User Manual

Rowing Machine Adapter

GNG 2101 - Introduction to Product Development and Management for Engineers

Faculty of Engineering - University of Ottawa

Adaptive Row

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Abstract

Wheelchair-users often face several difficulties when attempting to use fitness equipment, such as rowing machines, to perform physical activities. Those individuals are unable to utilize regular rowing machines since they cannot position themselves on the designated seats and strap their feet into the foot pads. The team developed a proposed design of an adapter that can make rowing machines wheelchair-accessible. The design primarily consists of 3D printed parts, along with metal support bars and a foam pad to achieve comfort for the users. It is lightweight, cost-effective, adjustable in height, and easy to install/detach. This manual provides detailed instructions for installation, operation, and maintenance of the product, as well as health and safety guidelines and other important precautions. The design team recommends the implementation and assembly of the product, as well as rigorous testing before usage.

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1. Introduction

Currently, many gyms and fitness centers do not contain adequate wheelchair-accessible fitness equipment to accommodate people with disabilities. This can hinder the ability of wheelchair-users to exercise and may further discourage them from leading active lifestyles. It is crucial for disabled people and everyone, in general, to regularly engage in physical activities. Research suggests that it is even more important for disabled people to exercise than it is for those without a disability.[2] Regular exercise can significantly reduce the risks of coronary heart disease, diabetes, high blood pressure, and other types of illnesses.[2] It can also improve one's mental health by reducing anxiety, risks of depression, and feelings of stress.[2]

Various types of wheelchair-accessible fitness equipment have been recently developed in order to accommodate disabled people with limited physical capabilities. One example of a piece of fitness equipment is the rowing machine. The design team's client is Brian Robitaille, the program coordinator at the Richcraft Recreation Complex in Kanata, Ontario. The recreation complex contains several adaptive fitness equipment, but the client was highly interested in acquiring an adapter for the rowing machines at the gym, which is a clear indicator that wheelchair-accessible rowing machines are in demand.

Regular rowing machines cannot be used by people in wheelchairs because they cannot sit on the machine and strap their feet into the foot pads. The proposed solution to this problem includes building an adapter that can be attached to the machine, making the rowing machine wheelchair-accessible and, hence, allowing people with disabilities to exercise their upper bodies

and use the machine comfortably. The main idea is for the adapter to be designed in a way that wheelchair-users are capable of performing the workout on the rowing machine independently, which is what they evidently desire. The product that the team is designing is differentiated and distinctive. Not only is it produced to make the rowing machine wheelchair-accessible, but the team also created an innovative way in which users can reach the handlebar on the machine easily to accommodate people who have limited upper-body mobility. The design is also quite lightweight, easy to install/detach, cost-effective, and adjustable in height. These aspects, among many others, make it unique and highly competitive with other similar products in the market.

2. Main Body

I. Important Features

Some key features of the rowing machine adapter are listed below.

- Easily and Quickly Installed
- Independently Used
- Cost-Effective
- Adjustable in Height
- Detachable
- Compatible with Different Sizes of Wheelchairs
- Secure, Rigid and Stable
- Lightweight and Easy to Carry
- Compact Storage
- Long Life Span

