uOttawa

GNG 2101

Design Project User and Product Manual

The Single Steerer Walker System

Submitted by:

The Fast and Fabricating Five - Team Z22

Elisha Khandaker, 300308377

David Mclntyre-Garcia, 300241605

Madeleine Forcese, 300287850

Jonathan Birmingham, 300247449

Tyler Yu, 300133533

July 23, 2023

University of Ottawa

Table of Contents

List of Figures

List of Tables

List of Acronyms

Table 1. Acronyms

Acronym	Definition
BOM	Bill Of Materials
CAD	Canadian Dollars
CM	Centimeters
EDS	Ehlers Danlos Syndrome
g	Grams
LBS	Pounds (Weight)
PCS	Pieces
PLA	Polylactic Acid
PVC	Polyvinyl Chloride
TA	Teacher Assistant
TSS	The Single Steerer
3D	Three Dimensional

1 Introduction

This User and Product Manual (UPM) provides the information necessary for *those who have difficulties using a Walker, including people who suffer from hypermobile Ehlers Danlos Syndrome* to effectively use The Single Steerer (TSS) and for prototype documentation. This document includes information regarding the reason for the development of the prototype, the key features of the prototype, the functionality of the prototype, and much more. The purpose of this document is to elaborate on how to use the prototype. Safety of privacy considerations associated with the use of the User and Product Manual are minimal. If the manual were to be used online, there are a few hyperlinks embedded, which takes the user to other websites. While the Fast and Fabricating Five have ensured that these links are safe and not of illegitimate systems, this is something to be considered. It is also important to note that the manual does not require any user to identify personal information to access it.

2 Overview

Our client suffers from a genetic tissue disorder known as hypermobile Ehlers Danlos Syndrome (EDS). Essentially, anyone who has this issue can easily dislocate any of their joints at any given moment, making them heavily reliant on a walker in order to simply get around places. This is important because generally speaking, walkers are designed to be used with two hands as opposed to only one. EDS proves to be very difficult to deal with as it makes everyday tasks more difficult to accomplish, such as shopping for groceries or even reaching for the TV remote. Whenever, our client dislocates one of their joints, they are forced to use one of their knees to help steer the walker if no one else is there to help. Below is the derived problem statement, defined by The Fast and Fabricating Five.

“The client requires a maneuverable, lightweight, easily attachable device that allows them to steer the walker effectively with one arm through narrow spaces and diverse terrain.”

After conducting several meetings with our client, we have established the fundamental needs of the user. These being the need for it to be **lightweight**, **convenient** as well as **flexible**. Those three words were repeated throughout all of our client meetings. Given the circumstances of our client, the product needed to be lightweight because it is already a challenge to simply get around with the walker and adding more weight would just worsen her situation. By convenience, the client needs the One-Handed Walker Steering system to reduce the most inconveniences possible, meaning being able to assemble and disassemble with ease. Our client further stressed the importance of our product not requiring any permanent adjustments to the walker.

When comparing our product from the ones made by other teams in previous semesters, our One-Handed Walker Steering system primarily focuses on **facilitating the steering** of the walker. With the help of an additional bar that is directed forward, the client is given a comfortable handle to hold while operating the walker. The second bar ensures better steering as it provides more leverage. Furthermore, it can be placed anywhere along the main bar, allowing for adaptability. One more key aspect that proves our product to be an improvement is the hinge located at the center of the main bar. With this, the client can store the product without it taking up a lot of space by folding with the hinge. Below (Figure 1) is a picture of the final product.

Figure 1. Photo of final product on Design Day.

As stated previously, some of the key features of the product include the main bar that can be folded in the middle for easy storing due to the hinge. Next, the second bar since it can be placed on either side of the main bar, ensuring the ability to steer with either arm. Additionally, increasing the amount of leverage the user has to steer the walker.

The architecture of the system involves a main PVC pipe that is drilled with holes along its center and is attached to the walker via 3D printed clamps. Two metal pins are used to attach a second shorter PVC steering port to any side of the main bar. In the center of the main bar is a metal hinge used to attach the whole system together. The user leans against this PVC pipe, placing their desired arm along the steering port. Below (Figure 2) is a block diagram of how the system connects all together.

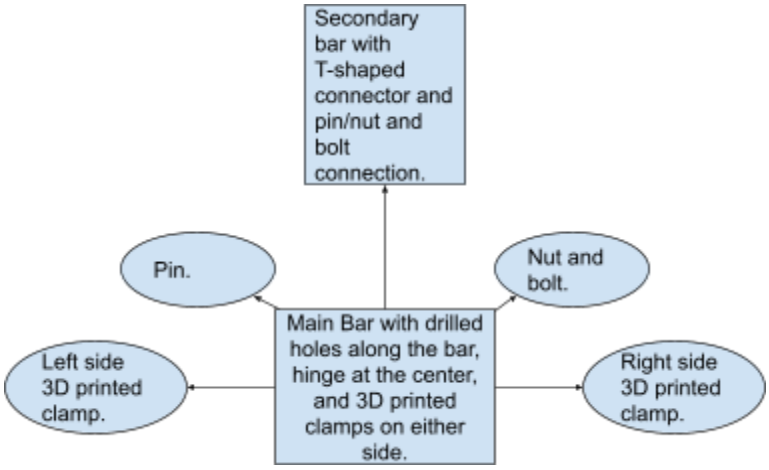

Figure 2. Block diagram of the entire product.

2.1 Cautions & Warnings

Our One-Handed Walker Steering system is very safe and free from danger. The most important precaution one should take before using it on the walker is to make sure it is installed on the walker properly. The hinge at the center of the main bar, although very strong, can only fold in one direction. It should be known that one should make sure that the product is not upside down, making the main bar fold when the user does not intend it to do so.

3 Getting started

Step 1 - Clamps: Obtain the main PVC bar attached to the hinge. Grabbing both clamps, with their open holes facing towards the pipe, slide one on either side of the pipe (one on the left side and one on the right side). The clamps themselves should be rotated the same way on either side of the pipe, with the open ends left to right, and the clamped parts facing up and down. Clamps of different lengths can be purchased to ensure that the system fits the given walker. Attach both clamps to either side of the walker, making sure they are snapped in and secured for proper use. Below (Figure 3) are photos of the right and left clamps attached to the main bar and the walker.

