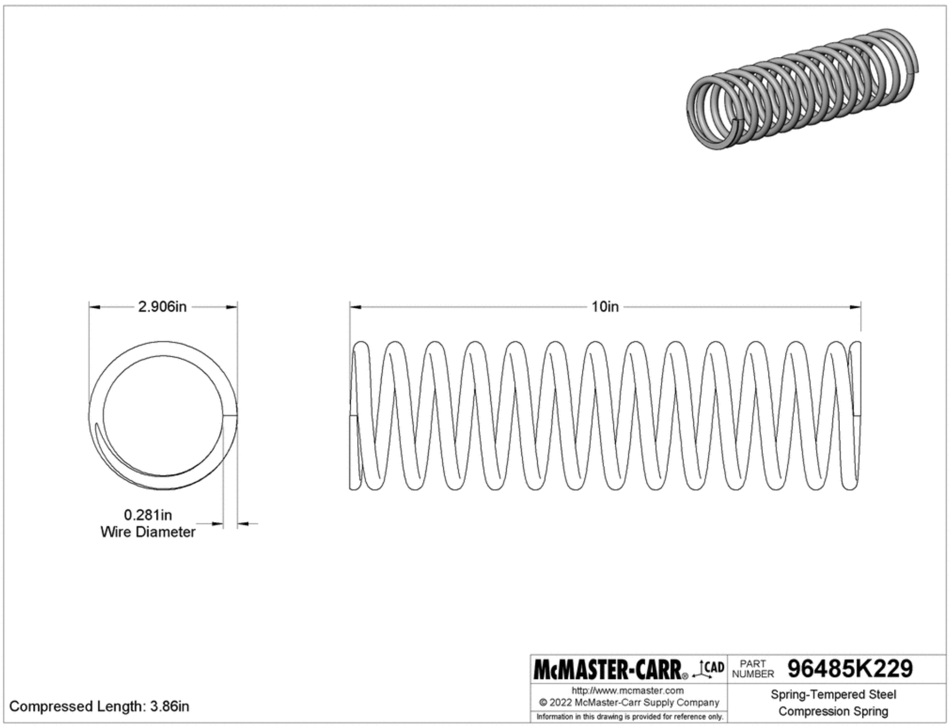


Figure 9: McMaster Carr Compression Spring Drawing

### 6.1.3.6 ¼”-20 Thread Nut

This part will be purchased from McMaster-Carr.

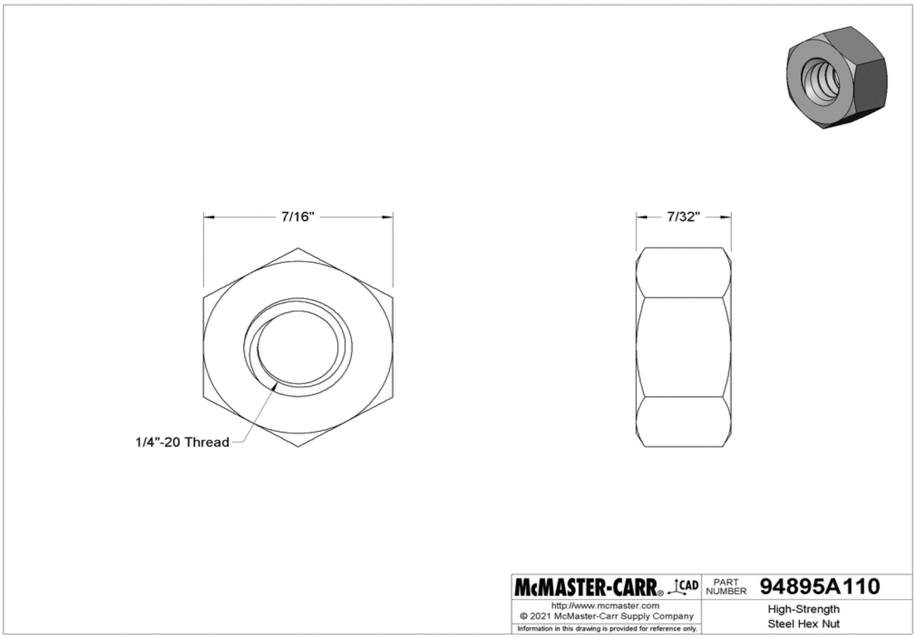


Figure 10: McMaster Carr Thread Nut Drawing

### 6.1.3.7 8” Stainless Steel Bolt

This part will be purchased from McMaster-Carr.

