GNG 2101

Design Project User and Product Manual

AQUA B11 PORTABLE SHOWER CHAIR

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Table of Contents

Table of Contents ii

List of Figures iv

List of Tables v

List of Acronyms and Glossary vi

1 Introduction 1

2 Overview 2

2.1 Conventions 3

2.2 Cautions & Warnings 3

3 Getting started 5

3.1 Configuration Considerations ..... **Error! Bookmark not defined.**

3.2 User Access Considerations 5

3.3 Accessing/setting-up the System ..... **Error! Bookmark not defined.**

3.4 System Organization & Navigation 13

3.4.1 Chair Body 13

3.4.2 Detachable Holding Clips 16

3.4.3 Legs 17

3.5 Exiting the System ..... **Error! Bookmark not defined.**

4 Using the System 23

4.1 <Given Function/Feature> ..... **Error! Bookmark not defined.**

4.1.1 <Given Sub-Function/Sub-Feature> ..... **Error! Bookmark not defined.**

5 Troubleshooting & Support 33

5.1 Error Messages or Behaviors ..... **Error! Bookmark not defined.**

5.2 Special Considerations 33

5.3 Maintenance 33

5.4 Support 34

6 ..... Product Documentation

..... 35

6.1 <Subsystem 1 of prototype> 47

6.1.1 BOM (Bill of Materials) ..... **Error! Bookmark not defined.**

6.1.2 Equipment list ..... **Error! Bookmark not defined.**

6.1.3 Instructions ..... **Error! Bookmark not defined.**

6.2 Testing & Validation ..... **Error! Bookmark not defined.**

7 Conclusions and Recommendations for Future Work 56

8 Bibliography 57

APPENDICES 58

9 APPENDIX I: Design Files 58

10 APPENDIX II: Other Appendices ..... **Error! Bookmark not defined.**

List of Figures

Insert your list of figures here (right-click to update this field).

List of Tables

Table 1. Acronyms vi

Table 2. Glossary vi

Table 3. Referenced Documents 58

List of Acronyms and Glossary

Table 1. Acronyms

Acronym	Definition
ABS	Acrylonitrile Butadiene Styrene
CAD	Computer Aided Design
UPM	User Product Manual
HDPE	High Density Polyethylene

Table 2. Glossary

Term	Acronym	Definition
Assemble	N/A	Fit together several components
Disassemble	N/A	Take apart several components
Notch	N/A	A V-shaped indentation
Threaded	N/A	Relates to a part with a screw thread.

1 Introduction

The AQUA B11 is a portable, lightweight, and low-cost shower chair for travels away from home. It serves as a practical and convenient utility for our client, as it only weighs 5lbs and can be easily transported in a carry-on luggage bag.

Our goal at AQUA is to facilitate the lives of disabled individuals through convenience and exceptional value for money. We cater our shower chairs to the needs of every customer, to ensure complete customer satisfaction. Based on client meetings, AQUA assumes that our user does not exceed 250 lbs., can lift objects weighing 5lbs and can assemble and disassemble the B11 components individually.

The User and Product Manual outlines the functional components, important precautions, instructions to assemble/disassemble the system, troubleshooting methods, emergency assistance and product documentation. The main purpose of the User and Product Manual is to provide the intended use, repairing and storing methods for the B11 Shower Chair. It is a guide to increase the longevity of one's B11.

This User and Product Manual (UPM) provides the information necessary for physically limited individuals, seniors, patients and their guardians, to effectively use the B11 and for prototype documentation.

2 Overview

A wheelchair bound user requires a bathtub showering seat for when he travels away from home. Our user requires a durable, portable, retractable, lightweight, and low-cost shower seat that can easily fit into their carry-on luggage bag. The current shower chairs on the market are not portable and lack adequate drainage systems for our user. The AQUA B11, however, was designed to be practical. In the retracted position, the B11 is the size of a suitcase, and is extremely lightweight. It contains a unique cleaning channel design and is equipped with anti-clogging technology to prevent sloshing and increase flow.

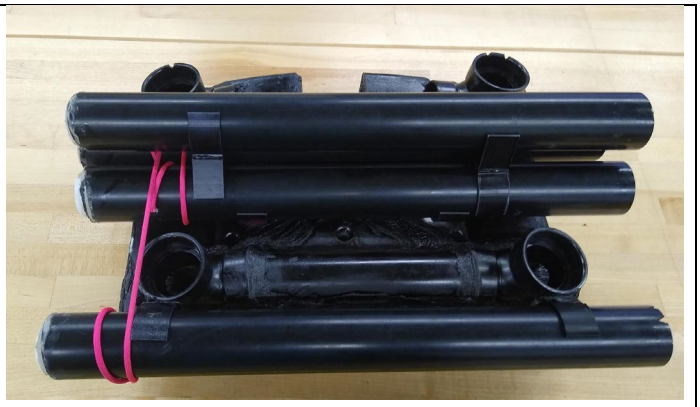


Figure 1 and 2: AQUA B11 Final Prototype

The leftmost image displays the B11 in the assembled position, while the rightmost image displays the B11 in the disassembled position. In the right image, the B11 is overturned to display the

retractable mechanism. Here, one sees the ABS legs attached to the two main clips located on the seat and the 2 portable clips located on the ABS legs.

Key features:

The B11 offers various key features, including:

- A convenient cleaning channel
- Slip-resistant feet
- Waterproof material
- Easy-to-use clip-mechanism
- Lightweight (5lbs)
- Strong, withstands 250 lbs
- Compact size: fits into a standard 22” x 14” x 9” carry-on luggage

Architecture/Construction of the system:

The AQUA B11’s construction is quite simple. It is comprised of T-shaped pipe fittings connected to the underside of the seat. An additional ABS pipe reinforces the rear of the seat. In the assembled position, the legs are attached to the fittings and in the disassembled position, the chair legs are attached to plastic clips. A set of clips are attached to the underside of the seat and a second set is portable. The second set is used when the seat is in the compact position.

2.1 Conventions

If an action is required to be performed by the user, it will be indicated by a line beginning with the word ‘Action’.

2.2 Cautions & Warnings

1) To ensure the safety of users, please do not load more than 250 pounds onto the chair seat. It may permanently damage the shower chair.
2) Only one individual may be seated on the AQUA B11 Shower Chair at a time.
3) Refrain from rotating the chair excessively while seated; this may damage the chair legs.

4) Safeguard the portable clips while the shower chair is assembled. Ensure they are stored in a safe and attainable area, to avoid losing the item.

3 Getting started

The AQUA B11 is designed to be functional, so that our customers can travel away from home, and shower just like at home. This section of the User Manual will provide a detailed procedure for the assembly and disassembly of the B11.

3.1 User Access Considerations

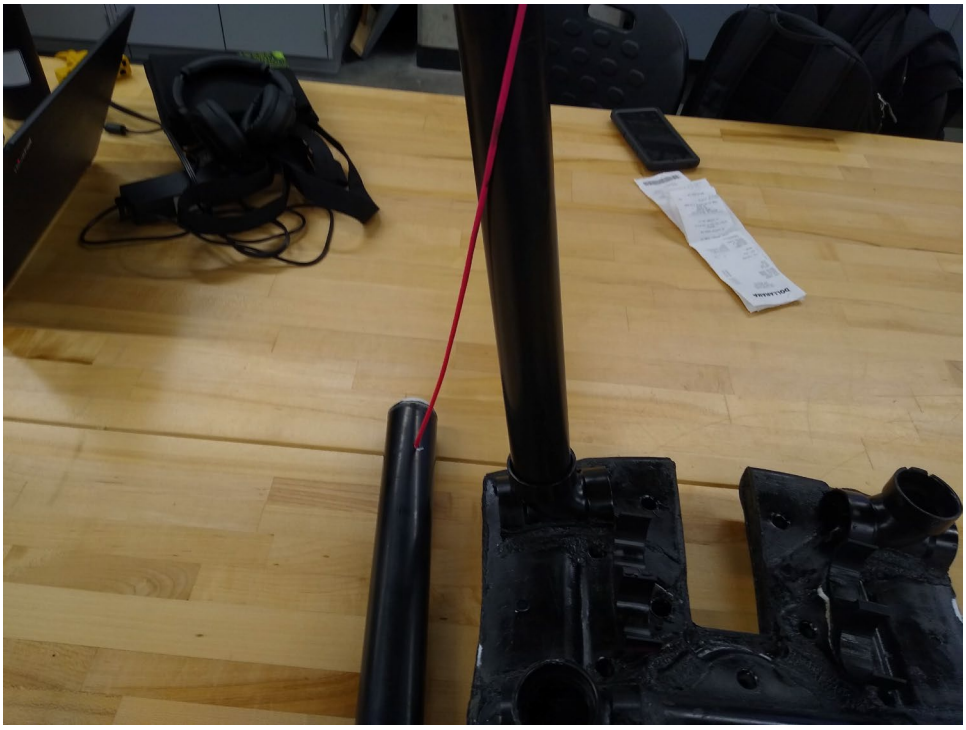
AQUA B11 users are physically disabled individuals and senior citizens. It is highly recommended that users mount and dismount from the shower chair using a safety bar. Please note that the chair is not recommended for angled or inconsistent surfaces.

3.2 How to Assemble the Chair

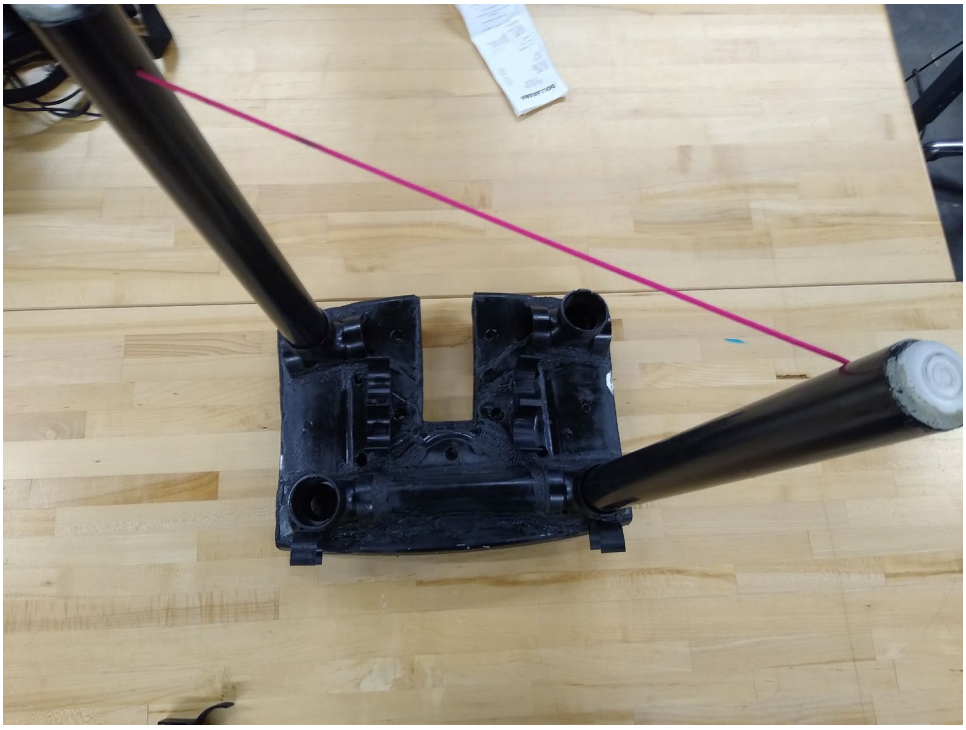
First, remove the legs from their holding clips and remove the two detachable clips. Place the detachable clips in a safe location.