II. Function and Capabilities

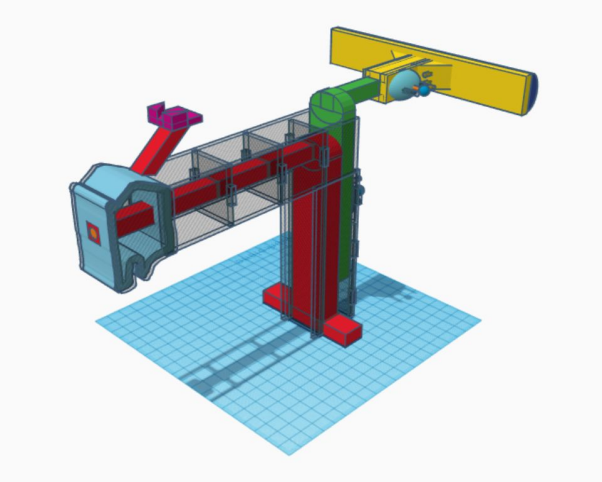

Figure 1. Final Prototype 3D Model

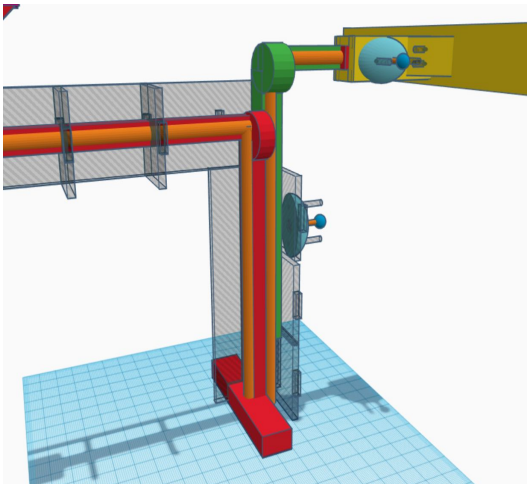

Figure 2. Final Prototype Model (Side)

The final concept consists of laser-cut acrylic sheets to serve as the frame, seen as the transparent flat pieces encasing the design (**Figures 1 & 2**). 3D printed blocks, the coloured components, are used to strategically support the frame and shin base. The blue attachment headpiece slides into the existing head of the rowing machine. The red blocks that extend from the attachment head along the frame and down into the base are held in place by acrylic braces that are interlocked with the frame. The green piece that extends up from the base and outwards towards the yellow shin support can slide up and down within the acrylic frame to offer height adjustment. The yellow T-shaped block is able to slide along the green support piece, allowing for horizontal adjustments. The dark blue part on the yellow knee support is foam padding that cushions the user's shins. On the inside of the red and green L-shaped supports is a steel rod that is inserted into holes in the 3D printed blocks, as seen in orange, to offer additional support. The purple piece extending from the attachment head acts as a closer handlebar-holder for easy resting. The two blue semi-domed pieces with protruding handles represent the pin locking

mechanisms for setting the adjustments in place while in use. Finally, there is a red base block to help stabilize the prototype. All components would be held together by a strong adhesive and screws where necessary.

The key capability of the adapter is that it will allow wheelchair-users to be able to exercise on a rowing machine without any external assistance after set-up. Furthermore, the simple mechanism used in this product not only makes it cost-effective, but also makes it easy to assemble. The combination of the base and the steel support bar, as well as the hollow 3D-printed attachment head, make the product lightweight while stable and rigid. The adjustable 3D printed part also makes the adapter capable of supporting different heights of wheelchairs. Moreover, the installed padded section is included for comfortability and safety. Finally, by placing the handlebar-holder closer to the user in this product, the problem of not being able to reach the handlebar comfortably during the workout is solved. Needless to say, due to the used materials and conditions, this product has a long life span and occupies a compact storage space.

III. Instructions on How the Prototype was Made

To develop the previously mentioned model of the prototype, the design team conducted an initial brainstorming process in which each member shared his/her ideas. By comparing each concept to the target specifications shown in **Table 1**, the best-fitting solution was selected. Next, the team built two preliminary prototypes. While developing the first and second prototypes, the design team had the chance to experiment with different materials and dimensions. This allowed for the choice of the optimum design, material, and building method

for the final prototype. Detailed instructions on how the product would be made are provided below.

Table 1. Target Specifications of the Final Product.

Number	Metric	Unit	Marginal Value	Ideal Value
1	Total mass	kg	<20	<15
2	Time to assemble/dismantle	s	<30	0
3	Unit manufacturing cost	$	<100	<761.25
4	Actions that need to be performed by a staff member	list	<3	None
5	Size of wheelchair that can be accommodated	cm	>70	any
6	Expected functioning duration	yr	>1	>3
7	Space taken up in storage	m^3	<0.100	<0.0742
8	Safety features	list	>2 features	>4 features

1. Measurements

The first step was to obtain appropriate dimensions. During the client meetings, the team gathered the initial dimensions and was able to refine them at the gym facilities available at the University of Ottawa because the rowing machines were fortunately of the same model. Also, during the client meetings, some pictures were taken in order to have references that can be looked back upon when necessary.