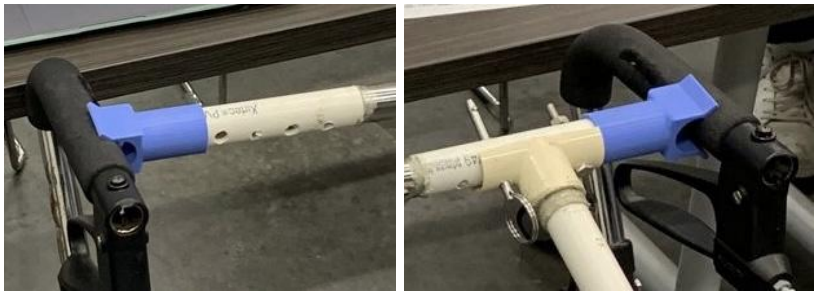

Figure 3. Left and right clamps attached to the walker and main bar.

Step 2 - Steering port: Take the steering port and insert it into the main PVC bar. This is done by inserting the pins attached on the bottom of the steering port into the holes located along the main bar. Note that the pins are directly attached to the steering port and function as one main subsystem. The steering port can be attached to any side of the main bar. Once the pins are inserted into the holes in the main bar, the system is attached using a nut and bolt. Below (Figure 4) is a photo of the steering port.

Figure 4. Steering port.

Step 3 - All together: The system is now ready to be used. Lean on the main bar and place the chosen arm onto the steering port. Grab the steering port and apply bodyweight onto the system to allow effective steering and maneuvering.

Step 4: To exit the system, the user must remove the steering port by loosening the bolt and removing it from the holes of the main bar. Below (Figure 5) is a photo of the bolt that needs to be loosened to remove the steering port.

Figure 5. Bolt to loosen in order to remove the steering port.

Step 5: The user can then grab the hinge and pull upwards to easily remove the clamps from either side of the walker and fold the main bar via the hinge at its center. Below (Figure 6) is a photo of where to grab and pull the bar to remove it from the walker.

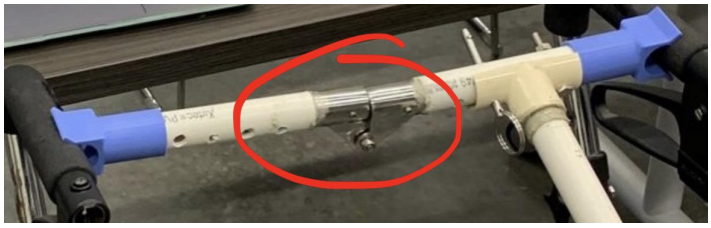

Figure 6. Hinge. Where the user grabs and pulls up to remove the system from the walker.

Step 6: Once the main bar is removed from the walker, the clamps can be taken off of either end of the walker and stored (they can also be kept on depending on user preference).

3.1 Configuration Considerations

There are a small number of important configurations that allow the product to perform as intended, these can be seen below;

1. The hinge must be oriented to allow the bar to bend upwards.
2. The holes on the main bar must be facing forwards/backwards and not upwards/downwards.
3. The secondary bar handle must be facing out (away from the user) and upwards.

3.2 User Access Considerations

The product allows any person with at least one arm to steer and operate a walker. The only things that are required are that the user needs to be able to use one of their arms and rotate their torso. It must also be noted that the system allows for a reasonable amount of force to be placed onto it, but it should not be used to support large amounts of weight. Resting of arms and some body weight are supported.

3.3 Accessing/Setting up the System

To set up the system, it is important to assemble all necessary parts as described above. For personal use, clamps will be printed at different lengths and sizes to accommodate different models of walkers. The main procedures necessary for setting up the system involve gathering the necessary subsystems (main bar, steering port, clamps) and attaching them using the detailed guidelines above.

3.3.1 Main bar assembly

To begin with, the product should come as 2 different bars, the main bar which involves the hinge and the clamps, and a secondary bar which includes the secondary bar dock and the handle. The main bar should come assembled fully, if not the only thing that needs to be done is the attachment of the clamps. This can be done by simply inserting the ends of the main bar into the holes on the clamp. Due to the shape of the clamps, the connection is strong enough to not need any adhesive to keep the clamps from falling off. The main bar should look like the image below (Figure A).

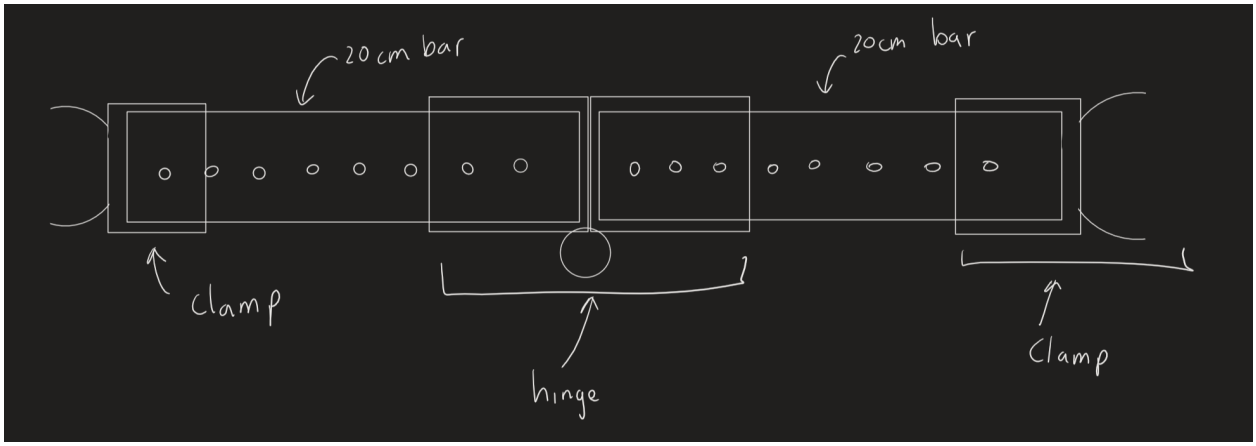

Figure A. Sketch of main bar put together.

