VIDEO:
https://youtu.be/4rRUXlgCB_k

GNG 2101

Design Project User and Product Manual

Adapted Fitness Equipment

Submitted by:

Team RowAbility Group 2.4

Jacob Hodgins, 300300367

Samanyu Itagi Shivayogi, 300299581

Chujian Xiao, 300256072

December 12th, 2023

University of Ottawa

Table of Contents

1 Introduction

This User and Product Manual (UPM) provides the information necessary for wheelchair users and their assistants to effectively use the RowAbility Adaptive Rowing Device and for prototype documentation. The manual is structured as follows:

Section Two: Offers an in-depth overview of the challenges addressed by the RowAbility device and an overall description of the product and its features.

Section Three: Provides step-by-step instructions for the setup and removal of the device.

Section Four: Delves into the specifics of the device's subsystems, offering a detailed explanation of each component's functionality.

Section Five: Dedicated to troubleshooting, this section goes over common operational issues. It also offers comprehensive maintenance guidelines to certify the longevity and optimal performance of your device.

Section Six: Presents a bill of materials used in the construction of the device, while including instructional insights on how to replicate the build process.

Section Seven: Recommends areas of future study for the continued improvement of the device.

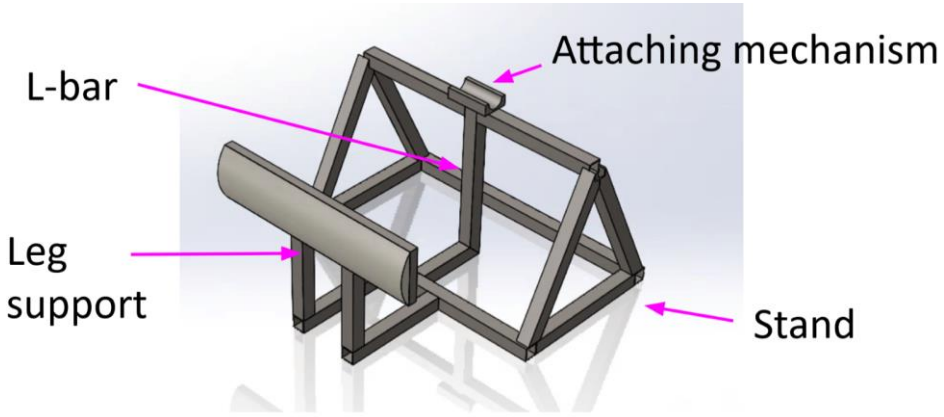
This manual is designed to be your go-to resource for all aspects related to the RowAbility Adaptive Rowing Device. Whether you are setting up the device for the first time, seeking maintenance advice, or trying to build your own interpretation, this manual aims to provide you with all the necessary information and guidance.

2 Overview

At the Jack Purcell Community Centre near the University of Ottawa, wheelchair users are unable to use the rowing machine located within the gym as they do not have the leg mobility and strength required for effective function of the sliding seat. The rowing machine located in the gym (Concept 2 Rower) can be split via clamp into two separate pieces. One is the sliding seat stand, and the other is the rowing machine containing flywheel and dampers. Using the rowing machine on its own without the sliding seat can be dangerous. Without any device to fix the distance between the user and machine, the device will jolt towards the use on pulling which can lead to injury. Additionally, the machine can twist to the side and lift from the ground.

In general, a device must be made that will secure the machine in place and allow easy and safe usage by the wheelchair user. Some more defined needs required for the device include the following: simple device setup and usage, safe and secure usage of the rowing machine, and no permanent modifications made to the original rowing machine. To solve this problem, our team designed a welded triangular prism structure that prevents the machine from tilting, adds rigidity to the overall structure while supporting the user's legs.

Our product is affordable, secure, and easy to use. We are committed to breaking down financial barriers to fitness accessibility. Our product is designed with cost-effectiveness in mind, featuring materials that total less than one hundred dollars. The prism shape gives the structure much rigidity to withstand substantial rotational or linear forces without failing. Furthermore, the setup can be completed in under two minutes, ensuring a swift transition to exercise.



The device features three main components: The stand, built from sturdy steel tubes, which supports the weight of the rowing machine and the force of the user's pulls; The leg support which provides cushioning and support for the user's legs; The attaching mechanism, which secures the device to the machine, ensuring that neither the device nor the machine moves during exercise.