2. Design

After gathering the dimensions, the team created a sketch of the initial design of the final prototype. Using SolidWorks, a three-dimensional model was also developed with the proper dimensions.

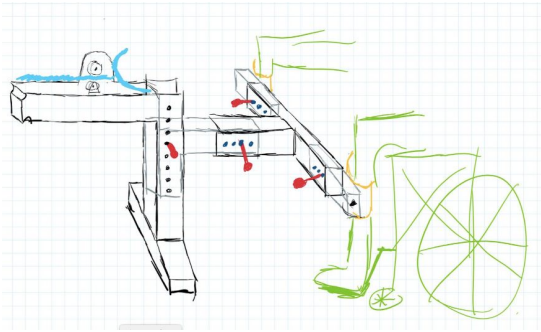

Figure 3. Initial Design Sketch

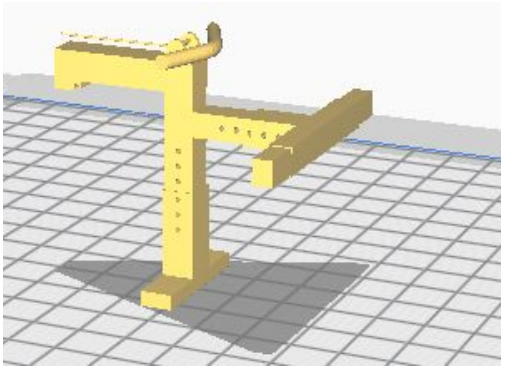

Figure 4. Initial Design 3D Model

3. Prototyping

The attachment head, which is the part of the adapter that clips onto the rowing machine, is a fundamental aspect of the design. Therefore, the team decided to create an initial prototype of the attachment head. A 3D model was created, and the prototype was 3D printed from PLA material. The main purpose of this prototype was to test the dimensions and the strength of 3D printed material.

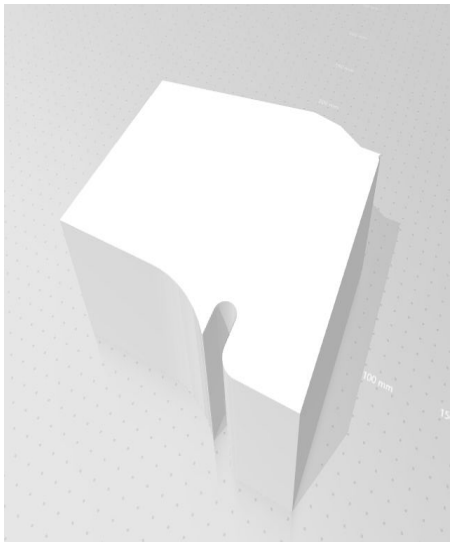

Figure 5. 3D Model of Prototype 1

Figure 6. Prototype 1

After testing, it was found that the dimensions were perfect and that 3D printed material is sufficiently strong to withstand the force of rowing.