3.3.2 Secondary bar assembly

The secondary bar might come fully assembled, but there is a high chance that it will be separated into 3 different components. The first of which will be a long bar attached to the docking system of the secondary bar, the two other parts are a T-shaped PVC connector and a smaller PVC pipe. To assemble the secondary bar, the end of the long bar should be inserted with the T-shaped connector. The connector should be oriented with one of the holes facing upwards, at this point the smaller bar is inserted in that hole. The secondary bar, once assembled should look like the image below (Figure B).

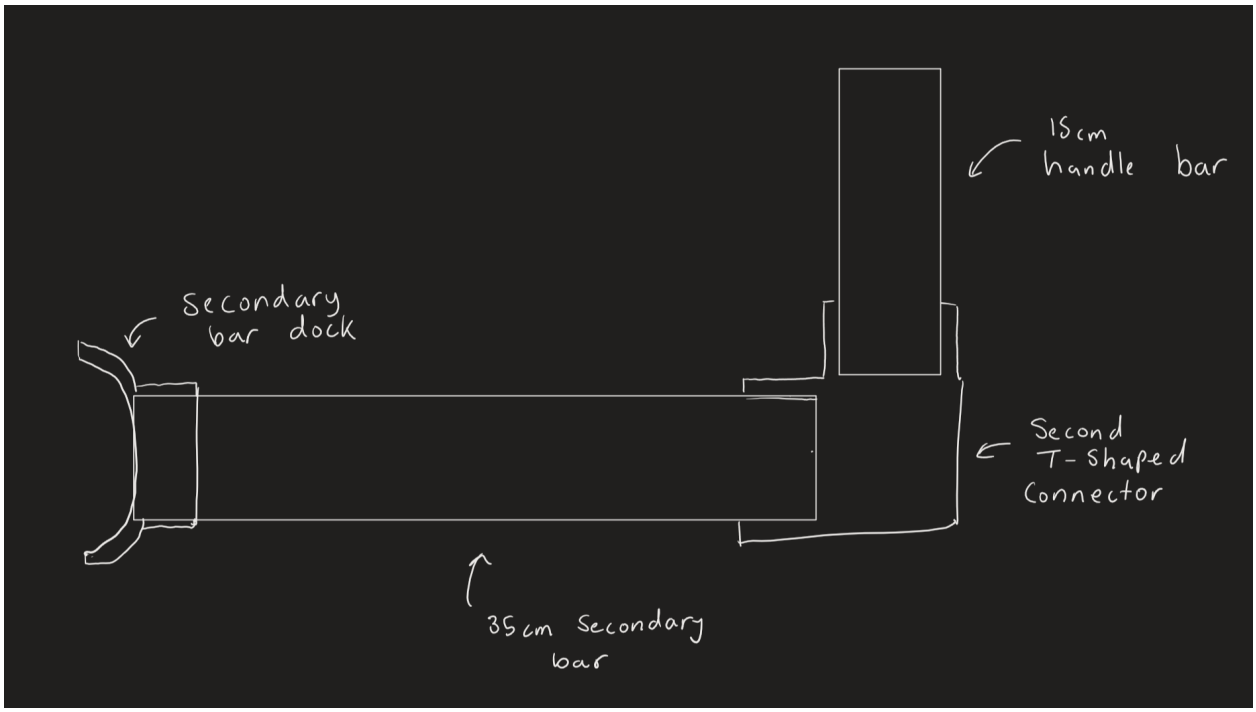

Figure B. Sketch of secondary bar put together.

3.3.3 Secondary bar connection to main bar

In order to connect the secondary bar to the main bar, the secondary bar dock should be placed on the PVC section of the main bar so that the holes on the dock line up with the holes on the main bar. At this point the pins can be inserted through all of the holes, it should be noted that the pins should be protruding out the back of the main bar.

3.4 System Organization & Navigation

The system is organized in the following fashion.

The two equal portions of PVC are connected to the hinge using adhesive, and is now known as the main bar. The two clamps are then placed onto the two ends of the main bar. The steering port is aligned with the holes on the front of the main on any side (left or right depending on which arm the user wants to use to steer) of the walker. The pin is then inserted into its aligned hole. The nut is also inserted into its aligned hole and secured with the bolt.

3.5 Exiting the System

To put the system away, users can fold the main bar in its center from the hinge. By doing so the main bar can be stored in a small backpack or wherever the user prefers. The steering port can be kept on the system, but it is recommended that it is removed and stored with the main bar rather than attached to it.

4 Using the System

The product is simple to use, it should be assembled before being connected to the walker, to assemble the device, the instructions are laid out in section 3.1.

Once everything has been assembled, the connection to the walker is simple, first make sure that the bar bends upwards, this is important as due to the shape of the hinge, the bar can only fold in one direction. Having the bar bend upwards allows the hinge to withstand the downwards force applied during use. Next, fold the bar slightly and connect the clamp on one side of the device to one of the handles of the walker. Then with the bar folded, line up the second clamp with the second handle and push down on the hinge. At this point the device is connected to the walker and the only thing left to do is begin using the product. To do this all that needs to be done is rest your forearm on the secondary bar and grab the handle. You can then use the device to steer the walker by pushing the handle.

5 Troubleshooting & Support

Errors that may occur: clamps break, hinge breaks, steering port does not have nuts and bolts to attach to the main bar (they are lost/misplaced).

5.1 Error Messages or Behaviors

The product is purely mechanical, therefore there will not be any error messages.

5.2 Maintenance

With months of extended use of the One-Handed Walker Steering system, it is crucial to take the time to do some maintenance to prolong the product's time where its quality is at its highest. Other than some simple cleaning, the 3D printed clamps located at the extremities of the main bar can break. Upon this happening, one will have to 3D print the clamps. Once 3D printed, the user simply pops the clamps in each end of the main bar and the product is as good as new.

5.3 Support

The user should contact 911 their healthcare provider for all medical related emergencies. For non medical emergencies the user can email The Fast and Fabricating Five for support and information regarding the product. The following is a list of the members of The Fast and Fabricating Five along with their email addresses.