2.1 Cautions & Warnings

The device is approximately 15kg in weight, although it is not too heavy, proper lifting form should be taken into consideration.

3 Getting started

3.1 Configuration Considerations

The device created by our team has been created specifically for rowing machines that can be split into two separate sections, a sliding seat and a flywheel. An example of which is the Concept 2 Rowing Machine (see figure, more details at https://www.concept2.com/indoor-rowers/concept2-rowerg). The device can be used with other rowing machines as long as it can safely be secured in place and does not damage or permanently change the machine. No other devices or tools are required to setup the device and it can be used in any environment as long as the ground is level.

Figure 3.3.1 – Concept 2 Rowing Machine

3.2 User Access Considerations

This device was created to grant wheelchair users accessibility to the Concept 2 Rower rowing machine. However, it is highly advised that someone in a wheelchair does not set up the device themselves and that they allow someone else to assist them. Otherwise, the machine can be used independently by the user. In some cases, a user may find it hard to reach the ergonomic handlebars on the rowing machine, it is then advised that someone assist in placing the handlebars within reach of the user.

3.3 Accessing/setting up the System

3.3.1 Rowing Machine Disassembly

First locate the RowAbility rowing machine assistance device and place it nearby the rowing machine.

Figure 3.3.1.1 – RowAbility Rowing Machine Assistance Device

Locate the black coloured clamp located in the middle of the rowing machine and lift it to loosen the two sections. With one hand lift the sliding seat section out of the clamp, use your other hand to hold the flywheel in place (see figure 3.3.1.2). When lifting the sliding section from the clamp, first tilt the end opposite the legs upwards to allow the seat to slide down and be secured by gravity so that the seat does not move around or hit your arm.

Figure 3.3.1.2 – Rowing Machine Disassembly

https://www.reviewsbylance.com/concept2-setup/

Rest the extending arm of the flywheel onto the floor. Then, secure the sliding seat section with both hands and relocate it away from the rowing machine in a safe spot.

3.3.2 Device Setup

Grab the RowAbility assistance device and place it in front of the extending arm of the flywheel ensuring the leg padding is facing away from the machine. There is a metal cylinder that extends horizontally between the footrests as shown in figure 3.3.2.1.

Figure 3.3.2.1 – Cylindrical Connector

This cylinder must be placed into the U-Shaped feature (see figure 3.3.2.2) extending above the rowing machine assistance device. Ensure that before placing the cylinder inside the device that the bolt and nut have been removed. The easiest way to connect the devices is to nudge the assistance device as close as possible to the end of the extending arm of the flywheel, then lift the extending arm with both hands and place the cylinder inside the U-Shape.

Figure 3.3.2.2 – U-Shaped Feature

Place the bolt through the two holes of the U-Shaped feature. For easy disassembly, insert the bolt through the hole on the flywheel side of the U-Shaped connector. If done correctly, the nut should be easily fastened onto the bolt from the assistance device side of the U-Shaped connector. For more detailed instructions on how to attach the rowing machine to the U-Shaped connector, please view **section 4.1** of this manual. The device is now securely in place. It is advised that users apply the brakes on their wheelchairs while using the device so that they do not roll away due to the pulling motion.

3.4 System Organization & Navigation

The rowing machine assistance device is organized into 2 different subsystems. A stand subsystem and a leg support subsystem, the following figure demonstrates this.