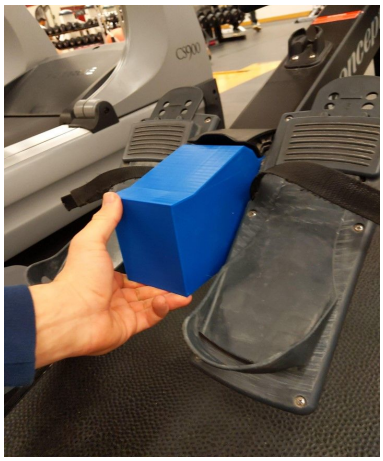

Figure 6a. Testing of Prototype 1

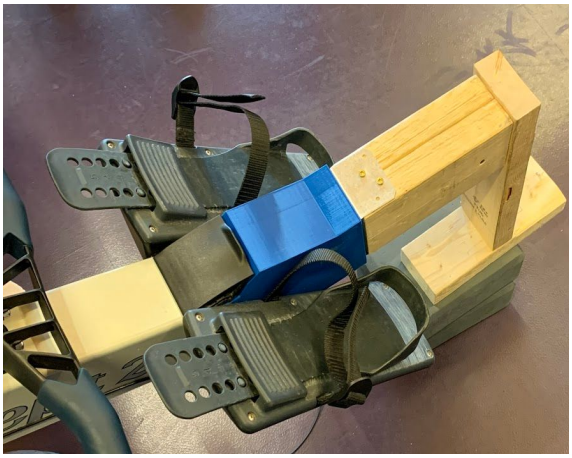

Figure 6b. Testing of Prototype 1

The next step was to create a second prototype that was more comprehensive and represented the product more closely. Its primary purpose was to test the remainder of the dimensions, as well as the stability and strength of materials used. The prototype was also used as a method to discover any potential issues that may arise while developing the final product. For the development of this prototype, the team first created a more accurate 3D model on

SolidWorks with proper dimensions, and then made a sketch that was converted into a pdf file in order to be laser cut (**Figure 7**). Acrylic sheets were used to make the two supports since the material is lightweight and easy to use. Holes were laser cut in the sheets and acrylic pieces were placed in between them to provide strength and support, while keeping it lightweight. A new 3D printed mount was also developed, which is similar to the first prototype, but it is hollow. This is because it makes it lighter, but doesn't result in a loss of too much strength. To finish it off, everything was attached using an adhesive.