- Elisha; ekhan082@uottawa.ca
- Madeleine; mforc055@uottawa.ca
- David; dmcin010@uottawa.ca
- Jonathan; jbirm054@uottawa.ca
- Tyler; tyu038@uottawa.ca

6 Product Documentation

6.1 Final Product Information

6.1.1 Bill of Materials

Table 2. BOM

Item No.	Part Name	Description	Quantity	Unit Cost	Extended Cost
1	PVC	¾” PVC pipe.	1	$8.86	$8.86
2	Clamp PLA	Used to print clamps.	1	$0.15/g	$2.72 (12 g)
3	Foam	Used to add padding to the main and secondary bar.	1	$9.00	$9.00
4	Hinge	Hinge at the center of the main bar.	1	$28.12	$28.12
5	LePage Construction Adhesive	Used to connect the main bar to hinge.	1	$9.55	$9.55
6	Nut and Bolt	Pack of 10pcs.	10	$3.47	$3.47
7	Stack Weight Pin	Used to attach the secondary handle to the main bar.	2	$4.75	$9.50
8	Secondary Bar Attachment Dock	Dock that will be used to connect the secondary bar to the main bar.	2	$1.33	$2.66
Total	$73.68				

6.1.2 Equipment list

Below is a list of the equipment to build the components of this product:

- Drill Press (used to drill holes into PVC pipes, allowing stack weight pins to be inserted and attached)
- Miter saw (used cut PVC pipes to desired length)
- 3D printing machine (used to produce side clamps with PLA)
- Solidworks (used to design 3D models and our first prototype)

6.1.3 Instructions

To preface, this tutorial assumes that the reader has a basic level knowledge of 3D modeling and 3D printing.

As this device is meant to be added to existing walkers to allow for one handed steering, the first step should be to take measurements of the walker. The two main measurements that will be required to create a model of the device that fits your walker would be the distance between the two handles, and the diameter of each of the handles. Once this information has been received, the first thing that should be done is the designing and printing of the clamps as this is a time consuming step that cannot be sped up. To do this, some sort of 3D modeling software must be utilized, in this manual Solidworks will be used.

Creation of the Clamps:

To begin designing the clamp, a “dock” must be made to connect the clamps to the PVC pipes, and as this product uses ¾” diameter pipes, they must be made to fit around the outer diameter of the pipes. When it comes to PVC pipes there are specified values for the inner and outer diameters, and in this case the outer diameter of the pipes is 1.05in. The image below (Figure C) shows an example “dock” and the measurements used.

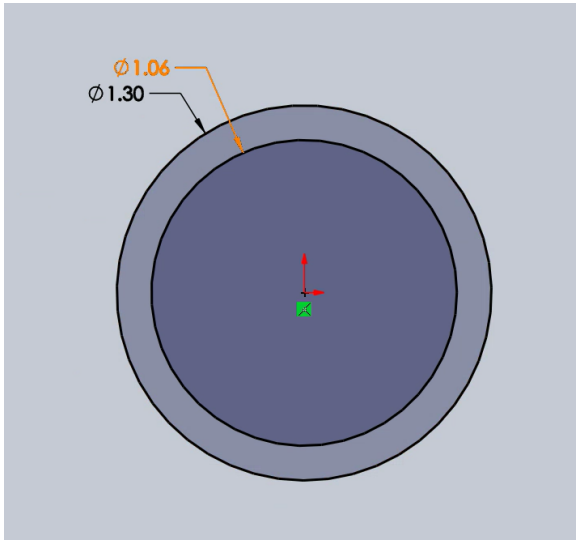

Figure C: Inner and outer diameter of “dock” to connect clamp to main bar.

The following images show the creation of our clamps.

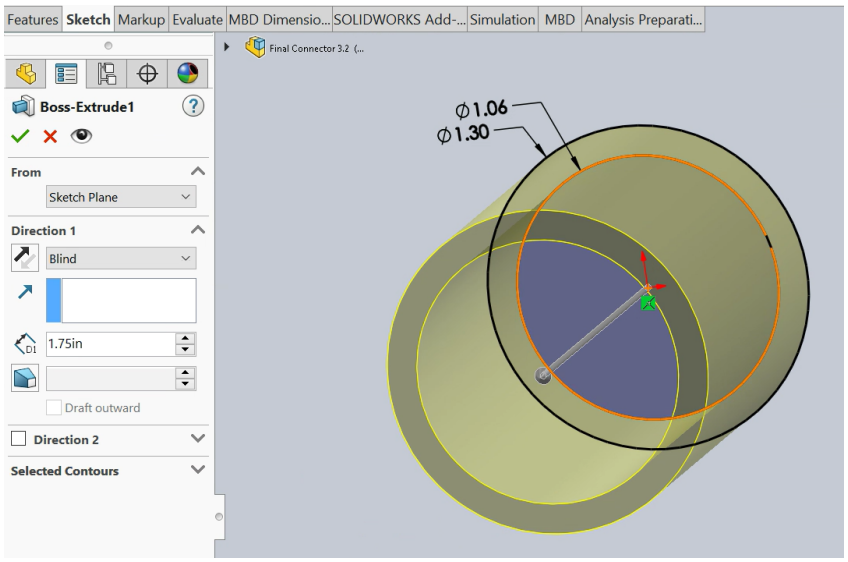

Figure D: Shell that fits around the PVC pipe.

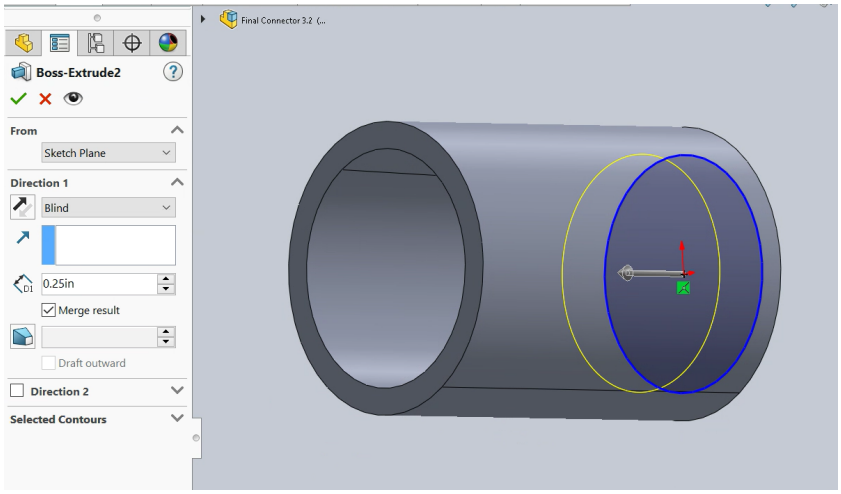

Figure E: Base plate.