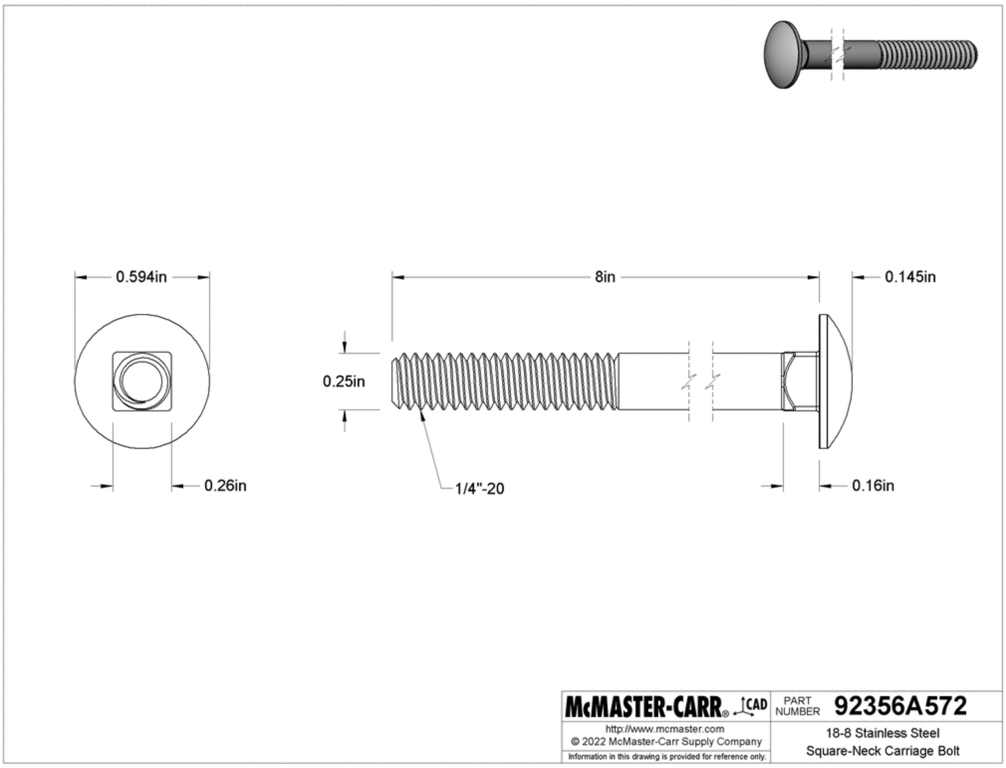


Figure 11: McMaster Carr 8” Stainless Steel Bolt Drawing

6.1.3.8 4” Stainless Steel Bolt

This part will be purchased from McMaster-Carr.