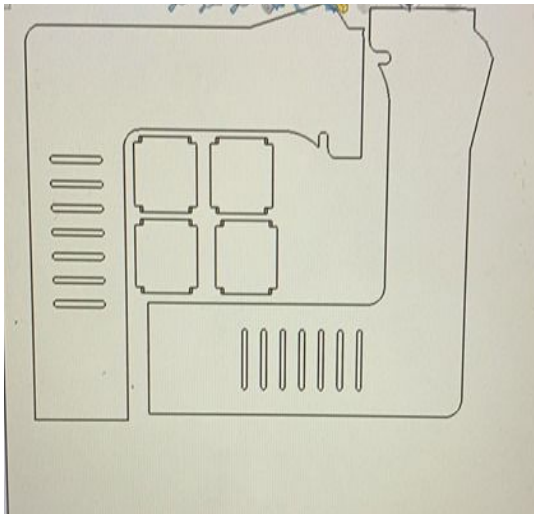

Figure 7. Laser Cutting Sketch

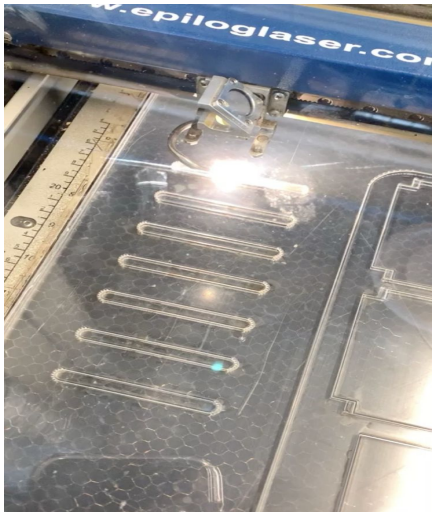

Figure 8a. Laser Cutting Process

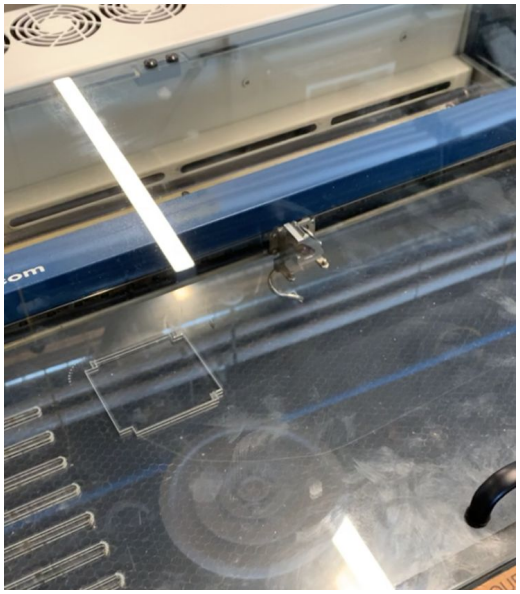

Figure 8b. Laser Cutting Process

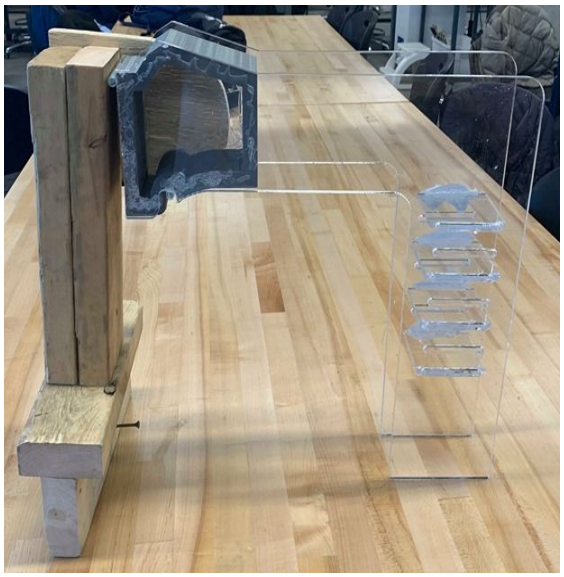

Figure 9. Prototype 2

4. Material Selection

Once prototyping was performed, the design team reflected on the results of the first and second prototypes; in particular, the strength of materials was closely examined. As mentioned previously, 3D printed material was found to be strong enough in both prototypes, as well as easy to use. Hence, the team decided to construct the final prototype primarily out of 3D printed materials. However, acrylic sheets proved to be weak while testing the second prototype. Therefore, the team decided to add more 3D printed support blocks as well as a steel support bar. Steel is relatively easy to use compared to other metals, it has a reasonable price, and it is quite strong. Moreover, the adhesive used during the second prototype (hot glue) was not strong enough either. For this reason, PVC Cement was chosen to attach all the parts in the final prototype. This material was selected according to research on the optimum materials used for attaching acrylic sheets and 3D printed parts. Finally, the team tested the comfortability of

materials that could be used as a shin support. This was done during the client meetings as well as separately as a team. It was concluded that foam pads are the best option.

5. Manufacturing

For the manufacturing process, the team used software programs, such as SolidWorks and TinkerCAD, for the development of the three-dimensional models. 3D printing machines were then used to print most of the parts of the prototype. As mentioned previously, the prototype was not completely built. However, laser cutting machines would have been used to cut the acrylic sheets to the correct dimensions. It was also intended to use a bending machine for the steel rod going through the structure. Even more, the foam pad would have been cut to fit the base, and PVC Cement would have been used to attach all the parts.

Even though the complete prototype was not developed, some major parts were 3D printed. Shown below is the attachment head that would have been used in the final product.

Figure 10. Attachment Head of Final Prototype

IV. Description of How the Product Works

The product is designed to act as a replacement for the seat monorail in regular rowing machines in order to make them wheelchair-accessible. The adapter clips easily onto the rowing machine. The handlebar of the rowing machine rests on the handlebar-holder on the adapter. Wheelchair-users would approach the adapter and adjust its height and length as described step-by-step in Section **V.** below. The entire adapter will resist the force of rowing by the user, and the foam pad will ensure comfortability.

V. Instructions on Installation and Operation

Compared to other adaptive equipment, this design makes the installation and operation relatively simple. These instructions are based on the assumption that the rowing machine model consists of two standard parts (the fan and the seat monorail), which are held together by a clipping mechanism.

<u>Installation:</u>

1. Detach the seat part of the machine attached to the fan. To do this:
    a. Lift the clip located between the fan and monorail of the sliding seat.
    b. Unhook the seat monorail from the bottom tube bolt that it is attached to.
2. Lift the monorail off the bottom tube bolt and place it elsewhere for storage.
3. Bring the fan and the attachment head section of the adapter together between the footplates of the fan piece. The top clipping portion of the adapter should be over the bottom bolt tube attached to the fan.