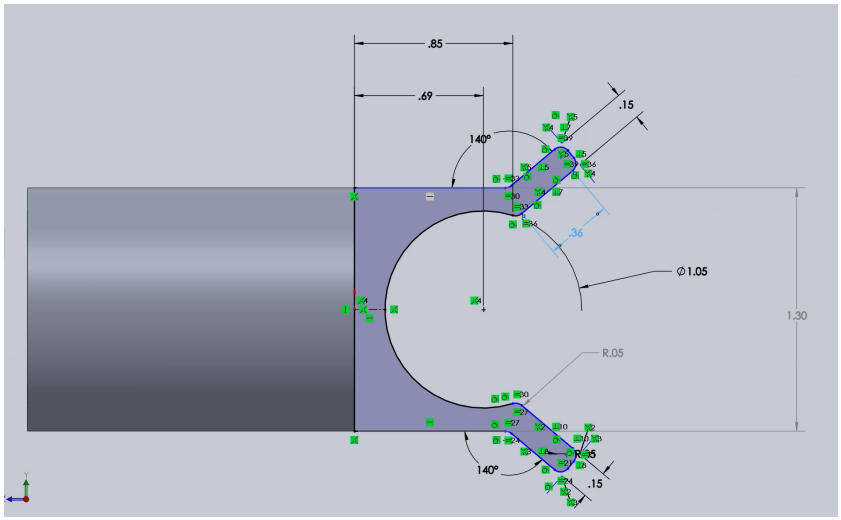

Figure F: Dimensions of the clamp (1.06in can be changed out for diameter of walker handles).

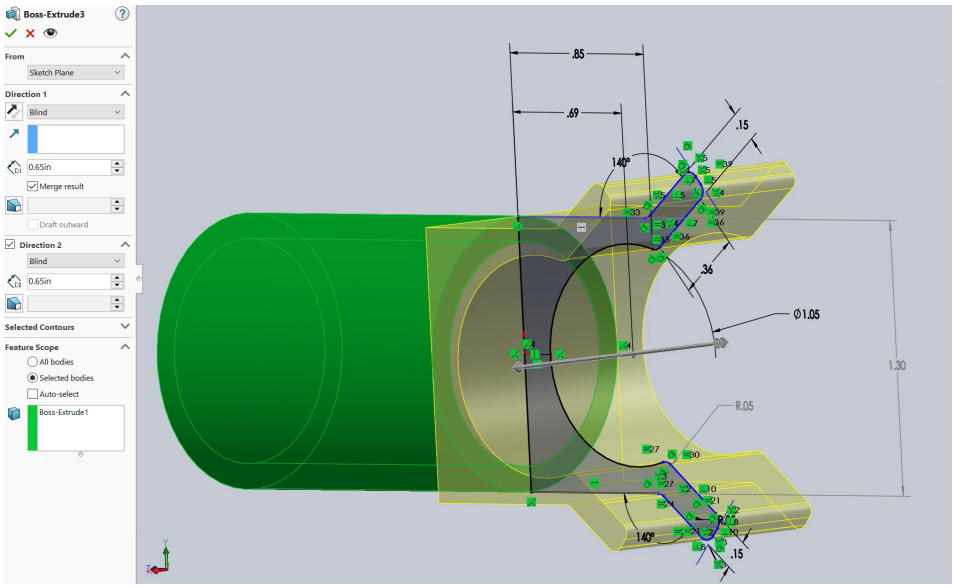

Figure G: Width of the clamp.

Once the final model for the clamp has been completed, it can be exported and formatted to fit whatever 3D printer is available. The recommended specification for the infill percentage to allow for a strong print is upwards of 70%. Supports will need to be added to ease the printer in printing any geometry that is overhanging. Below (Figure H) is a screenshot of the settings used for our version of the clamp.