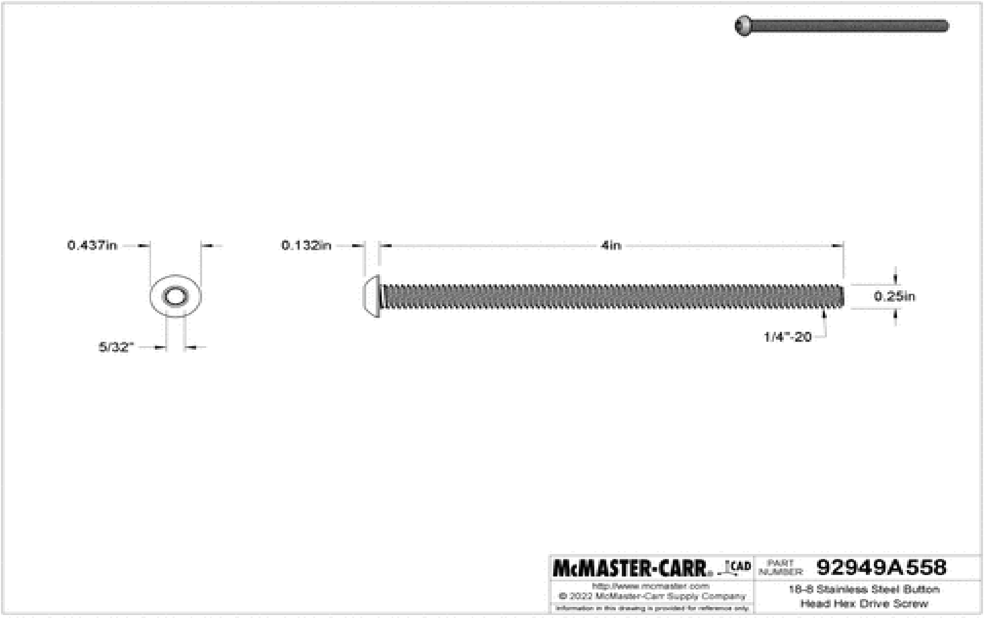


Figure 12: McMaster Carr 4” Stainless Steel Bolt Drawing

## 6.1.4 Assembly Instructions

To begin assembling this device, you must first grab the 6” laser cut disk, the 2 pipe fittings, the top platform and the 10” long 2” pipe. Insert the pipe fitting on each end of the pipe until the pipe is flush with the bottom of the fitting. This is an interference fit so a hammer may be required to ensure the pipe fitting is completely on. From there, use the pipe fitting to mark out 3 holes on the platform and on the 6” disk and drill the 3 holes. From there, use a ¼” bolt and a ¼” nut in each hole to secure the fittings to the platforms as seen below in figure 13 and 14.  We can now install the vinyl wrap and padding onto the top of the platform. To do this, put the padding on the platform and place the vinyl wrap over top with enough vinyl where you can staple it to the bottom of the platform to secure it.


Figures 13 and 14: Platform Assembly

Once the platform is connected, we need to ensure the 6” PVC has all the necessary features. The first feature is the slot. The mill will be required for this. Mill a slot ½” from the top of the wall up to halfway down the pipe. Repeat this slot 180 degrees around the pipe. The next required feature is the hole for the handle. To complete this feature, drill a hole at the required height for the handle. Once the holes are complete, take the 4” long ¼’ bolts and ¼” nuts and install it into the pipe as seen below in Figure 14.

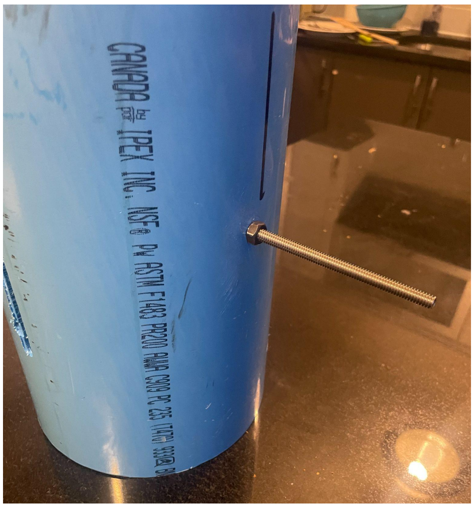


Figure 14: Handle Bolt

The next step is to manufacture the device base. For this step, you will need a piece of plywood to your desired size, one of the spring pushers, and your handle. The first part of this step is to put the PVC pipe over the piece of plywood and outline it in permanent marker where the pipe will sit. Once this is done, you can drill the spring pusher piece into the base. For our prototype, our handle was constructed from 2 x 4 pieces. The bolts previously installed into the side of the pipe will be used to connect the 2 x 4 pieces to the base so we first need to drill a ¼” hole into the side of the 2 x 4 pieces. From here, we can drill the 2 x 4 together as seen in Figure 15 below.