Locate the single notch chair leg

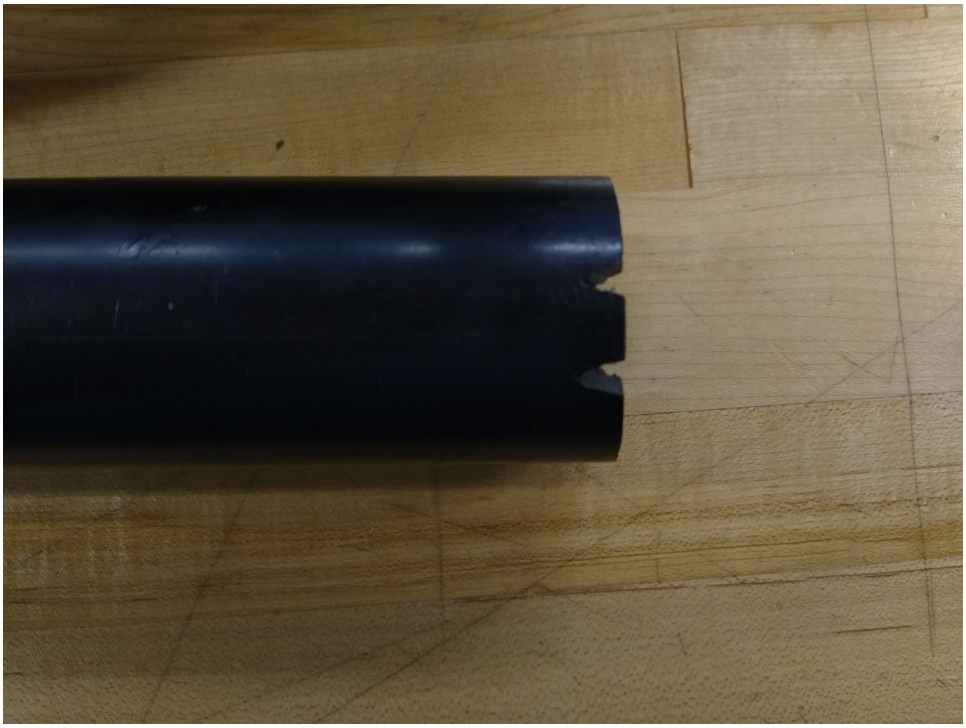
Insert the leg with the single notch into its associated single notch leg slot with the cord facing towards the center of the chair.



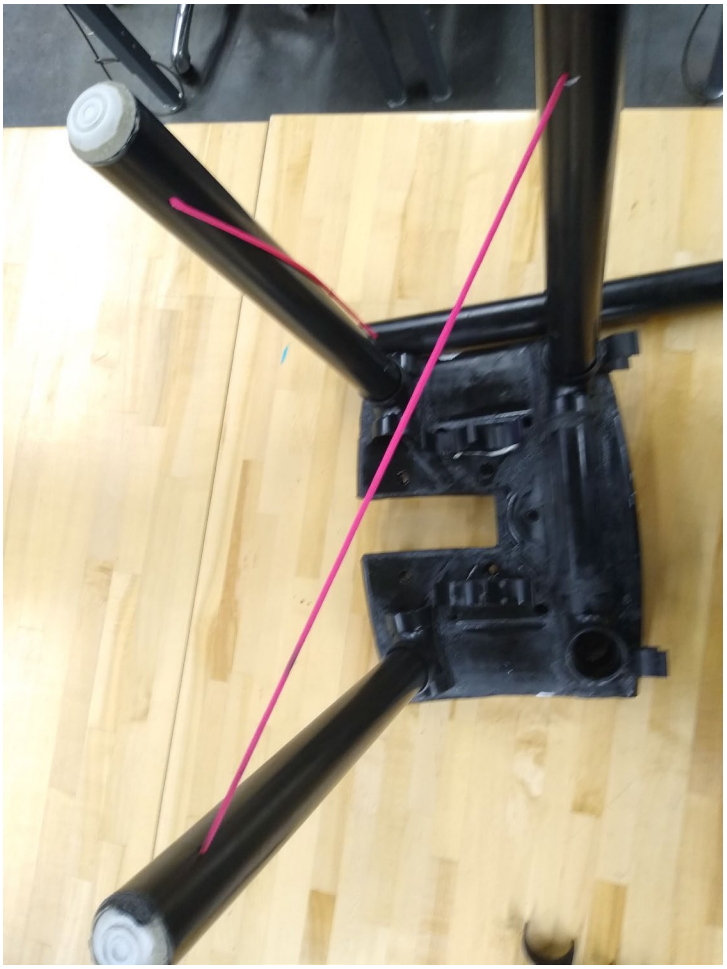
Insert the leg, which is attached to the cord into the leg slot diagonally across from the single-notched leg slot.



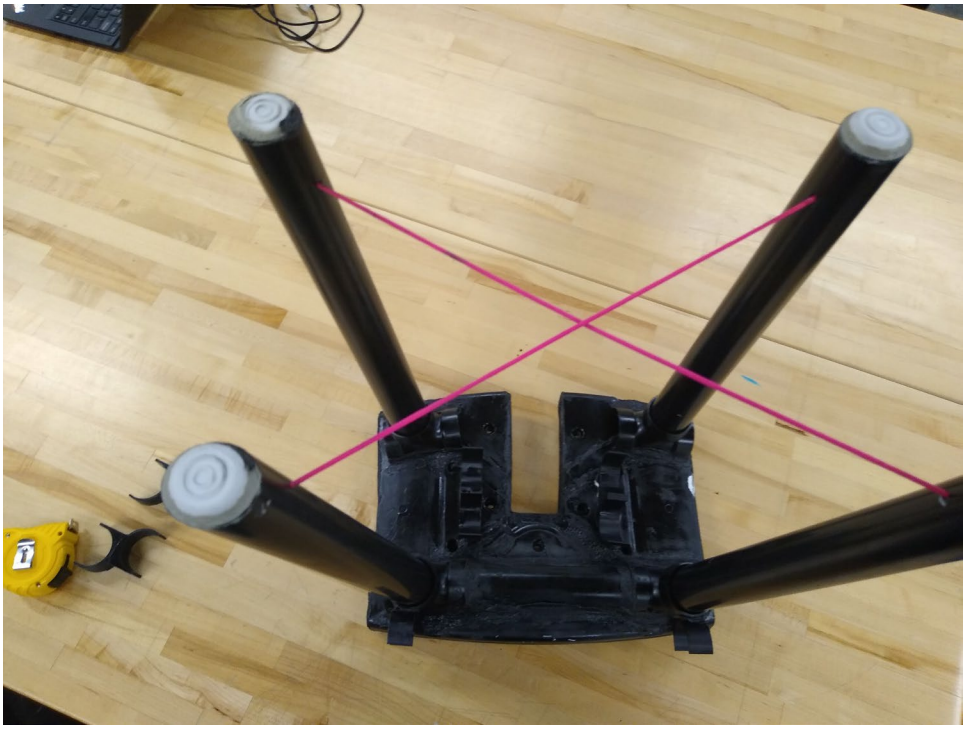
Locate the double-notched leg



Insert the leg into the double-notched leg slot with the cord facing toward the center of the chair.



Insert the final leg in the last leg slot.



Ensure that the legs are firmly in place.

To assemble the chair, remove all the legs from their holding clips, and remove the two detachable clips and place them in a safe location. Next, find the leg with a single notch. Insert the leg with the single notch into the leg slot with a single notch with the cord facing toward the center of the chair. Insert the leg attached to the cord into the leg slot diagonally across from the single-notched leg slot. Find the double-notched leg and insert the leg into the double-notched leg slot with the cord facing toward the center of the chair. insert the final leg in the last leg slot. Make sure that the legs are firmly in place.

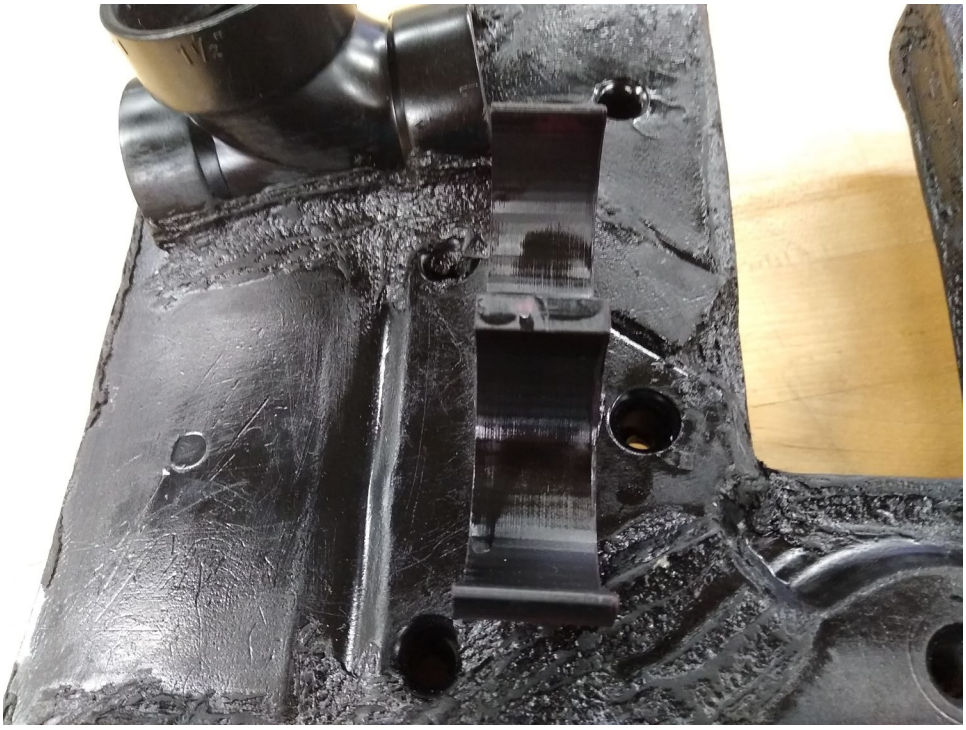
3.3 System Organization & Navigation

In this section of the User Manual, the main components and their navigation paths are outlined. A photo and description of each component is also provided.