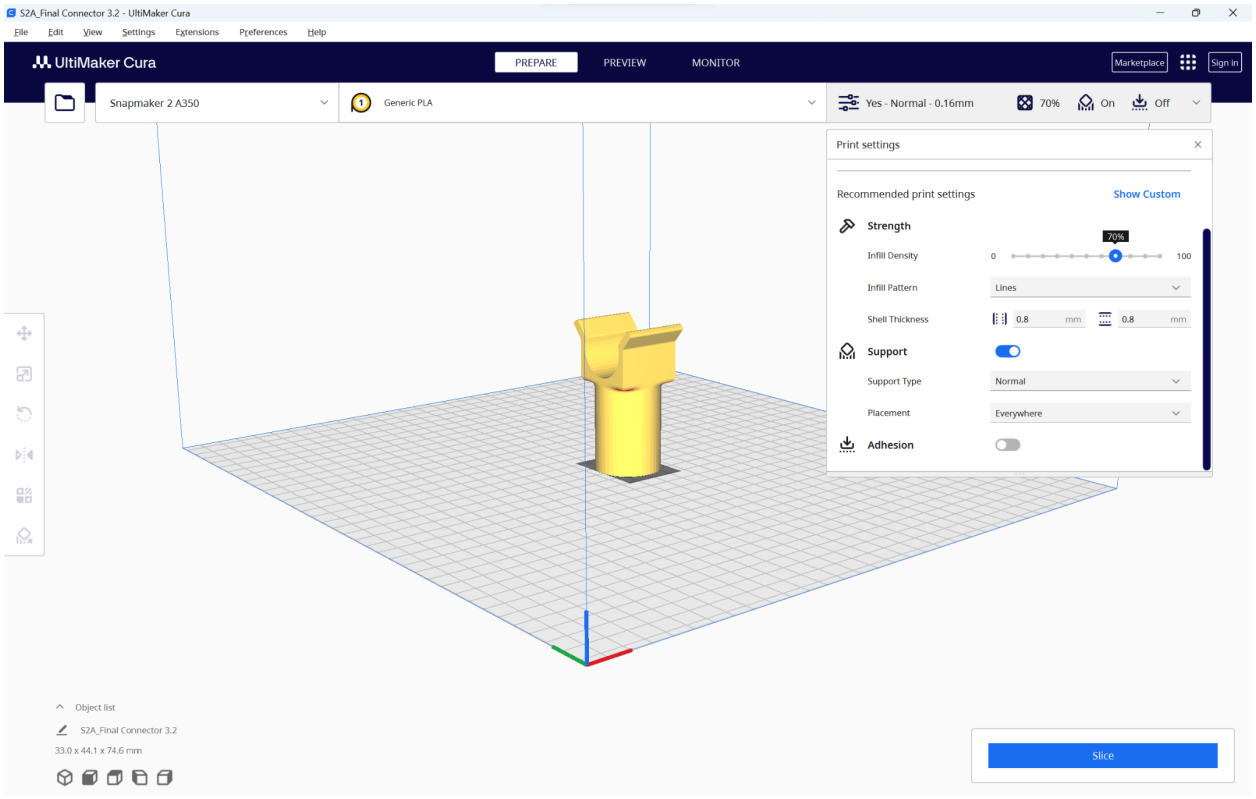

Figure H. Screenshot of settings for the clamp.

The next step involves cutting the PVC pipes into their needed lengths. This product requires 4 different sections of PVC pipes and their lengths are stated below.

- 20 cm (2x): These two sections will be used to construct the main bar of the device.
- 15 cm: This section acts as the handle that the user will hold on to.
- 35 cm: This section is the long portion of the secondary bar.

At this point you will have 4 different sections of PVC, along with the rest of the parts listed in the BOM. The next step that is needed involves the creation of the secondary bar dock, and to do this we need to cut one of the T-shaped PVC pipe connectors in half.

The T-shaped PVC connector is shown in the image below (Figure I) as well as the cut that was mentioned in the text above.

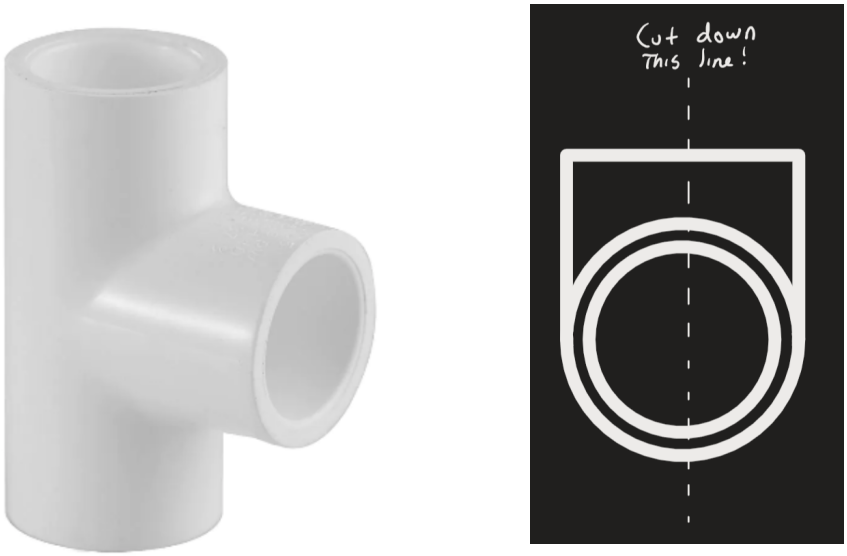

Figure I. PVC connector that is to be cut in half.

Once the connector is cut in half, the next step is to begin drilling the holes that will be used to mount the dock and the secondary bar onto the main bar. The holes will be made using the drill press and will have a diameter of ¼". They will be spaced 2.5cm from the center of the dock, making each hole on the dock 5 cm away from each other (Figure J).

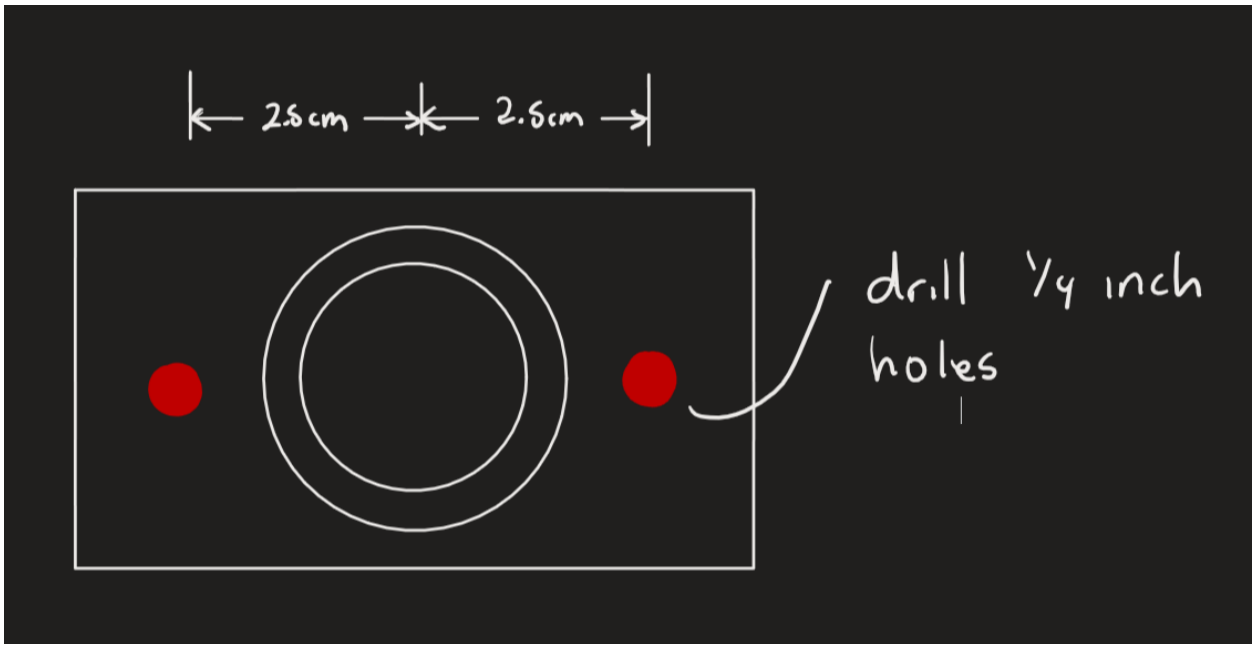

Figure J. Sketch of where holes should be drilled.