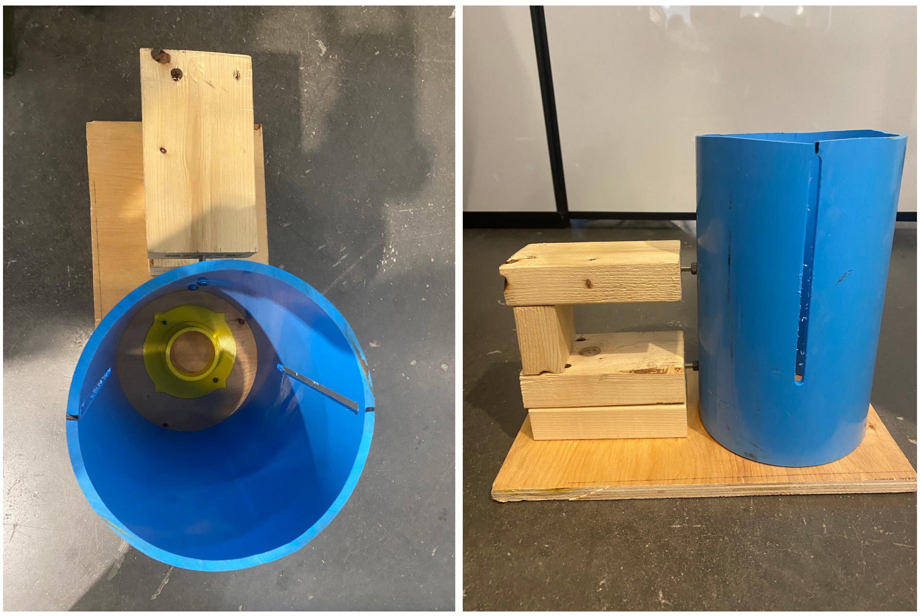

Figure 15: Device Base.

Now that we have our base and platform constructed, all we have left to do is put everything together. First, slide the bolts in the PVC pipe into the holes in the handle. Next, insert the spring onto the spring pusher on the base of the device and finally, install the spring pusher on the platform into the spring and put the 8” bolt through the slots of the PVC pipe which also goes through the drilled hole in the spring pusher. The final device should resemble Figure 16.

Figure 16: Final Prototype

## 6.2 Testing & Validation

In the following section, you will find an extensive list of all prototypes developed throughout the term while developing this product and the test accomplished to validate our assumptions.

### 6.2.1 Prototype 1

In this section, our team will outline the prototypes developed and the test conducted on said prototypes.

#### 6.2.1.1 Prototype 1a

For our first prototype, we wanted to validate if our custom pipe fittings would be useful or if we would need to purchase pipe fittings. We printed 3 different test models of the same fitting. One on a 0.8mm printer (white model), one on a 0.6mm printer (black model) and 1 on a 0.4mm printer (green model). Seen below in Figure 17 are the 3 models. All model flanges were printed smaller to save time on each print. These models are medium-fidelity, focused-physical prototypes.

Figure 17: Pipe Fitting Test prints

### 6.2.1.2 Prototype 1b

For our second prototype, we wanted to test out the strength of our custom spring connector. To do this, we decided to print a test model and apply 200 lbs. This first prototype model was printed on a 0.8mm printer. Since this print was 4 hours on the 0.8mm printer, we only printed one test model to save time. This model is a medium-fidelity, focused physical prototype.