3.3.1 Chair Body

3.3.1.1 Leg Slot

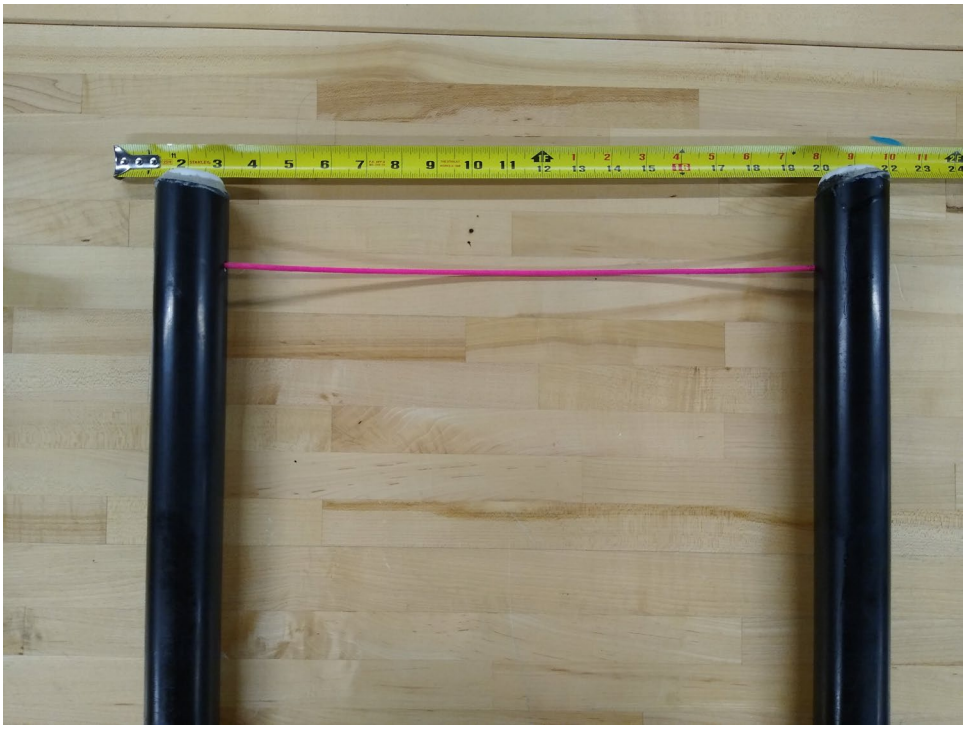
3.3.1.2 Holding Clips



3.3.2 Detachable Holding Clips

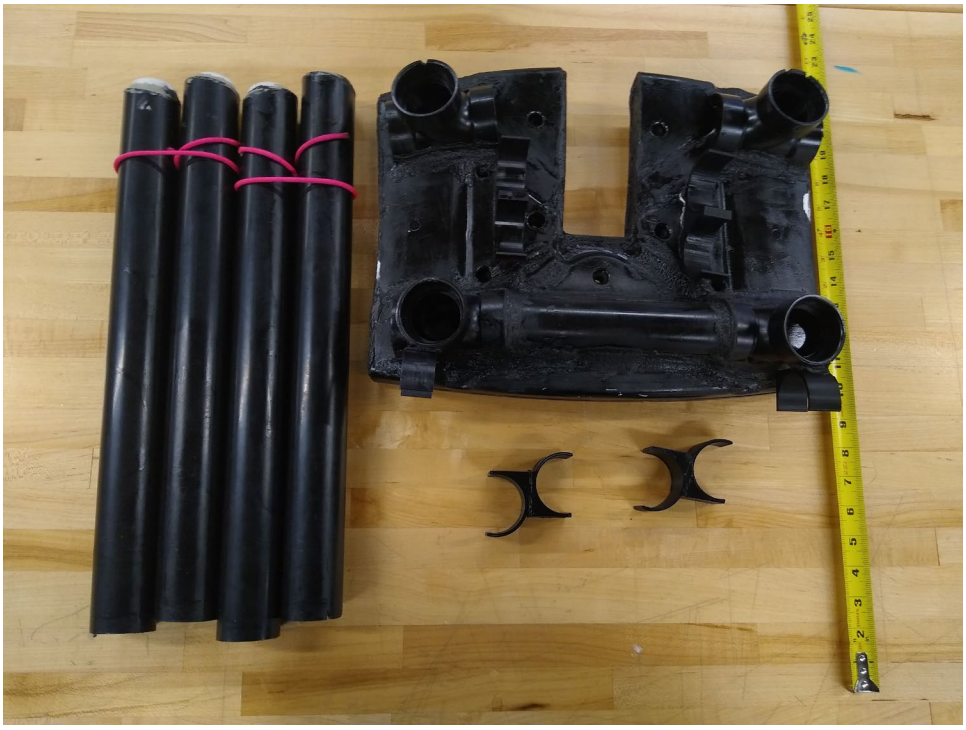
3.3.3 Chair Legs

3.3.3.1 Tension Cord

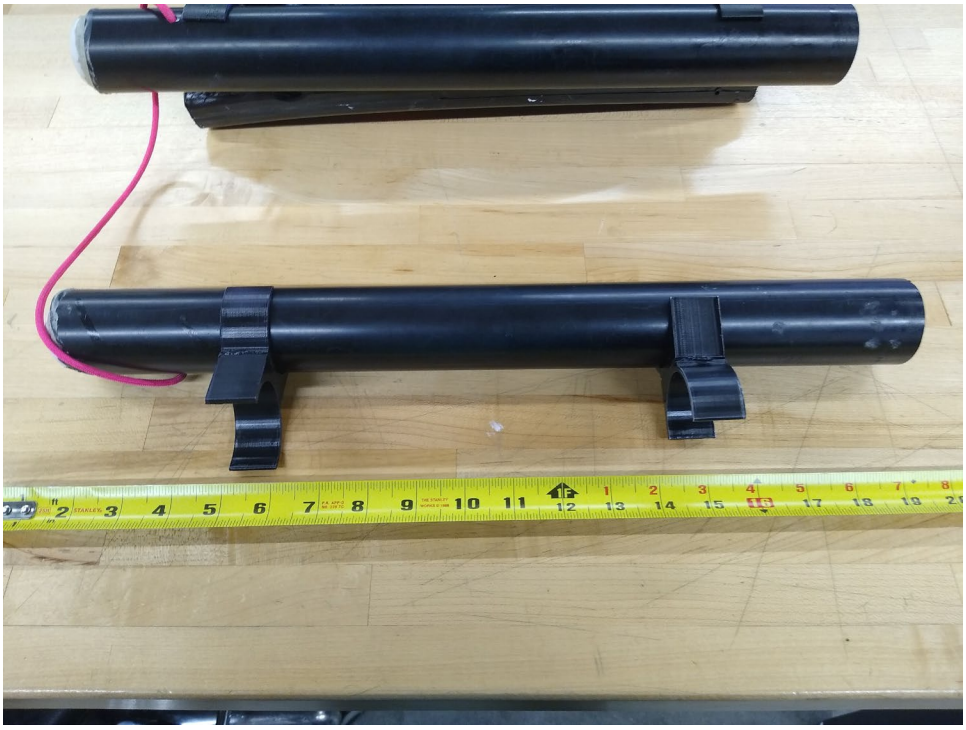


3.4 Disassembling the Chair

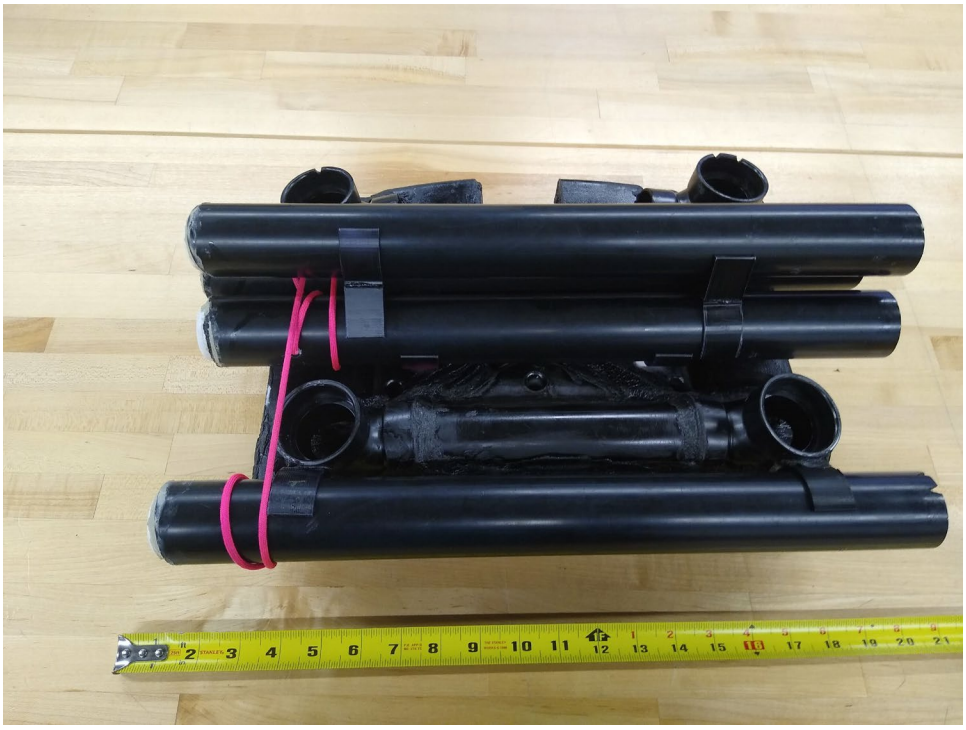
Flip the chair so that the top; the side with the flame is facing the ground. Remove the legs by applying a force normal to the base of the chair; away from the chair. This should remove a leg. Repeat this procedure for each leg.



Insert the legs into the holding clips of the chair. There should be three sets of holding clips on the chair.



Place the plastic clips on the remaining leg.



Flip the remaining chair leg with the plastic clip facing downwards and attach each clip to the chair leg, located in the center of the shower seat.

4 Using the System

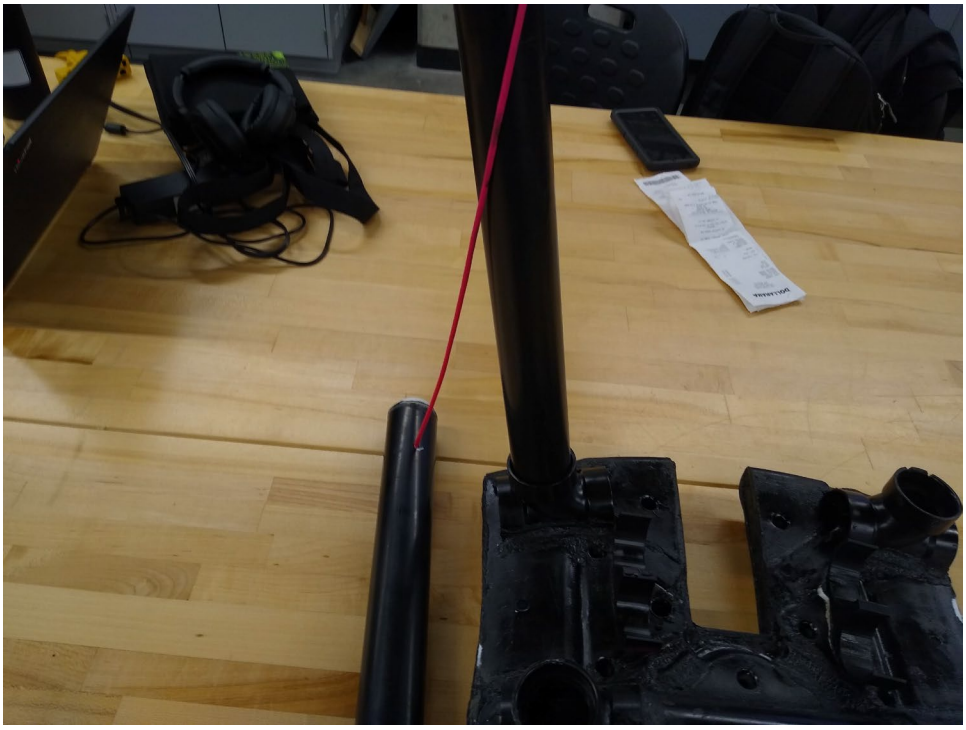
The following sub-sections provide detailed, step-by-step instructions on how to use the various functions or features of the AQUA B11.

4.1 Assembling the Chair:

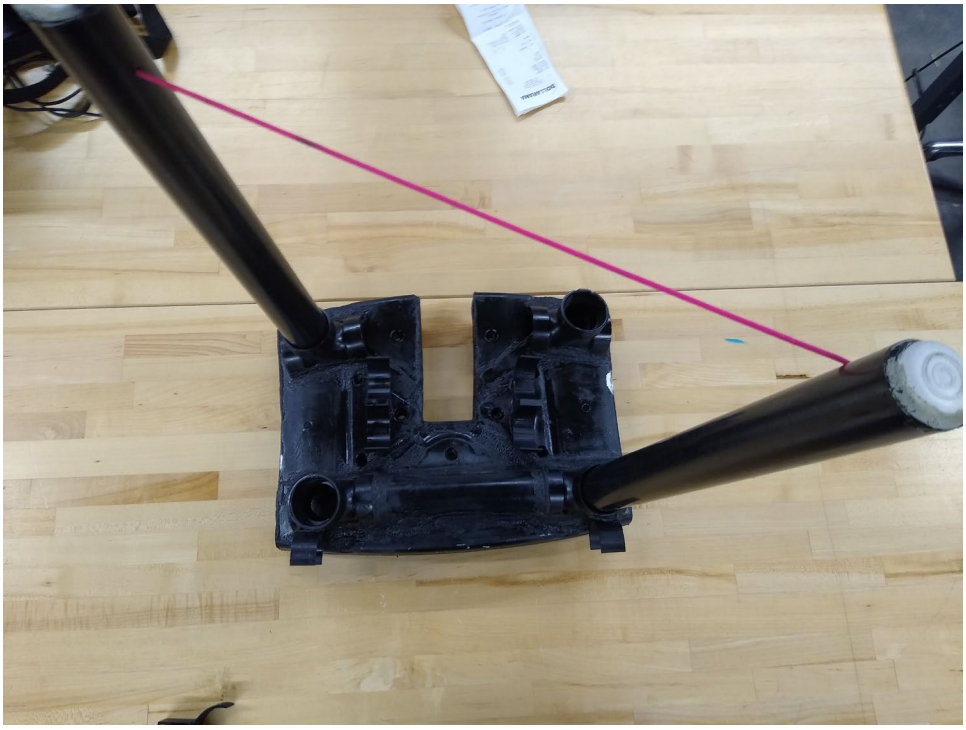
Remove all the legs from their holding clips and remove the two detachable clips and place them in a safe location.

Locate the leg with a single notch.