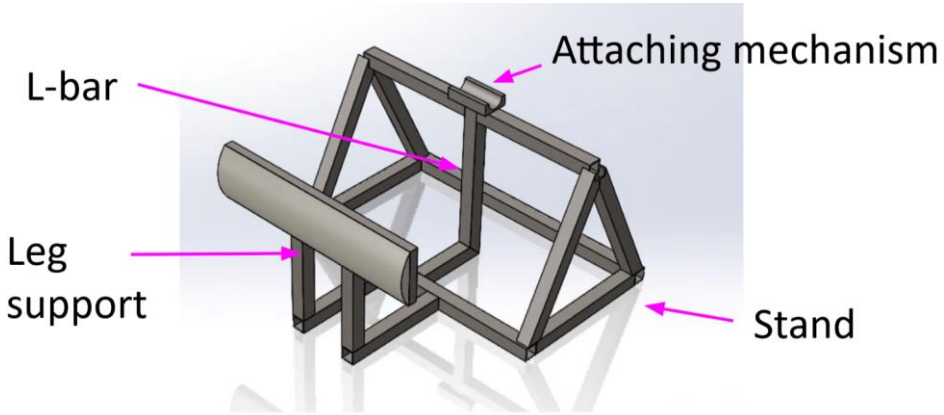


Figure 3.4.1 – Organization of Prototype

The stand subsystem consists of the stand, the L-bar, and the attaching mechanism. All parts of this subsystem were joined together by welded joints. The purpose of the stand subsystem is to support the weight of the flywheel, secure the machine in place, and attach the device and flywheel together.

The leg support subsystem consists of two extending L shaped supports and leg padding. The supports are joined by welds whereas the padding is joined by 2 sets of bolts, washers, spring washers, and nuts through a wooden 2” x 10” board and the metal supports. The purpose of the

leg support system is to fix the distance between the user and the rowing machine and to comfort the shins or knees.

3.5 Exiting the System

1. Allow the wheelchair user to move away from the device so that an assistant has enough space to move around.
2. Loosen the nut on the U-Shaped connector and remove the bolt. Place the two items aside in a spot temporarily.
3. Lift the arm of the flywheel out of the rowing machine, gently pushing it away from the device to obtain more clearance on the ground, then rest the arm on the floor.
4. Fasten the bolt and nut back into the U-Shaped connector so that it is not accidentally lost.
5. Safely lift the rowing machine assistance device from the ground and place it in storage.
6. Grab the sliding seat and connect it to the rowing machine at the area between the footrests.

4 Using the System

The following subsections provide detailed, step-by-step instructions on how to use the various functions or features of the RowAbility Adaptive Rowing Device.

4.1 Using the U-Shaped Connector

The U-shaped Connector is a critical component designed to securely fasten the rowing machine to the device. This mechanism features a U-shaped trough made of steel, a bolt, and a corresponding nut. Please follow the subsequent steps to ensure a secure attachment:

1. Carefully align the metal cylinder of the rowing machine with the U-shaped trough, holding the rowing machine with both hands. Insert the metal cylinder gently, making sure that it sits evenly within the trough.

Figure – Inserting the Metal Cylinder into the Trough

1. Locate the hole on the trough's side that faces towards the rowing machine. Insert the bolt through this hole. The nut should pass over the metal cylinder and into the hole on the opposite side of the trough.
1. Slide the nut onto the protruding end of the bolt.
1. Hand-tighten the nut until the bolt is securely fastened and no longer moves. For enhanced security, particularly under vigorous use, consider using a wrench to tighten the nut further. Hand-tightening should be sufficient for regular usage.

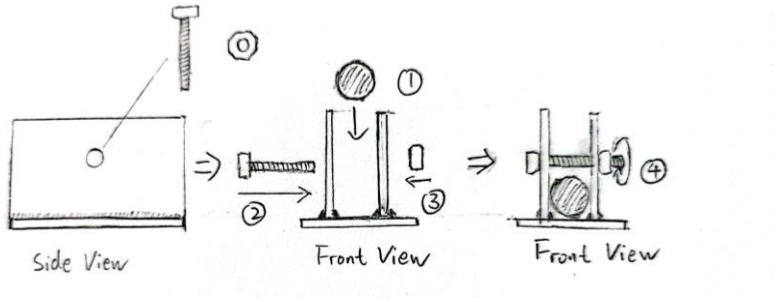


Figure – Visual Instructions for Attaching Rowing Machine to U-Shape Mechanism

After attaching the U-shaped connector, the results should look like this:

Figure – Cylinder Secured in U-Shape

4.2 Using the Leg Support

The leg support feature of our adaptive rowing device is designed to offer a cushioned rest for the user's legs, ensuring both comfort and stability during the rowing exercise. It effectively prevents the legs from moving towards the rowing machine, thereby enhancing safety. To maximize the benefits of the leg support, users are advised to follow these steps:

1. **Preparing the Wheelchair**:

Begin by adjusting the wheelchair for optimal positioning. This can be done by flipping up the footplate of the wheelchair or, alternatively, swinging the footrests to the side to clear the area in front of the user's legs.