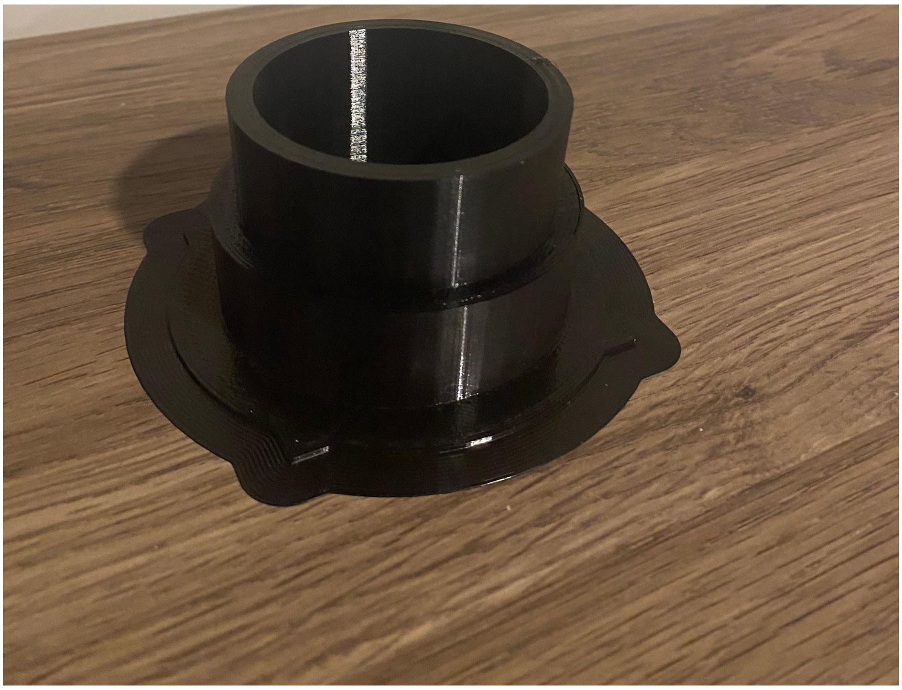

**Figure 18:** Spring Connector

#### 6.2.1.3 Prototype 1c

For our 3rd prototype, we wanted to prove our concept mathematically so this prototype is a more theoretical prototype which will outline the numerous known forces and enable us to calculate the other forces in the system by using assumptions and physics. This prototype is a low-fidelity, focused analytical prototype.

### 6.2.2 Prototype 1 Testing

After printing these three different pipe fittings, some general tests of stability and durability were run to check for the capabilities of these fittings. A general test plan (Table 4) is outlined below to provide details on testing results and objectives.

#### 6.2.2.1 Test Plan

**Table 4:** Test Plan

| Test ID | Test Objective | Prototype | Results Recorded | Duration |
|---|---|---|---|---|
| 1 | Determine the strength of pipe fitting | Prototype 1a | 1. Weight Applied<br>2. Fracture (yes/no)<br>3. Model Used<br>4. Time of Applied force | Until 200 lb of weight is supported for 1 min |
| 2 | Determine the strength of spring connection part | Prototype 1b | 1. Weight Applied<br>2. Fracture (yes/no)<br>3. Time of Applied force | Until 200 lb of weight is supported for 1 min |
| 3 | Determine total forces acting on the system and accompanying stresses | Prototype 1c | 1. Total Forces<br>2. Stress Concentrator<br>3. Stress | Until forces and stresses are determined |

#### 6.2.2.2 Test 1

During test 1, we planned on loading each test model with 200 lbs for a duration of 1 minute. For the 0.8mm model, we could not load the model since it was clearly visible that it would fracture under the weight of 200 lbs since it could be easily deformed by hand deformed as seen in figure 19. For the 0.6mm model and the 0.4mm model, 0 deformation and no cracks could be seen after unloading the specimens. This test confirms the hypothesis that these printed parts are strong enough to support the required weight of 200 lbs.