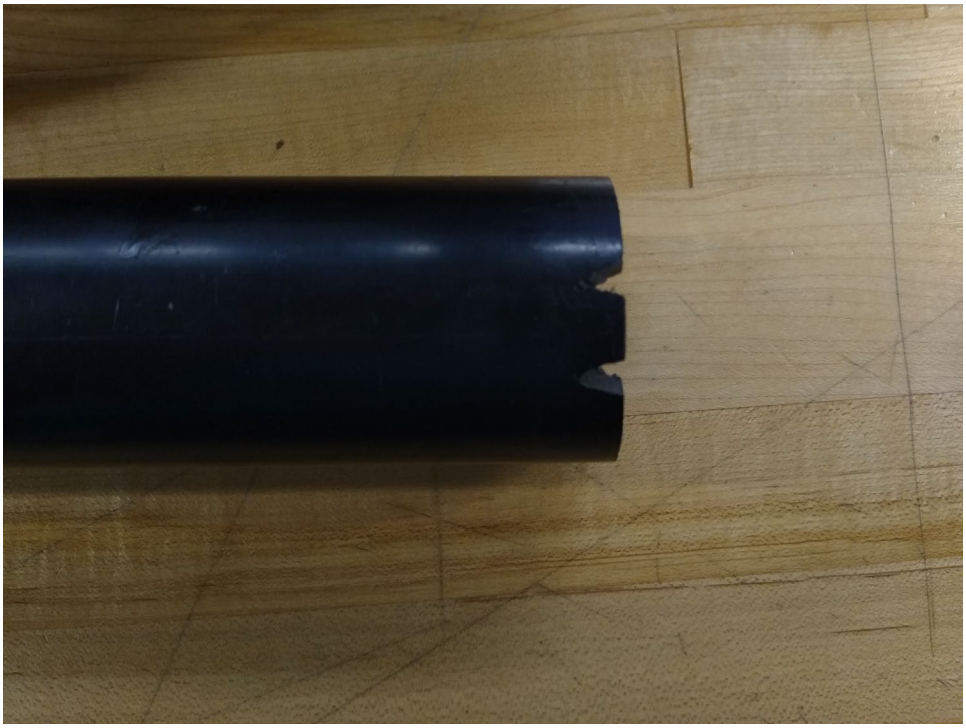
Insert the leg with the single notch into the leg slot with a single notch with the cord facing toward the center of the chair.



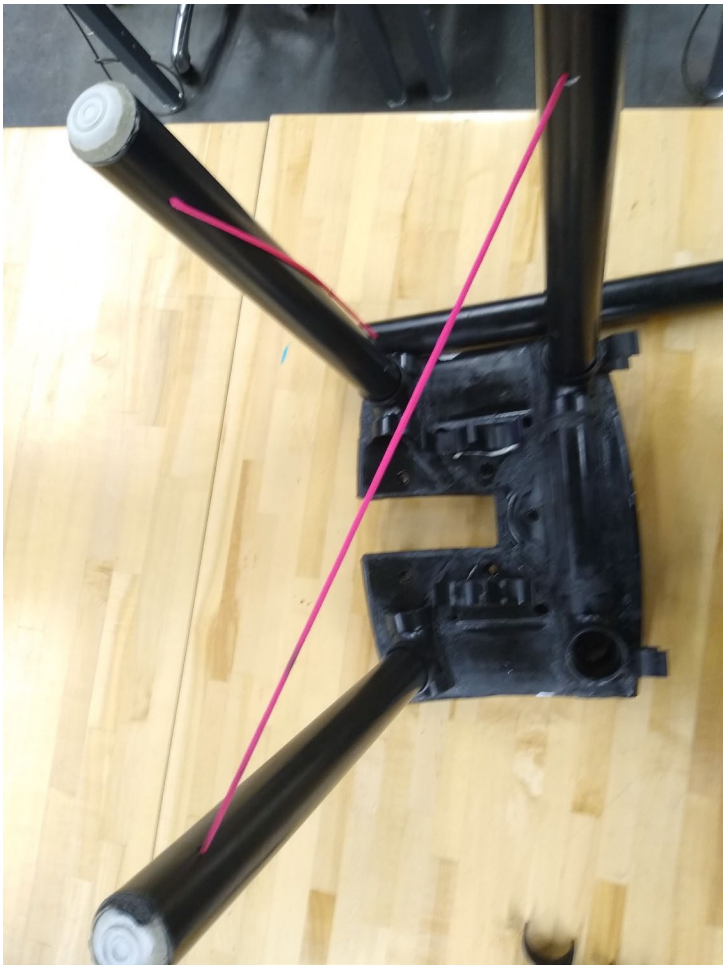
Insert the leg attached to the cord into the leg slot diagonally across from the single-notched leg slot.



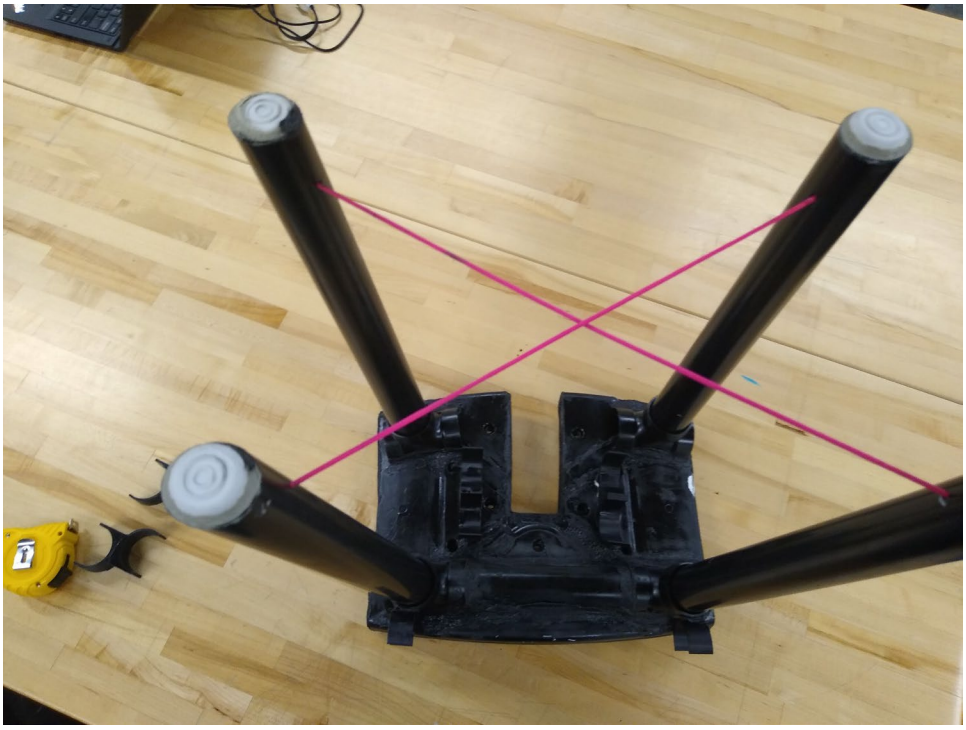
Locate the double-notched leg



Insert the leg into the double-notched leg slot with the cord facing toward the center of the chair.

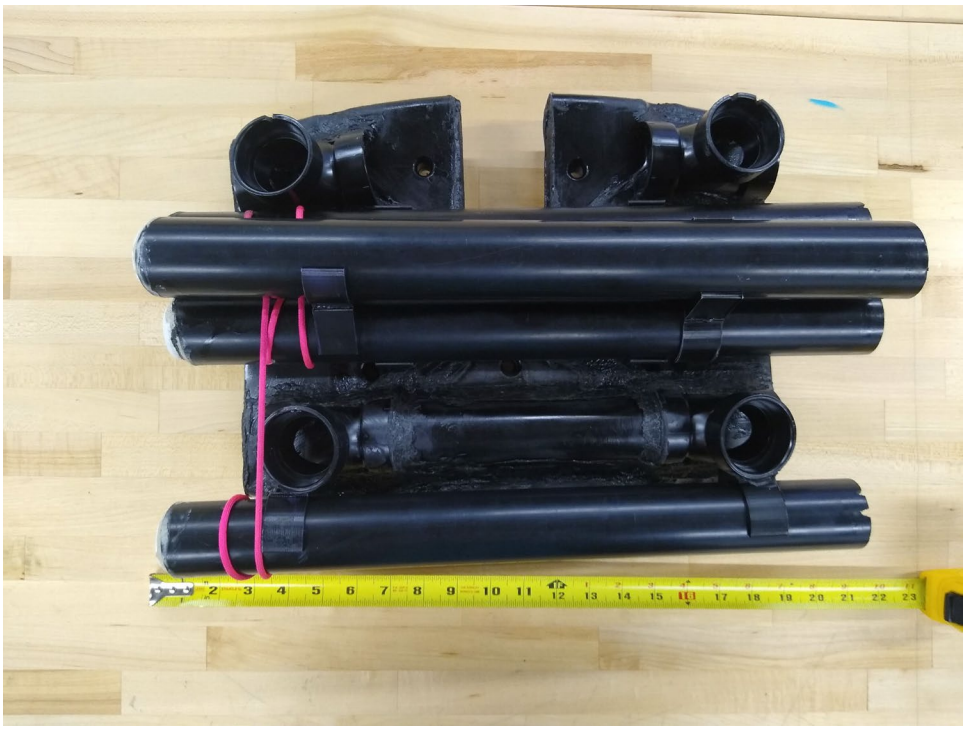


Insert the final leg in the last leg slot.



Ensure that the legs are inserted firmly into their associated slots

4.2 The Seat



Net weight of 4.5 lbs

4.3 Plastic, Detachable Clips


ft
25ft
STANLEY
in
2
3
4
5
6
7
8

5 Troubleshooting & Support

This section of the user manual explores the error conditions, special considerations and maintenance information for the B11 Shower chair.

Sensitive Parts

When using the AQUA B11, please refrain from rotating excessively in the seat. This may permanently damage the chair legs and/or potentially harm the user.

Special Considerations

The notched legs are not required to be attached to their respective slots. Matching the legs to their respective slots will improve the strength and performance of the B11, but it is not integral to the chair's durability.

5.1 Maintenance

To extend the product life of the AQUA B11 and prevent failure, users should:

- Dry the chair using a towel before long term storage
- Ensure the feet are clean to prevent slippage
- Tighten the nylon cords to prevent the legs from spreading

5.2 Support

For immediate shower chair assistance, users can contact AQUA's support staff. The staff support is David Fell and Omar El Kady. Their contact information is provided below.

Name	Phone Number	Email
David Fell	647-809-0064	dfell016@uottawa.ca
Omar El Kady	289-244-2365	oelka080@uottawa.ca

6 Product Documentation

6.1.1 BOM (Bill of Materials) and Link to Suppliers

Item Number	Item Name	Description	Units of measure	Quantity	Unit Cost (CAD)	Extended Cost (CAD)
1	Rubber Stoppers	Rubber stoppers for the feet of the shower chair	Package (4 units per package)	1	4.69	4.69
2	Suction Cups	Suction cups for the feet of the shower chair	Package (2 units per package)	2	5.49	11.98
3	Aluminum pipe	Aluminum pipe for legs of shower chair	8-foot length	1	21.99	21.99
4	Polyethylene (low density)	Polyethylene pad for seat cushioning (10”x8”x0.4” x 2 sheets)	Package (2 sheets per package)	1	13.99	13.99
5	Polyethylene (high density)	Polyethylene sheet for seat base (5/8”x12”x24”)	Sheet	1	36.44	36.44
Total Product Cost (Excluding Taxes and Shipping) (CAD)						89
Total Product Cost (Including Taxes and Shipping) (CAD)						100.57

Item Number	Link

1	https://www.homehardware.ca/en/4-pack-78-off-white-rubber-furniture-leg-tips/p/2349738?rrec=true
2	https://www.homehardware.ca/en/2-pack-large-clear-suction-hooks/p/2353610?page=search-results%20page
3	https://www.princessauto.com/en/3-4-x-1-16-in-aluminum-round-tubing/product/PA0008829491
4	https://www.amazon.ca/Polyethylene-Customizable-Convoluted-Polyethlene-Costumes/dp/B0B41RK4DP/ref=sr_1_3?keywords=polyethylene+foam&qid=1664908391&qu=eyJxc2MiOiI0LjM4IiwicXNhIjoiNC4xMyIsInFzcCI6IjMuNDAifQ%3D%3D&sprefix=polyet%2Caps%2C115&sr=8-3
5	https://www.amazon.ca/BuyPlastic-Natural-Plastic-Density-Polyethylene/dp/B08NK8Z28J/ref=sr_1_27?keywords=hdpe&qid=1664909842&qu=eyJxc2MiOiI1LjEzIiwicXNhIjoiNC43NSIsInFzcCI6IjMuOTMifQ%3D%3D&refinements=p_36%3A2500-6000&rnid=12035759011&s=industrial&sr=1-27&th=1

6.1.2 Equipment list

Table 6.1.2 List of Equipment Required for the AQUA B11

NAME	CATEGORY
3D Printer	Machinery
3D Printer Filament	Material/ Components
Bandsaw	Machinery
Jigsaw	Machinery
Safety Glasses	Equipment
Employee Training	Training
Mill Machine	Machinery
Drill Bit	Accessories
End Mill	Accessories
Collet	Accessories
Jackob's Chuck	Accessories
High Density Polyethylene (HDPE)	Material
Acrylonitrile Butadiene Styrene (ABS) Pipes	Material/ Components
Acrylonitrile Butadiene Styrene (ABS) Pipe Junctions	Material/ Components
Polymer Adhesive	Adhesive
Blow Molding Machine	Machinery
Warehouse Rental	Rent

Aqua B11 is a portable shower seat, when our team started the design process, we always considered 3 variables: weight, width, and height. Moreover, for the prototype to be most efficient, all three

variables were to be always balanced; for example, if we increased the height of legs for better sturdiness, the height variable will increase causing the weight variable to increase as well; while the weight variable can be decreased by decreasing the width variable, it would create an imbalanced product. Therefore, the relationship between the height and width variables is proportionally linked with the weight variable, and our objective was to reach an optimized balanced point between all 3 variables.