The same hole must be drilled onto the two sections of 20cm PVC pipes, with the same diameter and 2.5 cm between them (Figure K).

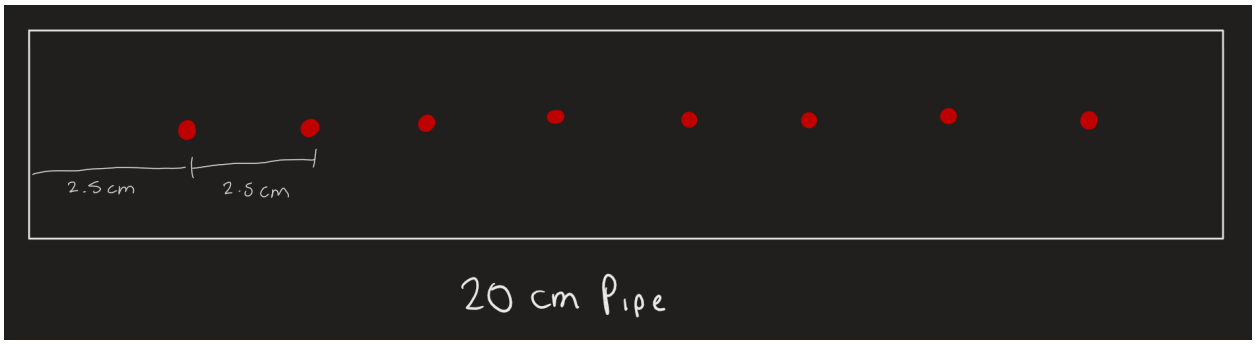

Figure K. Sketch of where all the holes should be drilled.

When the holes have been drilled, the secondary bar can then be connected to the secondary bar dock using the LePage adhesive. At the end of the secondary bar (35cm), the second T-shaped PVC connector can be added with the handle pipe (15cm) attached. The secondary bar should look like the following image (Figure L).

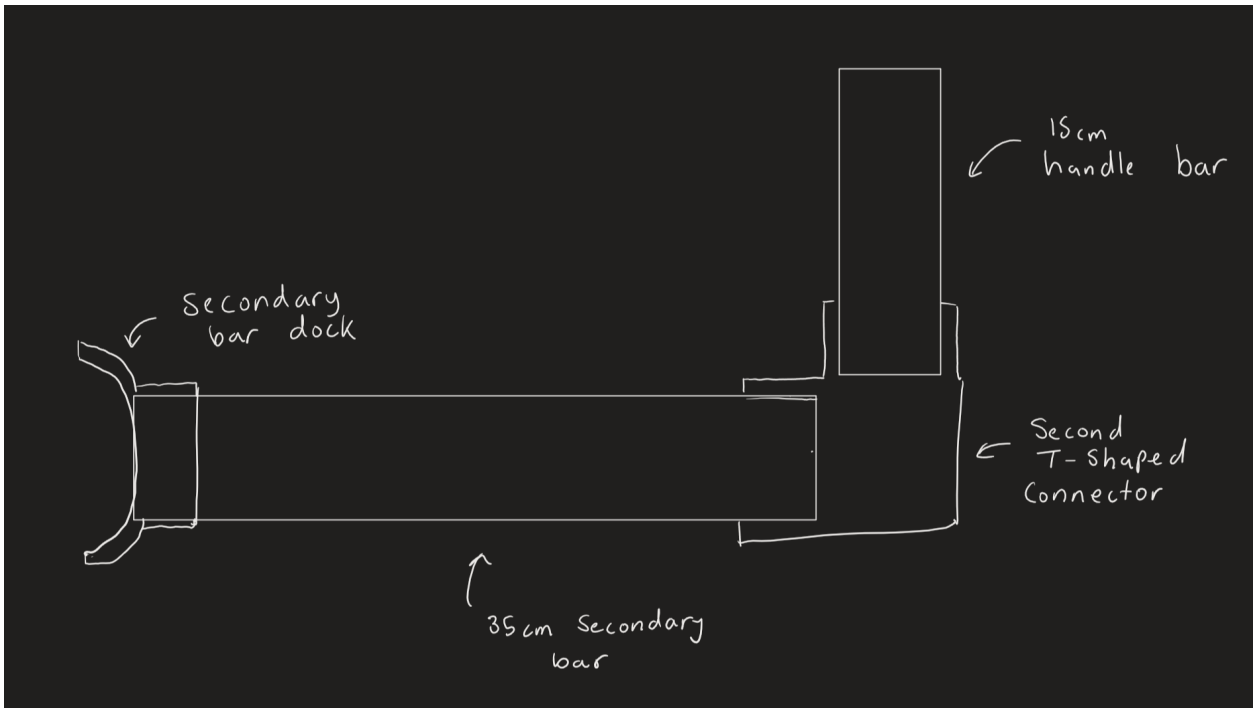

Figure L. Sketch of secondary bar connected to the secondary bar dock along with the T-shaped connector.

The next step of the process is to connect the two 20cm PVC pipes to the hinge. This is easy as the hinge selected is the right diameter to allow the 3/4 inch PVC pipe to rest inside of it, much like how the clamps are connected to the main bar. The 20cm PVC pipe segments can be

attached inside of the hinge using the adhesive, which should be left to dry for around 30 minutes. Once the time has passed the only major step left is to connect the clamps to the main bar which is as easy as sliding them on. In the end, the main bar should look like the image below (Figure M).