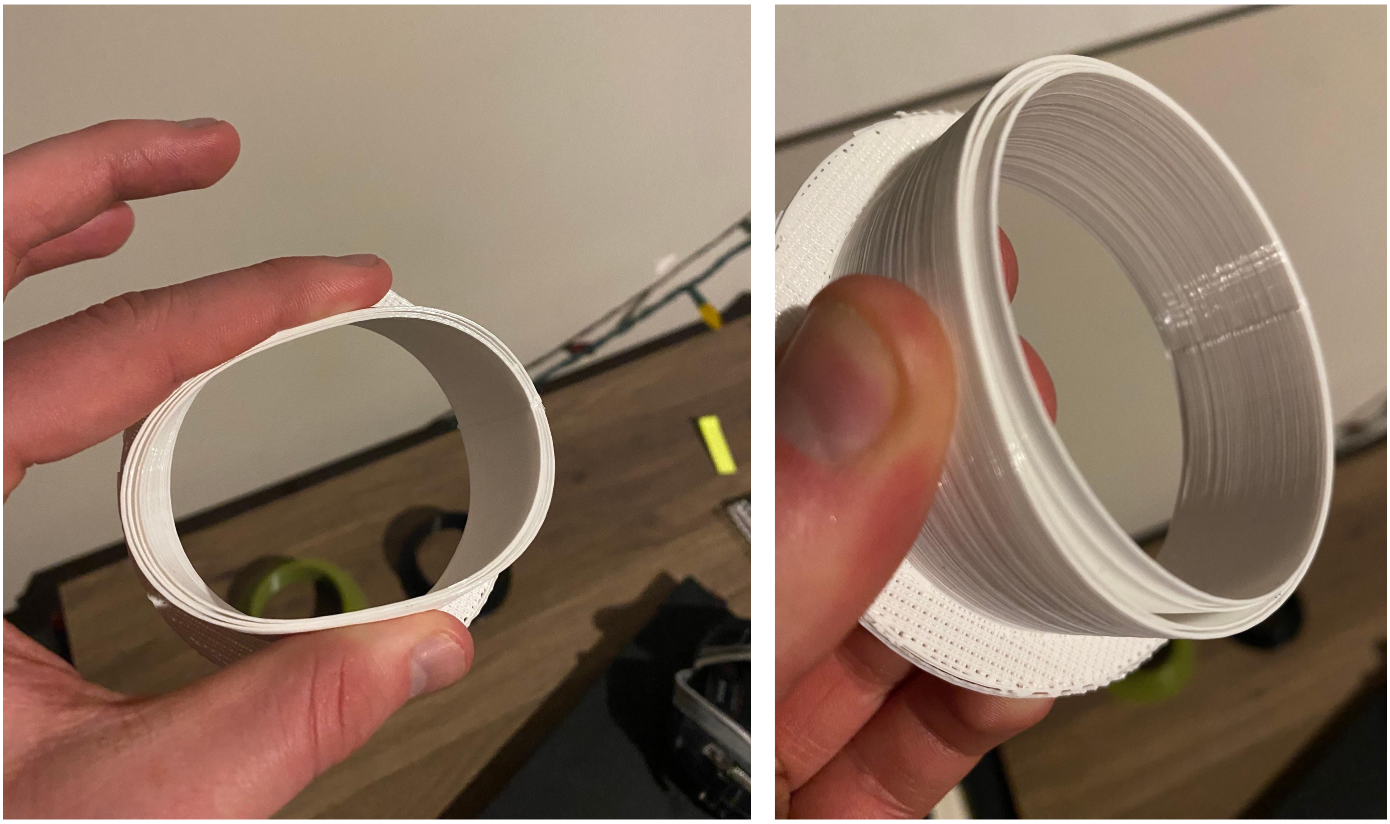

Figure 19: 0.8mm Model Deformation

#### 6.2.2.3 Test 2

During test 2, we conducted the same test as done during test 1 but this test was applied to prototype 1b. This model was quickly able to withstand the 200 lbs of weight for the 1-minute duration with no visible signs of permanent deformation or signs of failure.

#### 6.2.2.4 Test 3

The following test will show all calculations done to determine the force and stress in the part

Weight

$F = m * g$

$F = 90.72\, kg * 9.81\, m/s^2$

$F = 889.96\, N$

Force in arms analysis

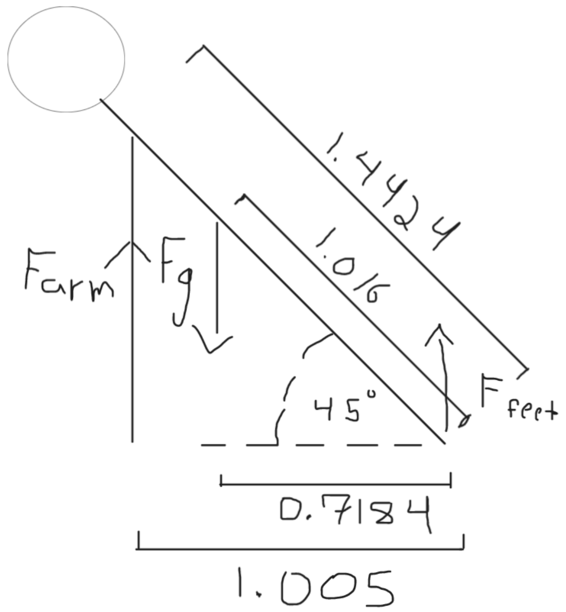


Figure 20: Beam Analysis

Assuming an angle of 45 degrees between the body and the floor

$\sum M_{feet} = 0$

$0 = F_g * 0.7184 - F_{arm} * 1.005$

$F_{arm} = 636.16\ N = 318.08\ N/arm$

$\sum F_y = 0 = F_g - F_{arm} - F_{feet}$

$F_{feet} = 253.79\ N$

Assuming full body weight is the force being applied to the device

$F = kx$
$x = F/k$
$x = 889.96\ N / 7.36\ N/mm$
$x = 120.91\ mm$ compressions from the spring