4. While holding the clip up, lower both pieces until they connect securely and push down into place.
5. Let the clip go and secure it over the attached pieces.
6. Adjust the vertical height and the horizontal length of the adapter's shin pad base so that the cushioning pad fits comfortably across the shins of the user while they are seated in the wheelchair.
7. Pull the handle and extend it to the handlebar-holder located on the adapter.
8. Allow the handlebar to clip onto the handlebar-holder on the adapter.

Operation:

1. Roll up to the adapter, allowing your shins to press against the padded area.
2. Lock your wheelchair in place.
3. Grab the two ends of the handlebar with both of your hands.
4. Pull and lift slightly so that the handlebar unclips from the handlebar-holder.
5. Pull the handlebar straight back with both hands.
6. Once the handlebar reaches your chest, allow it to recoil back to the fan without losing your grip on it.
7. Engage in the back and forth pulling motion until you are satisfied with the workout or a break is needed.
8. When the workout is over, place the handlebar on the extended handlebar-holder located on the adapter.

VI. Maintenance Instructions

- Test the adjustment locking mechanisms. Use Super Lube Silicone Lubricating Grease on the adjustment locking pins if they are not functioning properly.
- Inspect the wear on the shin pad. If the shin pad has degraded, replace it with a regular foam roller of the same dimensions using PVC Cement.
- Clean the adapter regularly using general-purpose soap with a high-alkaline content or an ultrasonic cleaner.
- After each usage, wipe down the foam pad using a clean rag and water-based disinfectant. To prevent too much disinfectant from being sprayed into the air, spray directly into the rag before wiping down the pad.
- Inspect the adapter and look for cracks or other signs of wear, check if the fastenings seem loose (i.e. screws), and feel for loosened or unsteady parts. Immediately contact the suppliers of the adapter to fix or replace any equipment that presents a safety hazard.

VII. Health and Safety Guidelines and Other Precautions

- Properly lock the attachment head to the rowing machine to prevent it from moving or detaching throughout the exercise.
- Ensure that the two adjustment pins are locked in place so that the cushioning pad does not slide up and down or back and forth during the workout.
- Lock the wheelchair before beginning the exercise for safety.
- Avoid releasing the handlebar suddenly to prevent it from recoiling unsteadily and colliding with the adapter or other parts of the rowing machine.

- To prevent the spread of communicable illnesses through viruses and bacteria, clean the adapter regularly as mentioned in the maintenance instructions.

VIII. Technical Instructions on Troubleshooting

- If the pins do not slide in and out easily, ensure that the holes are aligned.
- If the foam pad is moving during the workout, ensure that both pins are locked.
- If you cannot reach the handlebar, adjust the horizontal pin to bring you closer to the handlebar holder.

IX. Design Files

All the design files are clearly named and can be accessed through the design team's Makerrepo account using the following link.

https://makerepo.com/fomid/gng2101c2adaptive-row

- Attachment Head Piece
    - Custom-fitted piece that attaches the adapter to the rowing machine.
- Horizontal Support 1
    - Long rectangular block with a hollow center (for inserting the steel support) and a hollowed out base for the connection piece to be inserted into.
- Connection Piece

    - A quarter cylinder with an extruding part coming out of one face. This is to be inserted into Horizontal Support 1 and is hollow on the other face in order for the vertical support-top to be inserted into it.
    - It has a hollow part for steel support.
- Vertical Support-Top
    - It has an extruding part to be inserted into the Connection Piece.
    - It has two holes on the bottom for the lower part of the support to be inserted into.
    - It has a hollow part for steel support.
- Vertical Support-Bottom
    - It has extruding parts that fit into the Vertical Support-Top.
    - It has a hollow part for steel support.
- Vertical Slide-Top
    - It has an extruding part to be inserted into the connection piece.
    - It has two holes at the bottom for the lower part of the support to be inserted into.
    - It has a hollow part for steel support.
- Vertical Slide-Bottom (½)
    - It has extruding parts that fit into the Vertical Slide-Top
    - It also has a hollow part for steel support.
    - Two of these will stack on top of each other.
- Horizontal Support 2
    - Long rectangular block with a hollow center (for inserting the steel support) and a hollowed out base for the Connection Piece to be inserted into.