In the first stage of the design process, our team created preliminary designs and conceptual sketches, moreover, all designs were compared and analyzed by team members to agree on a design to proceed with. For this stage we used the design criteria technique to analyze which team member's design was most feasible to the client's needs. Furthermore, after agreeing on a conceptual design, our team started doing rough calculations to determine the dimensions of the first prototype. The calculations made by our team included moment of inertia calculations, stress calculations, and critical buckling load calculations.

After determining the prototype dimensions from the calculations, our team started the second stage of the design process which included CAD prototyping. Our team decided that for our preliminary prototype, we will use HDPE for the seat, and threaded aluminum for the legs. Our preliminary prototype served as a guide for our client to gain feedback, and to give him an idea of how the final prototype would look like.

Figure 6.1 Illustrating the CAD Preliminary Prototype

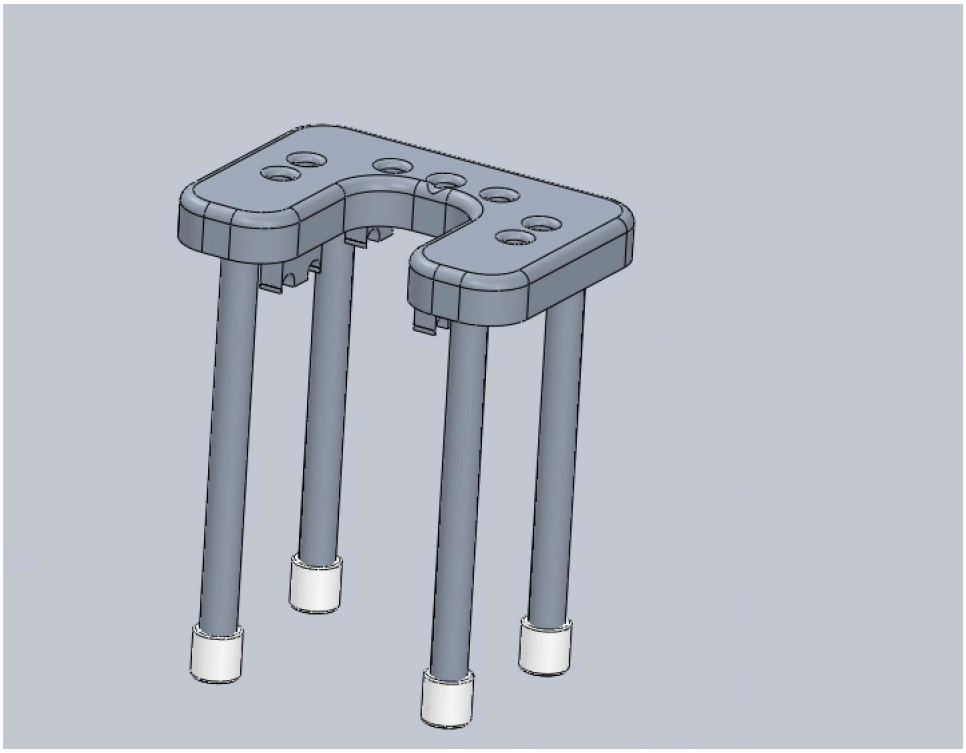


Figure 6.2 Illustrating the CAD Preliminary Prototype

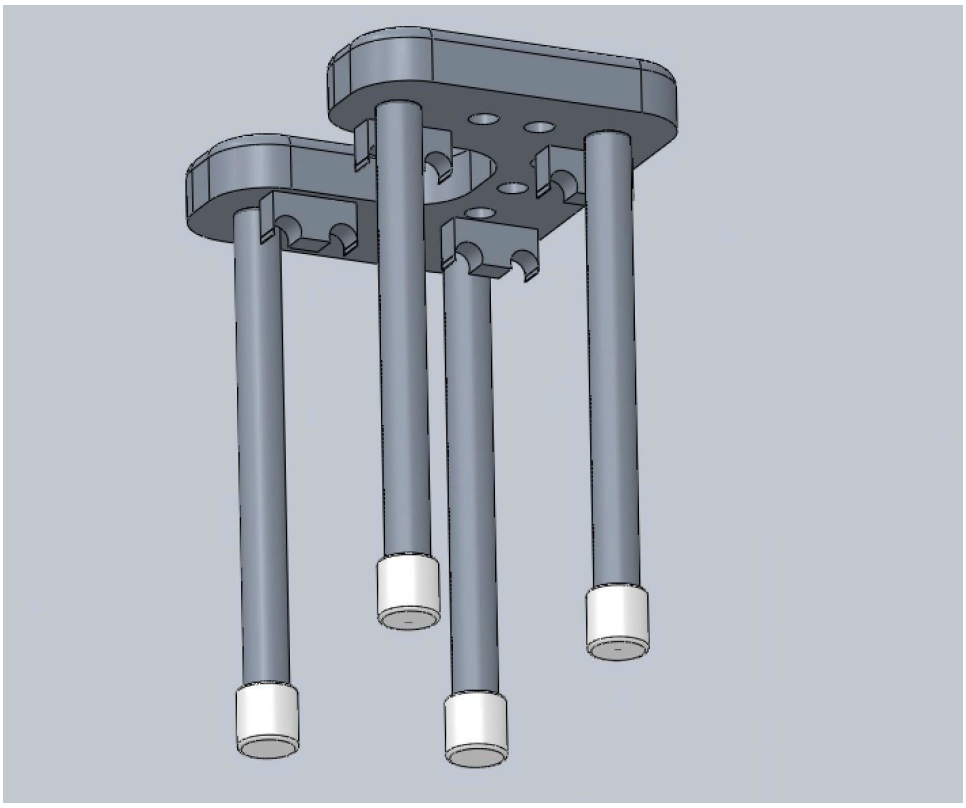
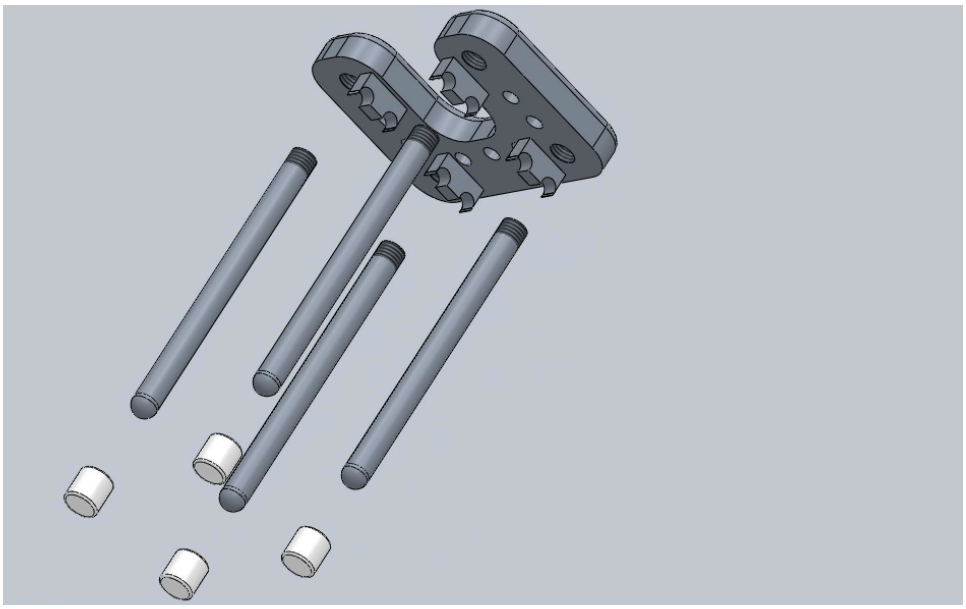


Figure 6.3 Illustrating the CAD Preliminary Prototype



The design shown above included features such as HDPE solid seat, water drainage holes, bottom storage clips, cleaning channel, aluminum legs, and non-slip leg cases. The feedback we received from the client was a crucial asset to the design of our next prototype.

Our second prototype included more features such as a detachable backrest mechanism, different drainage holes sizes and symmetry, and seat cushioning.