At full compression, the force in the spring and on the fittings is 889.96 N in compression

Stress in the fitting
$\sigma = F/A$
$\sigma = 889.96\ N/(\pi(76.2\ mm/2)^2 - \pi(50.8\ mm/2)^2)$
$\sigma = 0.35\ MPa < \sigma_{yield} = 35.9\ MPa\ for\ PLA$

## 6.2.3 Prototype 2

Outlined below are the various different prototypes we constructed to test some assumptions made during the design phase of this project and the test plan for the prototypes. For prototype 2, our team prototyped the handle system and the platform.

### 6.2.3.1 Test Plan

**Table 5:** Test Plan

| Test ID | Test Objective | Prototype | Results Recorded | Duration |
|---|---|---|---|---|
| 1 | Determine if the handle can support the weight | Handle system | 1. Weight applied<br>2. Any deflection in the handle<br>3. Any fracture | This test will last for 100 pushups |
| 2 | Determine if the handle can handle the moment created | Handle system | 1. Weight applied<br>2. Device stability | This test will last for 100 pushups |
| 3 | Determine if the platform system can handle the weight applied | Platform system | 1. Weight applied<br>2. Any fracture | This test will last for 5 minutes of applied weight |

### 6.2.3.2 Handle System

To construct the handle system prototype, we needed our 6” pipe, our 4” bolt, and our ¼”-20 threaded nut, along scrap pieces of 2x4 wood for the future modification of the handle. To begin, we drilled a ¼” hole in the side of the pipe. The hole is located 6.5” off the base of the pipe. We then installed the nut and bolt through these holes to stick out the side of the pipe. The assumption we wanted to test during this phase was that the handle could support the weight and that the moment created by forces on the handle was able to be controlled and wouldn’t tip the device. To test these assumptions, we completed 100 push-ups on the device over multiple days and noted down any results discovered. Throughout the testing, we realized the single use of a bolt would not suffice as a handle. This led us to think of a new handle design. We will be using scrap pieces of 2x4 wood to help design a more reliable handle. We will be drilling a second hole into the pipe where it is just slightly higher than the base. A second 4” bolt will be installed in that hole, which will be lined up with the current positioning of the bolt as seen in figure 21. We then drilled ¼“ holes into the 2x4 wood pieces to connect to the bolts and glued them for extra support. The shape of the handle will simulate a tea cup shape, thus ensuring stronger reinforcement for moment/tipping balance.