Figure – Picture Demonstrating Footrests Folded Up[1]

2. Positioning the Legs:

With the footrests adjusted, the user should gently place their feet on the ground. Their legs should then rest comfortably against the soft padding of the leg support.

3. Adjusting the Space:

Carefully adjust the space between the wheelchair and the leg support. Ample distance should be maintained to avoid any undue pressure on the user's legs. This spacing not only contributes to the user's comfort but also reduces the risk of discomfort or injury.

4.3 Rowing

To enjoy a safe and effective rowing session using our adaptive rowing device, follow these key steps:

1. Securing the Wheelchair:

Prior to initiating the rowing activity, confirm that the brakes of the wheelchair are engaged. It is imperative that the wheelchair remains stationary and stable throughout the exercise.

1. Preparation and Positioning:

After installing the device, make sure that the user's legs are positioned comfortably against the leg support. In some instances, the user may find it challenging to reach the handle of the rowing machine. If this is the case, a helper should assist by retrieving the handle for the user.

1. Executing the Rowing motion:

Commence rowing by pulling the handle towards the chest while maintaining an upright posture. In the release phase, follow through by stretching out the arms and slightly leaning forward, thereby completing the rowing stroke.

Figure–Demonstration of the Starting Position

Figure–Demonstration of the Release Position

1. Considerations for Limited Hip Mobility

For users with restricted hip mobility, consider using a strap to secure the waist to the wheelchair. This additional support helps maintain an upright position during the release.

Figure – Example of Waist Strap[2]

[1] https://www.youtube.com/watch?v=W8wTbyA-bbA

[2] https://www.britishrowing.org/indoor-rowing/go-row-indoor/how-to-indoor-row/adaptive-indoor-rowing/

5 Troubleshooting & Support

5.1 Error Messages or Behaviors

1. The user may slightly experience the flywheel side of the rowing machine lifting up when in use. The only method of identifying this is by visual inspection. The likely cause of this is due to counterweights (2, 20lbs dumbbells) on the flywheel side of the rowing machine is not placed if the user is intending to use the rowing machine with the RowAbility product for high-intensity training purposes rather than just mobility training purposes.

Solution: To fix this, place 2 dumbbells that are a minimum of 20lbs each on the base of the flywheel side of the rowing machine, if the issue does not resolve, increase the weight of the dumbbells used.

2. In very rare cases, the user may experience the side of the rowing machine closest to them using is making too much of a clanking sound or that this side is lifting up. This would be due to the bolt and nut not being installed above the U-shaped mechanism designed to connect the RowAbility product and the rowing machine.

Solution: Install the provided bolt and nut in the provided hole in the U-shaped connecting mechanism.

5.2 Special Considerations

1. Ensure the machine is not in use while installing or uninstalling the RowAbility product to the rowing machine.

5.3 Maintenance

Regular maintenance for this product is very limited, however every 1-2 months inspect all of the welded joints of the product and ensure that the welds are still in good condition, meaning there should not be any sort of cracking or any sort of detachment between any of the welding pieces. Also ensure that the bolt and nut are in good shape which are defined by the bolt and nut not being deformed or in a bent condition. If any of these issues are seen, please refer to our contact information for replacing parts. The bolt and nut can be replaced by the user themselves since it is a generic bolt and nut that can be bought from any hardware store.

5.4 Support

For support and information about the RowAbility product, please contact Samanyu Itagi Shivayogi at +1 (647) 887-8482 or email at sitag086@uottawa.ca.

6 Product Documentation

6.1 U-Shape Connector

6.1.1 BOM (Bill of Materials)

Item Name	Quantity	Unit Cost	Link
Metal piece (3 ¼” x 2” x 1/8”)	3	$1	https://makerstore.ca/shop/ols/products/metal-bars-brunsfield
Bolt and nut (3/8” diameter)	1	free	Found in metal shop miscellaneous section

6.1.2 Equipment list

- Angle grinder
- Bench vise
- Marker
- Ruler
- MIG welding machine
- MIG welding PPE (Personal Protective Equipment):

    - Gloves
    - Auto-dimming helmet
    - Safety glasses
    - Welding jacket
    - Welding cap for hair
- Pliers with wire cutter
- Welding magnets
- Drill press
- 3/8” drill bit
- Clamps

6.1.3 Instructions

1. First, the metal pieces need to be cut to 3 1/8” in length, so mark each piece with a ruler and marker.

2. Then prepare the angle grinder, make sure the screw that holds the cutter in place is tight, place the metal piece on a bench vice such that the marker is visible to you, make sure to put on appropriate PPE.