Figure 6.4 Illustrating the Detailed Drawing of Prototype II

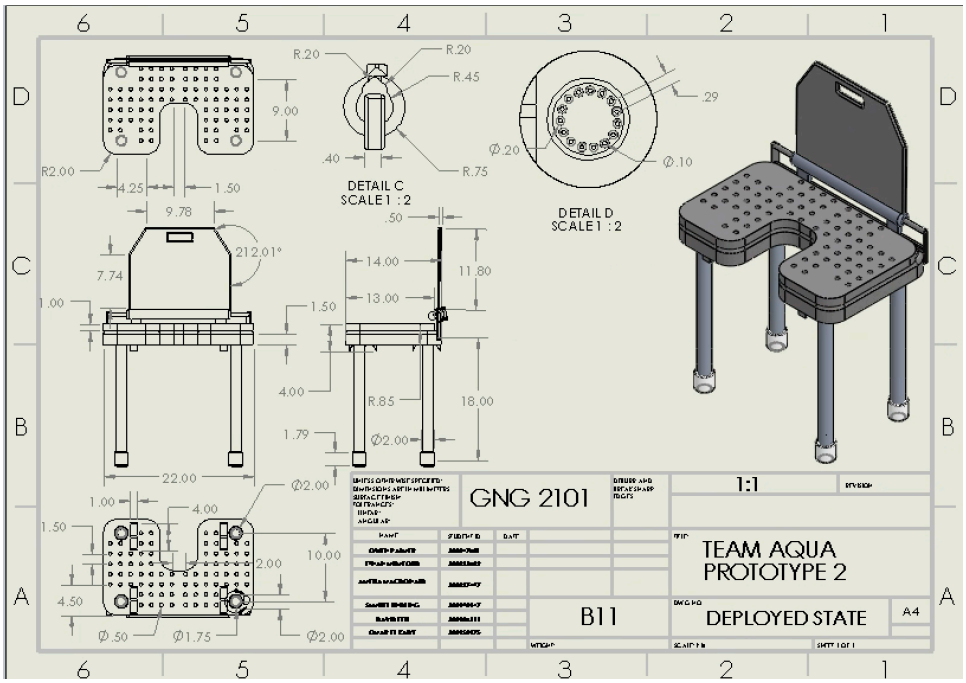


Figure 6.5 Illustrating the CAD of Prototype II

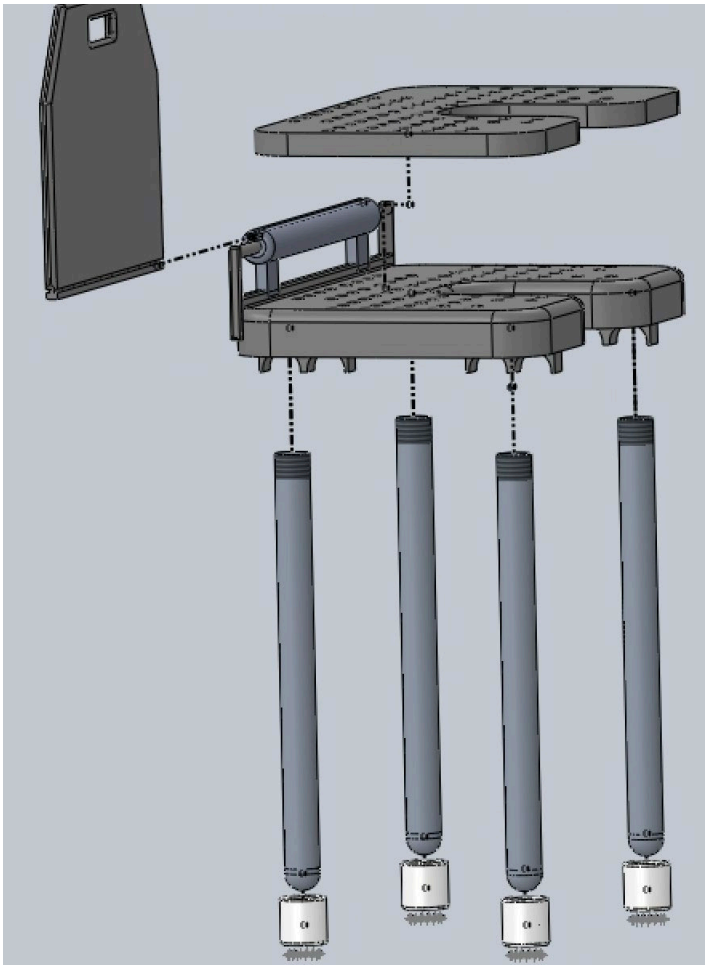


Figure 6.6 Illustrating the CAD of Prototype II

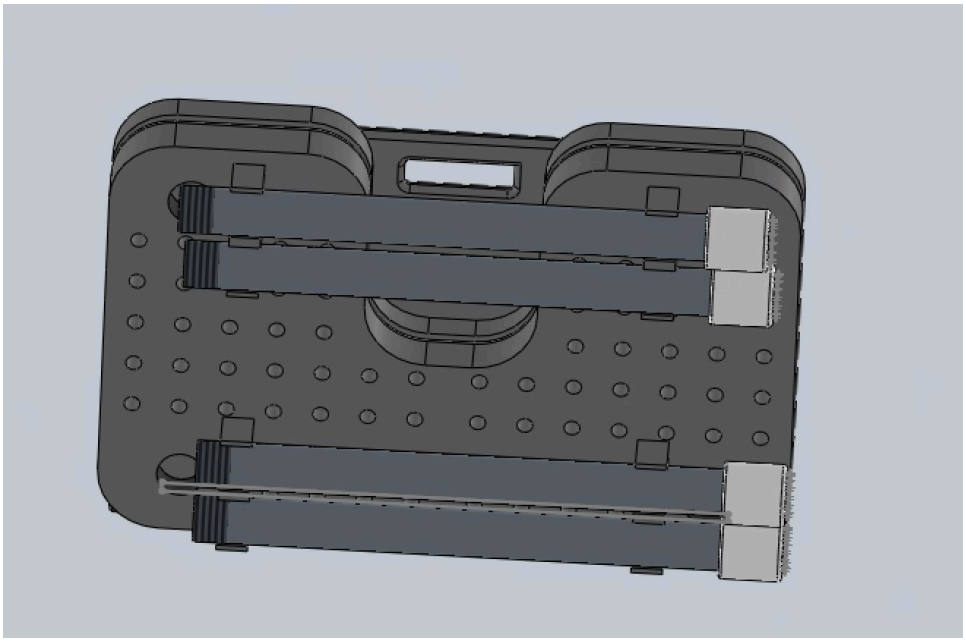
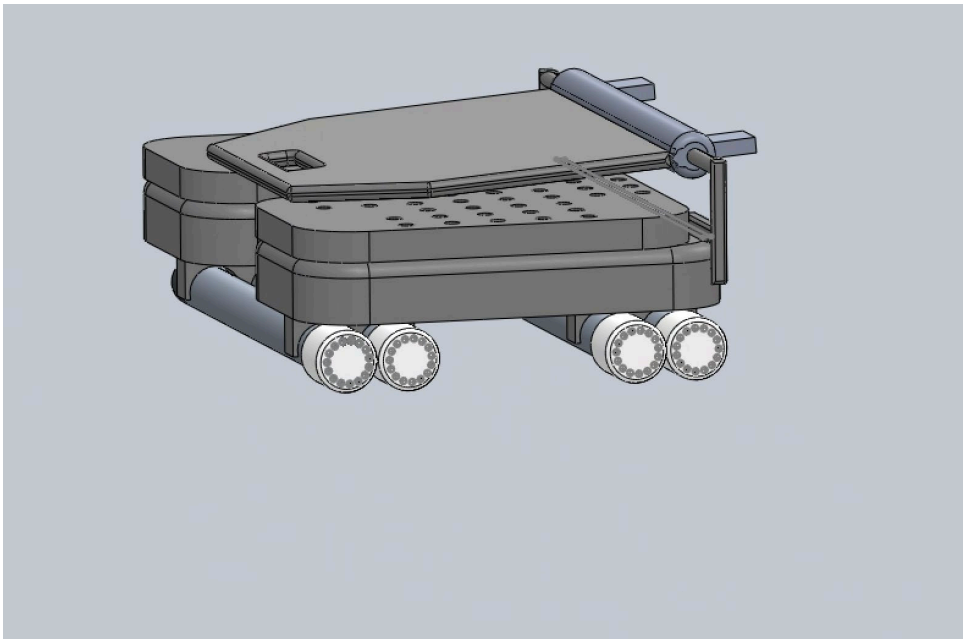


Figure 6.7 Illustrating the CAD of Prototype II



After designing our second prototype, our team started preparing for the design of our physical prototype; while we were still in the early stages of the process, our team decided it would be best to design and test early to be able to deal with any issues we may encounter early on. The first step in the physical design process was to gather the necessary materials required for the manufacturing of our prototype. Our team faced a major issue in this stage where the aluminum that was available was anodized and unfit for our prototype. After searching, testing, and analyzing, our team agreed on ABS as a substitute for aluminum. The new variables were set and the last step before building the physical prototype was to software test the prototype for failure.

6.2 Testing & Validation

During the tests, the seat withstood the weight capacity needed, however, it showed significant deformation in the middle due to the lack of support. The two solutions to this problem were to either increase the thickness of the seat which will increase the cross-sectional area and in turn its moment of inertia, or to add braces to reduce the effective length of the chair. Since this prototype was a solid seat, increasing the thickness would significantly increase the weight variable, and it would also affect the height of the chair which was already maximized; therefore, our team decided to go with the other solution and add braces. Adding braces would still affect the weight variable, therefore, our team compensated for the added weight by removing the backrest.

Figure 6.2.1 Illustrating the Von Mises Stress Analysis of Prototype II

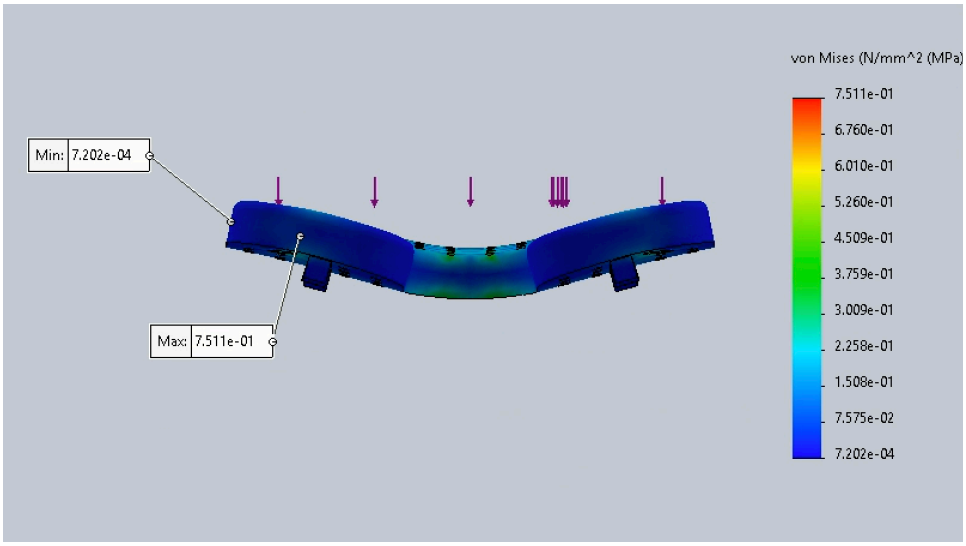


Figure 6.2.2 Illustrating the Von Mises Stress Analysis of Prototype II

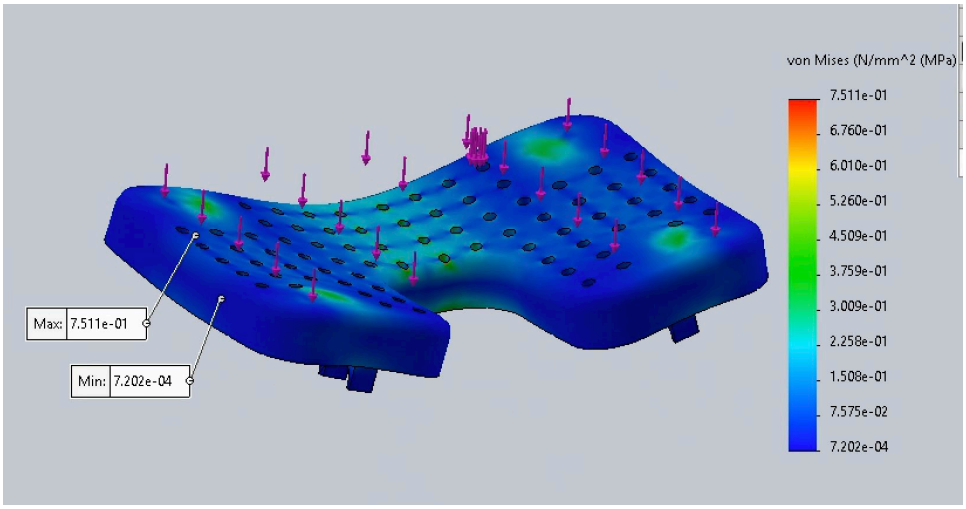
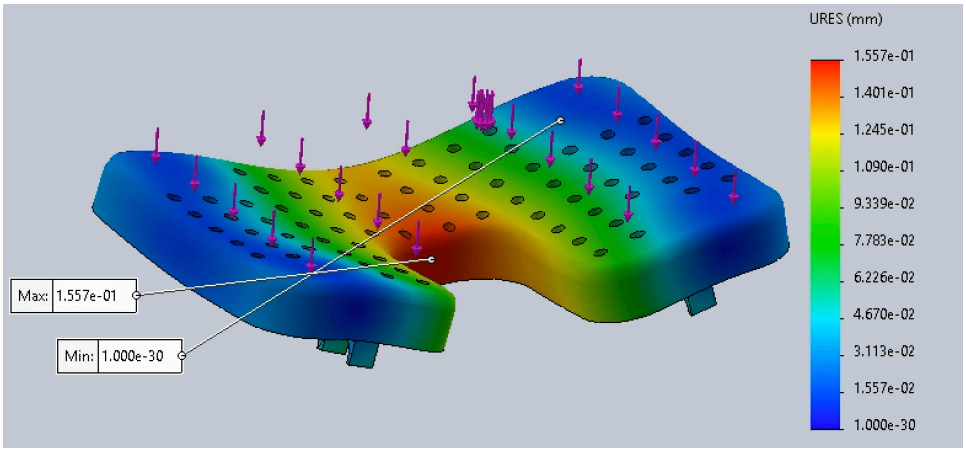


Figure 6.2.3 Illustrating the Displacement Test of Prototype II



6.3 Final Prototype

This prototype is our final prototype, it is an upgraded version of prototype II; whereas, it was designed using the same tested dimensions of prototype II, this prototype however, was designed to be curved and hollow with supports at each drainage hole. This simple upgrade has not only significantly reduced the overall weight of the chair, but also offered more comfort and stability for the user. Additionally, our team also replaced the threaded system with a push in system using junctions for added convenience and increased sturdiness.