- Knee Support
    - A hollowed out rectangular box (allowing the knee support to slide along the horizontal support) that connects to another rectangular support with radial supports.
- Pad Support
    - A densely-filled and flat rectangular support for the foam pad that will be mounted on the knee support.
- Base
    - A densely-filled and flat rectangular support for the foam pad that will be mounted on the bottom of the main Vertical Support and frame.
- Locking Mechanism
    - A semi-ellipse with a hole allowing for the adjustment bolt to slide.
    - It has a slightly larger diameter on the face side, allowing for a washer to be attached to the bolt to travel a fixed amount. This, with a spring placed on the bolt after the washer, is what holds the bolt in place when desired.
    - There are two semi-domes that are placed on the end of the bolt, ceiling, and the head of the bolt inside that acts as a handle.
- Frame
    - A laser-cut acrylic sheet to serve as a frame and to offer additional support to the adapter.
- Handle holder
    - Extending arm from attachment head with slot to hold rowing handle

All files are in STL format and are 3D printed except for the SVG laser cut frame.

3. Conclusions and Recommendations for Future Work

I. Summary

To respond to the client's needs and to solve the problem of inaccessible rowing machines, the design team created an innovative idea for the development of a rowing machine adapter. A detailed three-dimensional model of the adapter was fully developed with all the required dimensions and parameters. The design essentially consists of a 3D printed base with various other 3D printed parts, metal bars for support, and a foam pad for comfortability. It is unique and competitive with other designs since it is significantly cost-effective, adjustable in height, lightweight, and quite simple to attach/detach.

II. Lessons Learned

The model of the adapter was designed based on the results of testing and evaluating two prototypes. From the first prototype, the team learned how important it was to measure the dimensions accurately, particularly for 3D printing and modelling. Furthermore, the team discovered that the material used for the 3D printed parts of the prototype were strong enough. Therefore, that was implemented for the final product. The second prototype testing process taught the team that one has to always be ready for reconsiderations (creating any sudden change in dimensions of the design, materials, etc.) in order to have a fully functional product. In this prototype, it was found that the body part of the design, which was made from bare acrylic sheets, was not strong enough. Therefore, that led to the idea of placing a steel bar in the skeleton

of the adapter. Applying client feedback was another crucial lesson learnt. The client drew our attention to aspects that the team may have not otherwise considered. For instance, the client mentioned that the chain of the handlebar may recoil unsafely back into the machine if the adapter is too short. Therefore, to avoid this, the team designed the handlebar holder in a way that causes it to be lifted from the attachment head. All the concerns mentioned in the client interviews were taken into consideration and implemented in the final design.

The group members also learned how to effectively communicate with one another. They obtained useful information from each other to extend their knowledge and abilities through cooperation. While working on the project, the design team learned how to break down the more complex problems into simpler ones, divide roles and responsibilities, and share diverse perspectives.

III. Future Work

Since the prototype was not completely developed, the first productive avenue for future work would be to assemble the product appropriately as mentioned in this manual, as well as to perform rigorous testing to ensure full functionality. Some possible areas of improvement include a better handlebar-holder and a reduction in storage size. If the final prototype was used and the user were to accidentally drop the handlebar, it would recoil all the way back into the machine, interrupting their work out. Therefore, a handlebar-holder that can catch the handle, but not interfere with the chain would be ideal. This could be done through a combination of strategically placed pulleys and framework. The main issues faced, though, would be the interference with the oscillation of the chain as it recoils. For storage size reduction, the easiest

way would be for the user to disassemble the adapter further, but this brings up the issue of increased steps for installation; hence, a balance must be achieved. The team plans to assemble the product in the future and confidently expects that the product would function due to the thorough analysis and steps taken to ensure the production of this design.

4. Bibliography

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