3. Cut the 3 metal pieces along the marked lines

4. Mark the 2 metal pieces with a dot that is centered widthwise and is ½"-¾" from the top and use a drill press with the appropriate settings (for 1/8” steel) and a 3/8” drill bit to drill holes for the marked dots. Make sure to use clamps to secure the pieces to the workbench.

5. Prepare the MIG welding machine by setting it to the appropriate wire speed and amperage based on the settings posted on the machine for 1/8” thickness steel.

6. Mark one of the metal pieces with 2 lines that are centered and ½ - 5/8” apart from each other, this is where the other two metal pieces will be placed so that the cylinder of the rowing machine fits on this area.

7. Place the 90 degree welding magnet to secure one of the metal pieces on the marked base metal piece and weld this together, now take the nut and bolt and put it through the holes and hand tighten the nut so that you can accurately place the 2nd piece of metal on the 2nd line and then weld this as well. The welds do not have to be completely along the entire line of contact between the base and the 2 metal pieces, a few small strips are sufficient, but the more it’s welded the strong it is.

6.2 Frame

Figure - frame

6.2.1 BOM (Bill of Materials)

Item Name	Quantity	Unit Cost	Link
Square tube - cold rolled steel (1” x 1” x 1/8”)	20ft	$78	https://www.metalsupermarkets.com/product/mild-steel-square-tube-structural-welded/

6.2.2 Equipment list

- Angle grinder
- Horizontal band saw

- Files
- Bench vise
- Marker
- Ruler
- MIG welding machine
- MIG welding PPE (Personal Protective Equipment):
    - Gloves
    - Auto-dimming helmet
    - Safety glasses
    - Welding jacket
    - Welding cap for hair
- Pliers with wire cutter
- Welding magnets
- Drill press
- 1/2” drill bit
- Clamps
- Measuring tape
- Protractor

6.2.3 Instructions

1. Using the measuring tape, a ruler, and marker, mark the metal on 2 faces with the dimensions listed in the following table:

Item #	# of pieces	Dimension (cm)	Dimension (in)	Description
1	3	61	24	Base horizontal bars
2	3	35	13 3/4	Side base bars
3	1	37	14 1/2	Height L bar
4	4	39	15 3/8	Triangle pieces
5	2	30	11 3/4	Leg support height bar
6	2	25	9 3/4	Extended base leg support bar