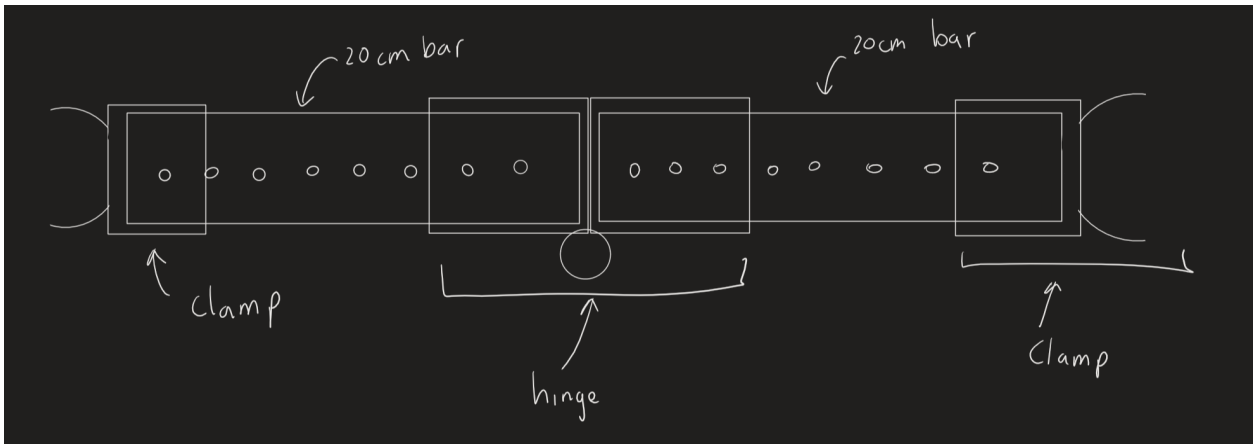

Figure M. Sketch of how the system should look at the end.

The final thing that needs to be done to conclude the production of the device, is to cut up and glue foam to the secondary bar and its handle. Once this has been finished the device has been completed and can now be used.

6.2 Testing & Validation

Testing was mainly done on the second and final prototype. Prototype 2 was a physical focused prototype that was mainly based around the main bar. As we were happy with the results found from the testing, we continued using the same system and parts for our final prototype. The metrics tested in our second prototype are listed in Table 1 below, as well as the target value and the achieved value.

Table 3. Prototype 2 Testing

Feature Tested	Testing Method	Target Metric	Achieved Value
Total Weight	Scale	< 5 lbs	< 2 lbs
Total Length While Folded	Rulers/Measuring Tape	< 40 cm	38 cm

Weight Supported by main Bar	Use of set weights and rope (Weights)	> 30 lbs (Center of main bar)	> 40 lbs
Length of Main Bar	Rulers/Measuring Tape	< 75 cm	68 cm

Our third and final prototype was a built up and edited version of our second prototype, this time being a comprehensive physical model with all of the features that we had planned included. The tests performed on our final prototype were mainly focused on the usability of our device. Table 2 below displays the tests performed on prototype 3.

Table 4. Prototype 3 Testing

Feature Tested	Testing Method	Target Metric	Achieved Value
Total Weight	Scale	< 5 lbs	< 2 lbs
Time to assemble	Timer/Stopwatch	< 45 seconds	< 30 seconds
Time to attach to walker	Timer/Stopwatch	< 30 s	< 5 s

From these two testing plan tables, it can be seen that the results of the testing were positive and all of our target specifications had been met.

7 Conclusions and Recommendations for Future Work

Throughout the Spring/Summer semester at uOttawa, The Fast and Fabricating Five have learned so much whether it be valuable pieces of information given by our professor and TAs or through trial and error while following the design process.

To summarize, here are three of the most valuable lessons learned:

1. Having a proper testing plan allows for the prototyping phase to have much less risk and provide a greater outcome.
2. Failure is good if you are able to learn from it and adapt when the time comes to tackle the next hurdle in your design process.
3. Understanding the reasoning behind each design process step makes it much easier to completely fulfill the need put forward by the client.

If we were to be given a few more months to work on this project, we discussed five things we would do as future work. Firstly, we would do some more testing of specific aspects of the product and conduct additional virtual meetings via zoom. This will ensure we remain to be on the right path into developing a product that our client will be even more satisfied with. Next, we would put our focus into the braking system. After successfully coming up with a solution for steering, we would want to make sure that she can safely activate the brakes on the walker without having to reach for either handle, ensuring the product's convenience. Lastly, we would take the time to work on the product's aesthetics. Initially, we determined that it is much more important to get the product to function properly before thinking about making it look aesthetically pleasing to the eye. Once all that has been completed and we are happy with our product, we would start expanding the product's compatibility, designing different models or a way for it to be used with different types of walkers.

8 Bibliography

PLA:
https://www.alibaba.com/pla/3D-printing-materials-PLA-ABS-PETG_60755973703.html?mark=oogle_shopping&biz=pla&searchText=plastic+rods&product_id=60755973703&language=en

Foam:
https://www.amazon.ca/Swimming-Children-Beginners-Interactive-Attractive/dp/B0BX311GQL/ref=sr_1_56?keywords=Pool+Noodles&qid=1690083460&sr=8-56

Adhesive:
https://www.homedepot.ca/product/lepage-pl-premium-polyurethane-construction-adhesive-interior-exterior-waterproof-295-ml/1000403473

Hinge:
https://www.amazon.ca/Stainless-Folding-Swivel-Connector-Fitting/dp/B08FHZWVHF

Connector:
https://www.homedepot.ca/product/lesso-pvc-tee-soc-x-soc-x-soc-3-4-inch/1000166802

Pin:
https://www.amazon.ca/Release-Diameter-Effective-Stainless-Hardware/dp/B07N1JG3L2/ref=sr_1_4?crid=209OKX7FMV10S&keywords=2+pack+quick+release+pin&qid=1690083771&s=sports&sprefix=2+pack+quick+release+pin%2Csporting%2C114&sr=1-4

APPENDICES

APPENDIX I: Design Files

Link to MakerRepo for The Single Steerer by The Fast and Fabricating Five:

https://makerepo.com/elishakhan/1674.the-fffs-one-handed-walker-steering-component

Youtube link to video submission:

Z22 one handed walker... friend or foe - YouTube

Table 5. Referenced Documents

Document Name	Document Location and/or URL	Issuance Date
Deliverable A	**MakerRepo**	**May 7, 2023**
Deliverable B	**MakerRepo**	**May 14, 2023**
Deliverable C	**MakerRepo**	**May 21, 2023**
Deliverable D	**MakerRepo**	**June 8, 2023**
Deliverable E	**MakerRepo**	**June 25, 2023**
Deliverable F	**MakerRepo**	**July 2, 2023**
Deliverable G	**MakerRepo**	**July 13, 2023**
Deliverable I	**MakerRepo**	**July 16, 2023**
Z22 One Handed Walker Video	**Z22 one handed walker... friend or foe - YouTube**	**July 23, 2023**