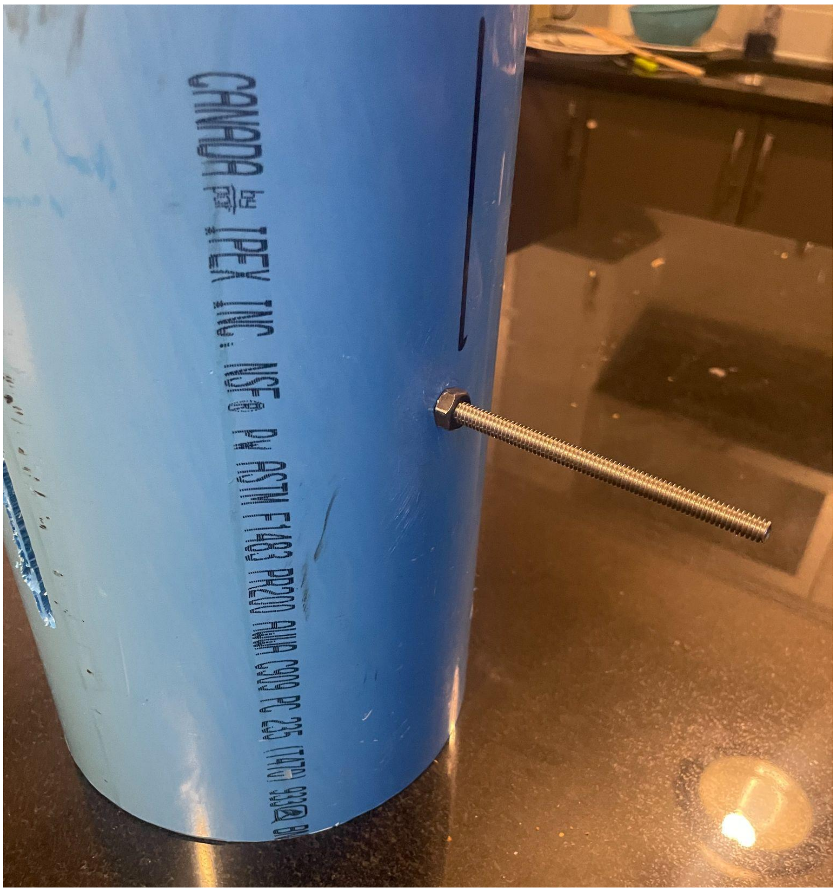


Figure 21: Handle System Prototype

### 6.2.3.4 Platform System

To construct the platform system, we needed our 7” x 9” platform, 4 separate ¼” diameter, 1” long bolts, 2 separate ¼” diameter, 3” long diameter bolts, 2 of our custom pipe fittings, 6 separate ¼”-20 threaded bolts and a 10” long, 2” in diameter pipe. To construct this prototype, we drilled 4 ¼” holes through the flange of the custom pipe fitting and 4 ¼” holes through the platform and bolted them together. We drilled 2 ¼” holes through the fitting cylinder and 2 ¼” holes through the 2” pipe and bolt them together and we repeated this on the other end of the pipe and on the other pipe fitting and bolted that together. The assumption being tested in this prototype is that the platform system can support the weight that will be applied during the use of the device. To test these assumptions, we applied 100 pounds to the platform for 30 minutes. After our results, the platform successfully withstood the weight with no visible cracks or damage.


Figure 22: Platform System Prototype

# 7 Conclusions and Recommendations for Future Work

While doing this project, we learned how to use various equipment such as; a mill, drill press, and various saws. We learned how to laser cut while also developing our 3D printing designs. In addition, previous skills were expanded and developed while working in a team environment on a complex issue. These skills include, designing 3d models in CAD, using various hand tools efficiently, material choice selection, and effectively working as a team. Some direct lessons we learned from this project are that the spring plays a major role in our product's success. Having a better and more accurate spring will help our product be more functional. We also learned that the pipe fitting-spring connector didn’t properly fit with the pre-bought metallic pipe fittings. This caused us to make slight modifications in the alignment and stability of our design, which allowed it to be in working condition, but with a lack of stability. Another modification needed was to counter the tipping factor on our initial handle design. In order to counter this moment, we created a more stable handle design by having it sit flush with the pipe. This eliminated all tipping during use and allowed for greater overall stability. An aesthetic aspect of our design is the addition of comfort foam and vinyl wrapping which made the platform more comfortable during use in order to avoid any pain or discomfort. For future considerations, a customized spring would be ideal in order to obtain the desired length required without compensating the spring coefficient. In our design, searching various catalogues for pre-bought springs, we couldn’t find a spring that has the desired length, diameter and strength. For our design, we mainly wanted to create a portable product that can be carried around easily. However, if we were to improve our design, a more simple and ergonomic handle would be ideal to lower the weight and overall size of our device. Finally, replacing all 3D-printed parts with metallic ones would be ideal in order to ensure all parts easily mesh and fit together.

# 8 Bibliography

[1]CDC, "Move More; Sit Less," *Centers for Disease Control and Prevention*, Oct. 07, 2020. https://www.cdc.gov/physicalactivity/basics/adults/index.htm#:~:text=Physical%20activity%20is%20anything%20that

# APPENDICES

# APPENDIX I: Design Files

**Table 6. Referenced Documents**

| **Document Name** | **Document Location and/or URL** | **Issuance Date** |
|---|---|---|
| **MakerRepo** | **AerobicsRUs - D1.4 \| MakerRepo (makerepo.com)** | **April 11, 2023** |