7	1	7	2 3/4	Horizontal bar of leg support

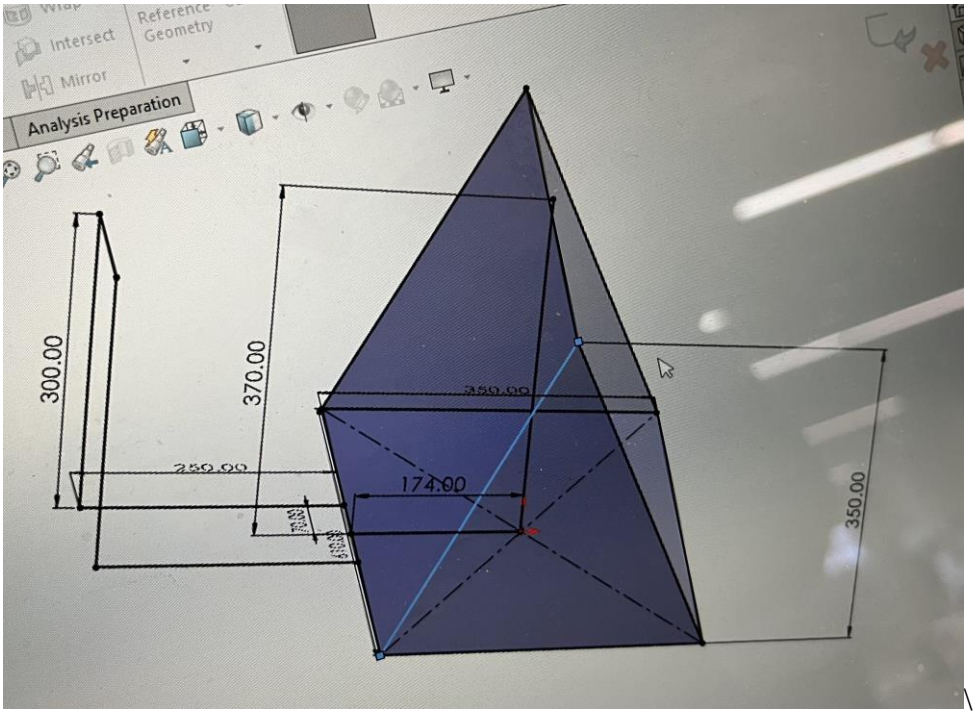


Figure – reference dimensions

2. Using a horizontal band saw, cut along the marked lines, make sure to ask for assistance if it is your first time using a horizontal band saw.

3. Now identify the 4 metal pieces that are part of item #4 (triangle pieces), for each of the bars, using a protractor measure and mark 30 degrees on one side and 61 degrees on the other end of the bar.

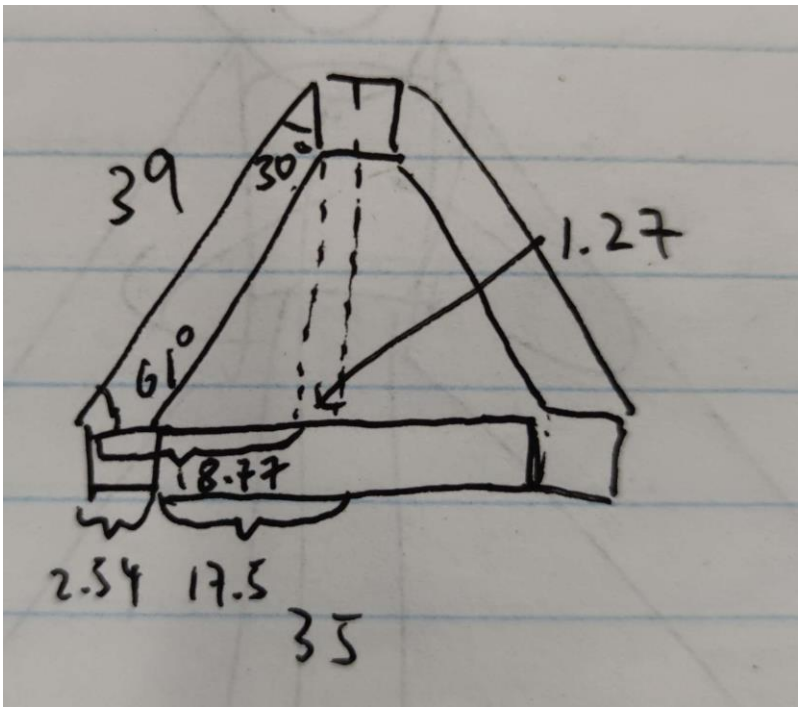


Figure – Schematics of angles

4. Now set up the angle grinder and working station exactly how it was when constructing 6.1: U-shape connector, and cut along the marked lines. It will look like this on the 30 degree angled sides:

Figure – 30 degree cuts

5. Use the 2 bars that under the name item #5 and mark 1 dot on each of the 2 metal pieces, 1” from the top and centered widthwise, these will be the holes where the leg support pads will be placed.

6. Use the ½" drill bit and drill press and set the appropriate settings and drill item #5 on the marked holes.

7. All of the pieces required for making the frame are now cut, now set up the MIG machine like how it was done in 6.1: U-shape connector. Start by Welding the base together, then the triangle pieces, leg support pieces, and finally the bar with the U-shaped connector. Make sure to just add small welds so that you can adjust some parts if they move and once satisfied with the fitment of the pieces, completely weld the joints together.

8. Your frame should now be done and welded together. Before moving to the next step, use a file to smoothen any rough edges or corners, pay special attention to the welded areas and corners.