Figure 6.3.1 Aqua B11 Seat

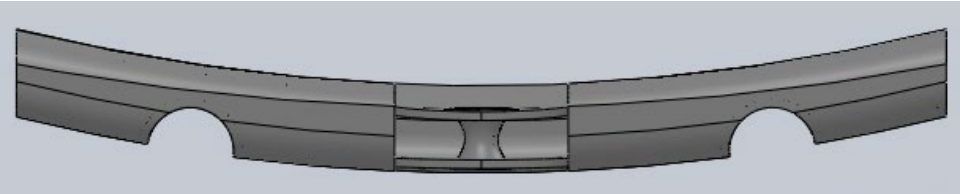


Figure 6.3.2 Aqua B11 Seat

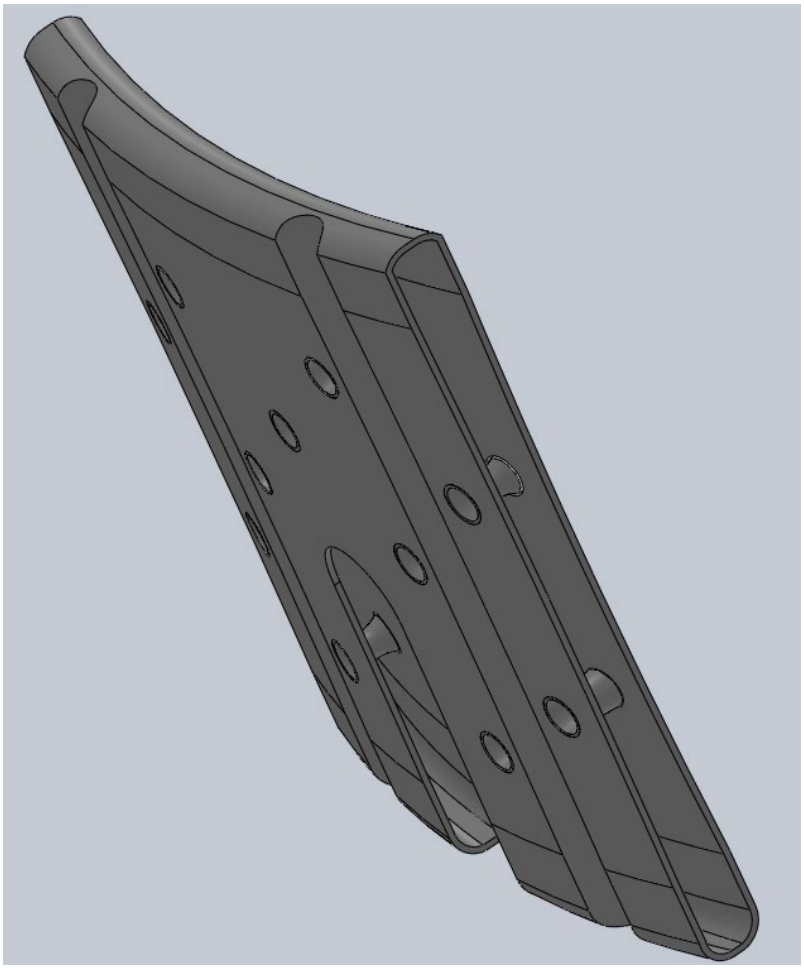


Figure 6.3.3 Aqua B11 Junction

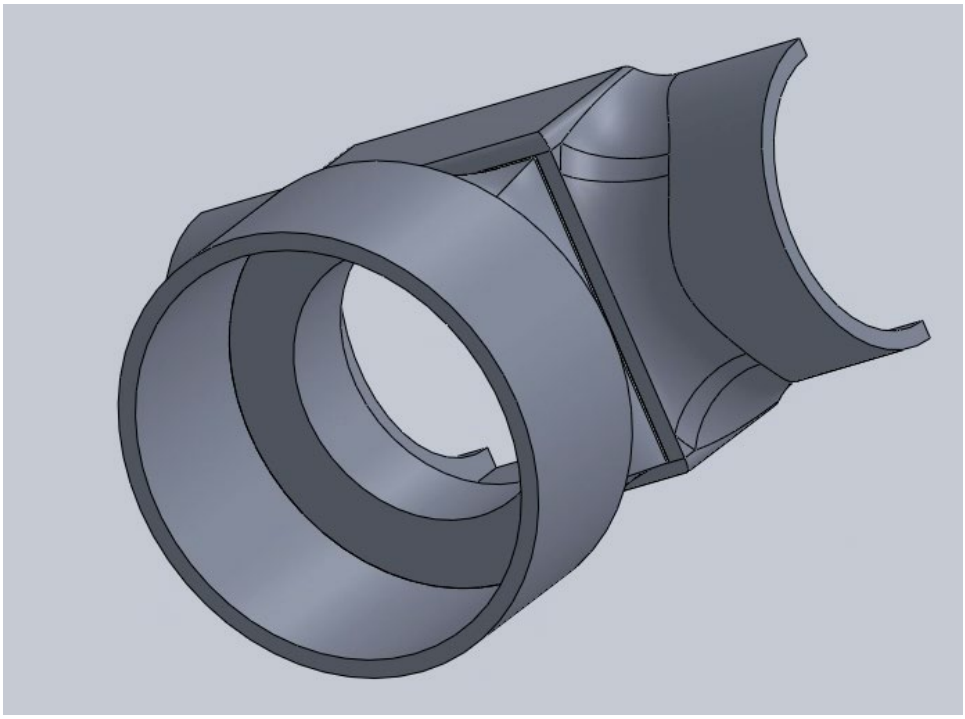


Figure 6.3.4 Aqua B11 Junction

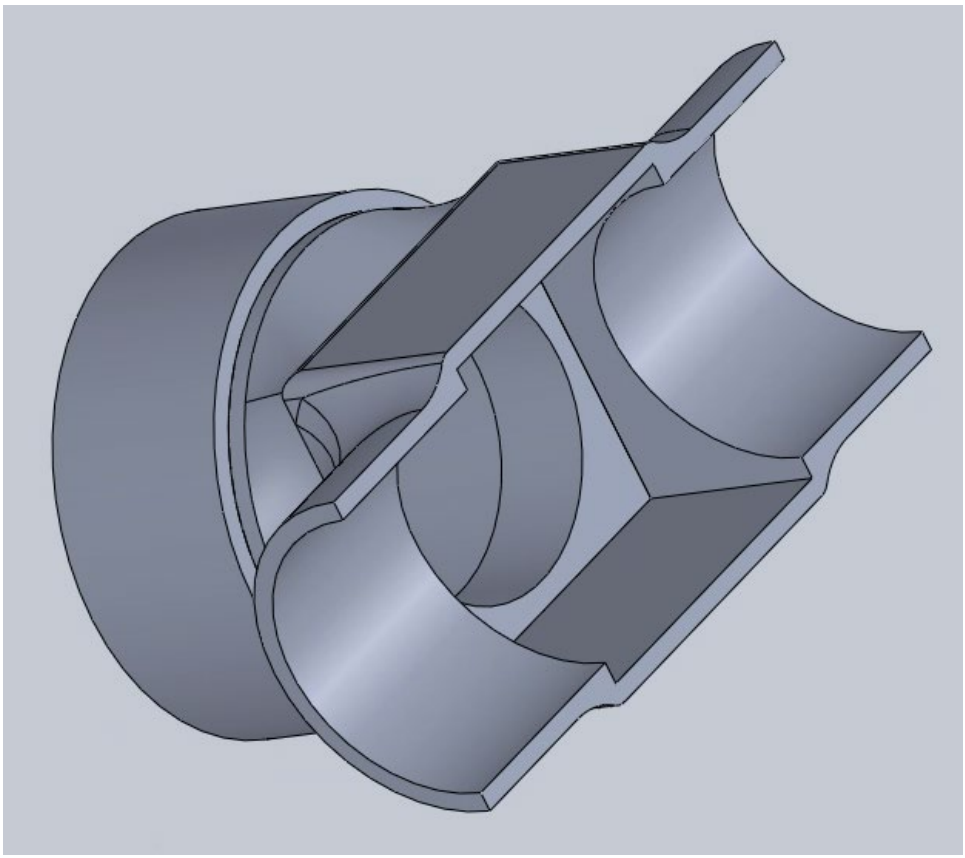


Figure 6.3.5 Aqua B11 Seat & Junctions

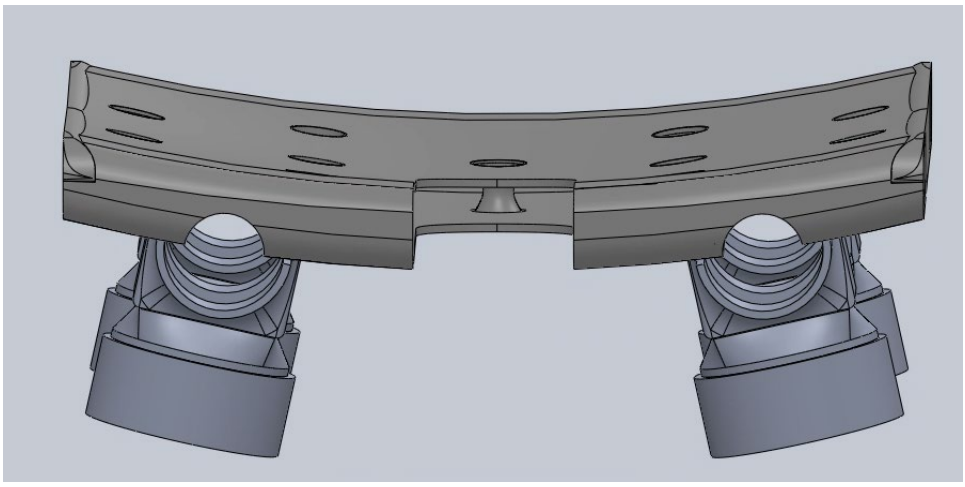


Figure 6.3.6 Aqua B11 Seat & Junctions

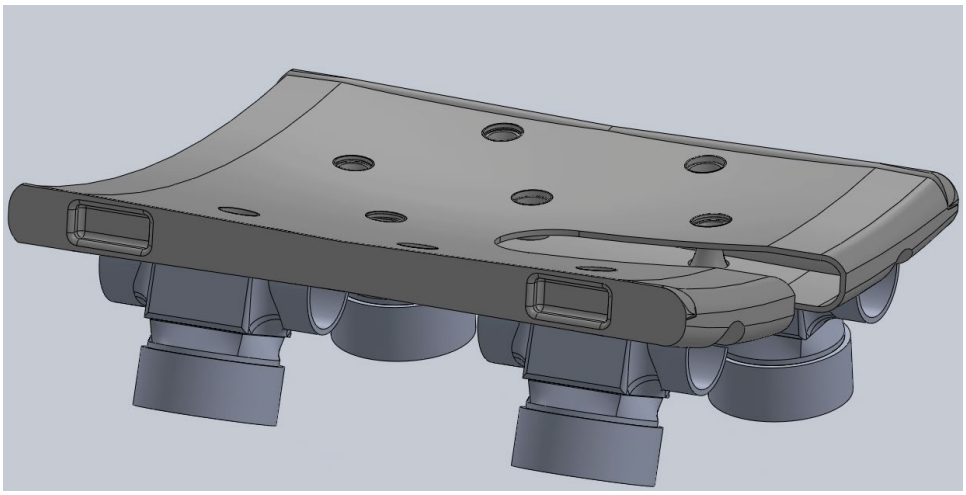


Figure 6.3.6 the Aqua B11

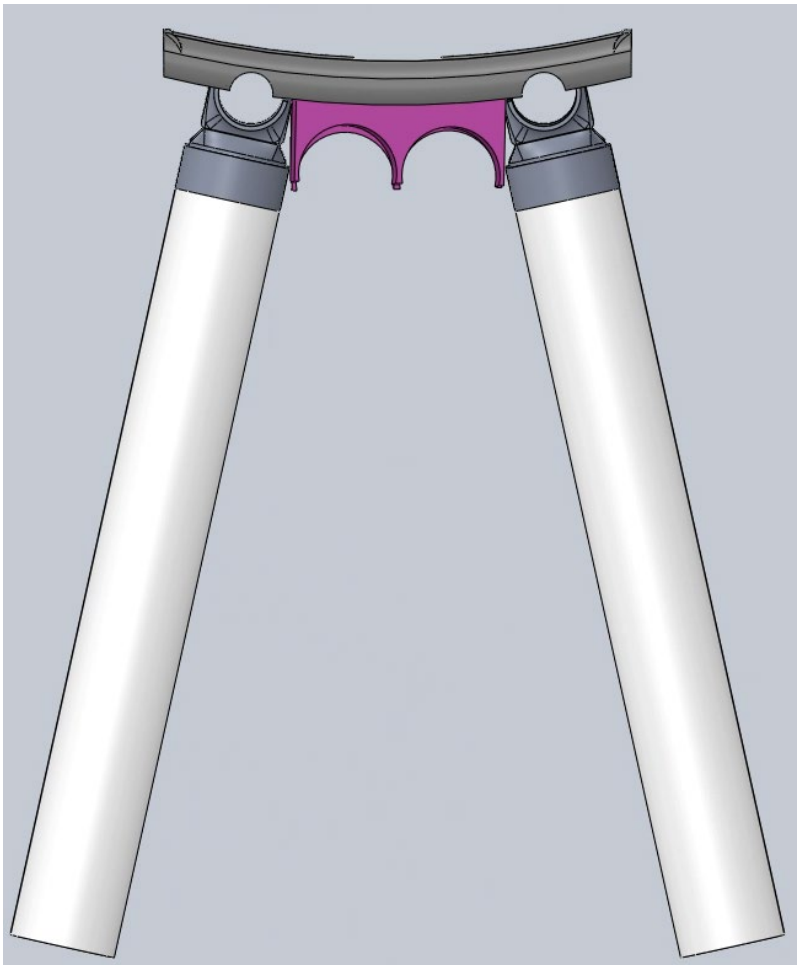
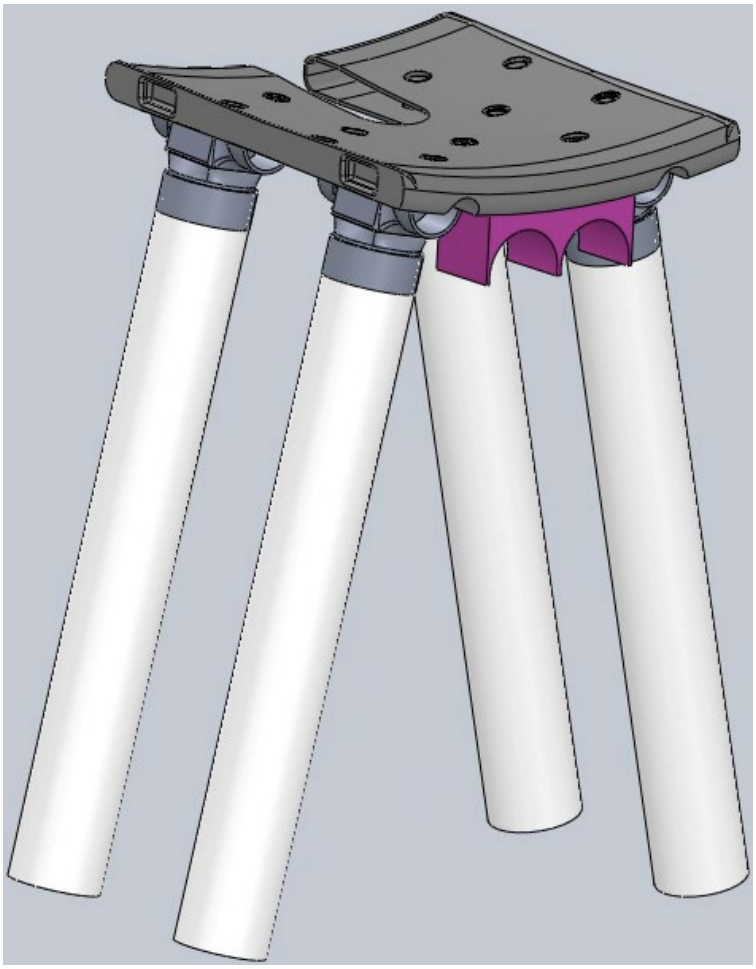


Figure 6.3.7 the Aqua B11



Finally, this prototype was tested one last time before manufacture.

Figure 6.3.8 the Aqua B11 Von Mises Stress Analysis

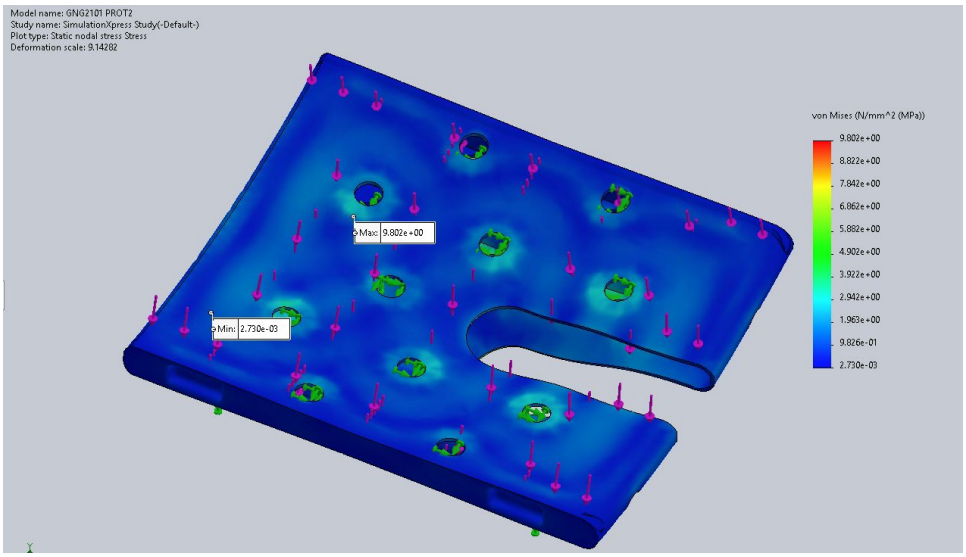


Figure 6.3.9 the Aqua B11 Leg Displacement Test

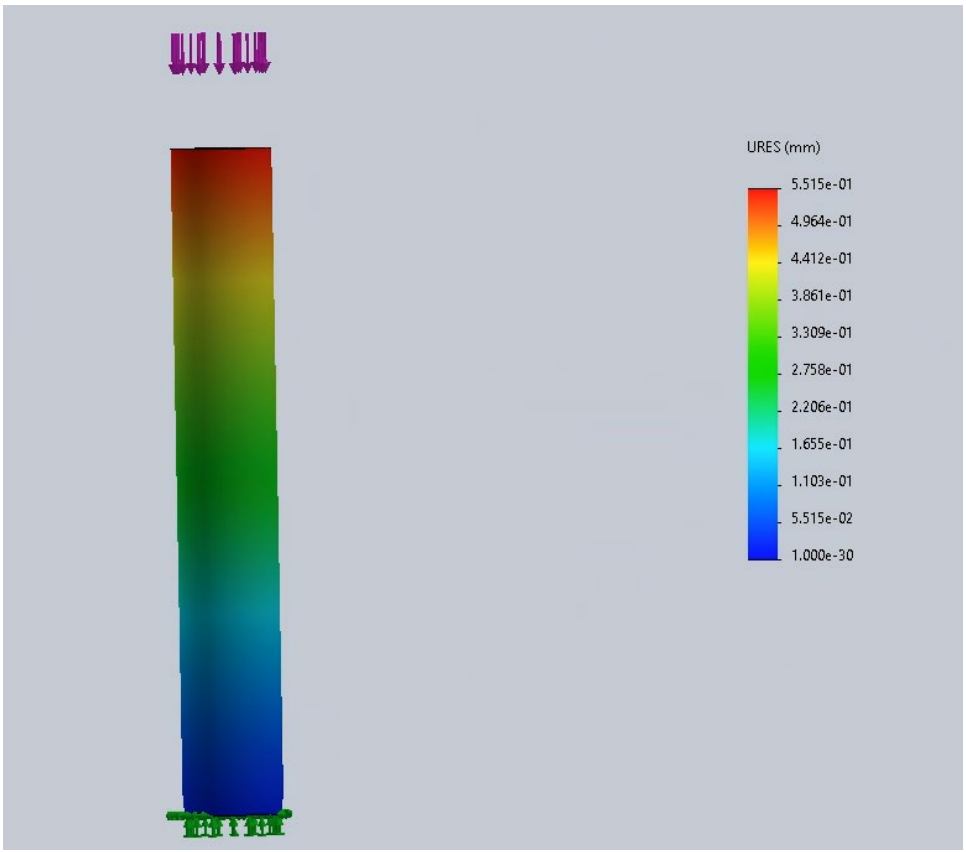
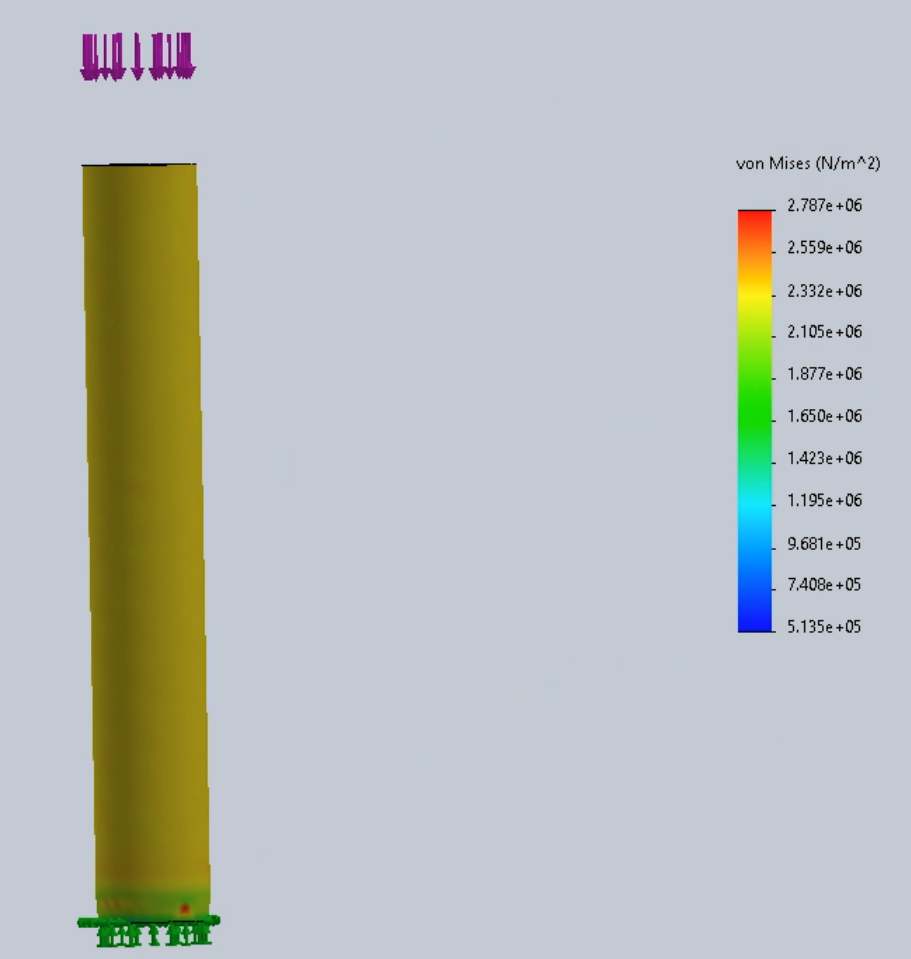


Figure 6.3.10 the Aqua B11 Leg Von Mises Stress Analysis



The Aqua B11 test results showed a significantly enhanced stress distribution than its predecessors, additionally, each leg of the Aqua B11 was tested solely with a load of 250 lbs, which is the load all 4 legs are expected to withstand combined; the tests showed slight axial deformation, however, all deformations occurred within the elastic region and no failure occurred. After the successful testing phase, our team assembled the physical prototype and tested it physically.

7 Conclusions and Recommendations for Future Work

The Portable Shower Chair project was a positive learning experience for our team. It forced us to implement the engineering concepts learned in class and gain hands-on prototyping experience. Through our trials and tribulations, our team learned extremely valuable lessons. First, we learned the importance of project management and breaking down design problems into sub tasks. At times, the deliverable work felt overwhelming and with deadlines every week, we had to manage our time effectively. Using Professor Bouendeu's advice, our team broke down tasks using OKRs and KPIs using the Wrike project management tool; this proved to be extremely effective. It simplified and divided our workload equally, so that our team was prepared for every deadline and each team member understood their role. Another key lesson we learned was that outsourcing products is much more efficient than building them from scratch. Our team spent so much time measuring and cuttingABS pipes, when we could have just bought the same components from a used Kijij or Facebook Marketplace product. These components would have accelerated the construction of our prototype, while still being low-cost and decent quality. We would not have had to pay for shipping nor commute long distance for parts.

If our team had additional time to complete our product, we would have incorporated aluminum components into our final design. We could have learned to weld anodized aluminum with the TIG welder, and implemented aluminum legs, braces and slots instead of using ABS. This would have increased the strength, and safety factor of our shower chair. In addition, our team would have redesigned the plastic clip system so that both sets could be attached to the seat. This would have improved the practicality of the shower chair and prevented the clips from getting lost. Lastly, we would make the chair a little bit more aesthetically pleasing, with another layer of spray paint to prevent the beautiful flame and black finish from wearing off.

8 Bibliography

MakerRepo (2022). “Team Aqua” https://makerepo.com/SamuelFindling/1388.team-aqua (Accessed Dec 11th 2022)

APPENDICES

9 APPENDIX I: Design Files

All the required design files are to be accessed through the MakerRepo website. The Solidworks prototypes and Onshape clip designs can be accessed there.

Table 3. Referenced Documents

Document Name	Document Location and/or URL	Issuance Date
MakerRepo Documents	https://makerepo.com/SamuelFindling/1388.team-aqua	Dec 11th, 2022