6.3 Leg Support

Figure – leg support (padding)

6.3.1 BOM (Bill of Materials)

Item Name	Quantity	Unit Cost	Link
Wood block (2’ x ½' x 3”)	1	free	Found in miscellaneous in workshop
Washer and nut (3/8” diameter)	1	free	Found in workshop miscellaneous
Washer and spring washer (with 3/8” hole)	4	free	Found in workshop miscellaneous

Pool noodle (1.5m)	1	$3	Canadian tire/dollarama, not listed online
Vinyl (54” x 12”)	1	$7	Any fabric store, not listed online
Sponges (pack of 3	1	$3	Dollarama, not listed online

6.3.2 Equipment list

- Sanding machine
- Horizontal band saw
- Marker
- Ruler
- Drill press
- 1/2” drill bit
- Clamps
- Measuring tape
- Gorilla glue
- Industry grade staple gun with staples
- 2 Wrenches

6.3.3 Instructions

1. Take the wooden piece and measure 3 ¾" and center it height and widthwise and mark it, this is where it will be drilled using the appropraite settings using the drill press and the ½" drill bit.

2. Once the holes are drilled, use a sanding machine to smoothen all the surfaces, corners, and edges of the wooden block.

3. Now use the bolt, spring washer, washer, and nut to attach the wooden block to the leg support part of the frame, and use 2 wrenches to tighten it, make sure it is tight because you will not be able to tighten it afterwards.

4. Now cut the pool noodles into 2 pieces that match the length of the wooden block and make slits so that it fits on the top and bottom edges of the wooden block like this:

Figure – pool noodle on top edge of wooden block, (also add it to the bottom edge as well)

5. Now cut the sponges so that it fits in between the pool noodles and fills up the entire length of the wooden block.

6. Use the vinyl to cover the pool noodles and sponges and cut the vinyl so that it leaves excess for the back of the wooden block and use the stapler to staple the vinyl to the wooden block, be generous with this to make sure it doesn't come undone.

6.4 Testing & Validation

Once the final prototype was built, the validation for this is to test it out on the rowing machine at the gym. So, the final prototype was tested at the Jack Purcell Community Center gym where the final prototype was used in a way that would be used by a person in a wheelchair. The final prototype was installed onto the rowing machine and tested out by having one of the team members in a wheelchair and see if the product did its job of making sure the rowing machine is secure and useable by people in wheelchairs as well as people not in wheelchairs.

Figure–Demonstration of the Starting Position

Figure–Demonstration of the Release Position

Knowing that most people who would use our product would be using for mobility training purposes, team members took turns (since everyone is a different height) to use the product with the rowing machine and put an “average” amount of force, and the rowing machine did not move at all. Then for the rare occurrence of users wanting more higher-intensity training with the rowing machine, more force was applied for the exercise, and was found that the product worked well but the rowing machine is too light on the opposite end of the installed product where the rowing machine would sometimes move just a bit. To make sure this was further secured, we added on two 20lb dumbbells and tried it again, and then the rowing machine did not move at all. So we added a note (in the troubleshooting section) regarding that if the user wishes to do high-intensity training, at least two 20lbs dumbbells need to put on the flywheel end of the rowing machine to further secure the machine. In the case of testing out dimensions, we found that our product was very optimized for the given dimensions, as it cleared obstacles just enough (within 1 inch) such that the product minimized the space it required without making the product too large where it is an obstruction and inconvenience to use the machine and for other people in the gym.

7 Conclusions and Recommendations for Future Work

In concluding the project, our team is quite satisfied with our final design. Although we were able to produce an effective product on time and within budget, we do have some final thoughts to share.

Our team recommends pursuing a feature that allows the rowing machine handlebars to rest closer to the user. Additionally, we recommend adding a telescoping, adjustable height feature for the leg support to account for different leg heights and for comfort in general. Skinnier tubes could be used to cut costs on the device and reduce weight, for example ½" to ¾" diameter. For the attaching mechanism, it is recommended to purchase the original connector on the Concept 2 Rowing Machine itself instead of making a customized part. Make sure that when welding, you do not produce too large of bulges at the seams to ensure that you don’t inhibit the installation of other parts. Using spray paint can clean up the aesthetics of the device as well to make it look less scrappy. If possible, learn TIG welding and use aluminum for the product. Other than that, make sure to properly plan your construction (order of installation and time constraints) and ensure you have enough material to finish by the end.