THOMPSON RIVERS UNIVERSITY

ENGR 1100 - Engineering Design I

Project 3 - Cerebral Palsy Chair

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1 Introduction

Cerebral palsy is one of the most common physical disabilities all over the world. In Canada, 1 out of 400 individuals is diagnosed with cerebral palsy, a disorder that prevents the individual from moving due to the impairment of the developing central nervous system [1]. There are many types of cerebral palsy, some that are not that severe, but can make it a hard time to control arms and legs to some which can affect the entire body with awkward movements that are uncontrollable [2]. These individuals are bound to use walkers or chairs for most of their life, as they cannot move certain parts of their body. Living with these challenges can also be difficult and frustrating for people who have cerebral palsy as it can lead to emotional and behavioral problems such as anxiety and depression. These problems can also make it harder to make friends and to do activities as others are more likely to get upset or find it difficult around these people [3]. These people who have cerebral palsy need a unique chair. That is where our cerebral palsy chair comes in.

To begin with our cerebral palsy chair, we came up with many ideas on how to create a reliable, easy to build chair that can also be used as a walker for children who have cerebral palsy, while following the project requirements and constraints. Our goal was to first come up with a design for a cerebral palsy chair that is able to support a child, while allowing the child to move around freely. We built these designs using the program SolidWorks to come up with the best possible cerebral palsy chair. After choosing our final design, we built a 1:1 scale version of it, where we then did all the necessary tests to ensure that they fit the project requirements and constraints.

Through this report, we will discuss the problems we faced when designing and building a chair for children who have cerebral palsy. We will also discuss the other solutions that we didn’t use but took some inspiration from to come up with our final design. Additionally, the environmental, societal, safety, economic considerations as well as sustainability are some other key factors that will be discussed throughout this report.

2 Design Problem

2.1 Problem Definition

Wheelchairs for children with cerebral palsy will range in price depending on the make, model, and accessories. Costs will also depend on the store and the manufacturer. Countless families cannot afford some of the abrupt prices that come with the mobility aid that their child needs. Sometimes insurance plans will cover the costs of necessary aids in many cases. Another option is to purchase a used wheelchair or scooter. This comes with the inconvenience of ensuring it is inspected thoroughly to guarantee it is working and meet the child's needs. That is why a low-cost made from recyclable material wheelchair is an excellent option for those who cannot afford a more expensive one. Our solutions are also robust, lightweight, easy to assemble and disassemble, and it is strictly tested to meet all the possible user requirements [4].

2.2 Design Requirements

2.2.1 Functions

- Our design has to meet all requirements just as any regular wheelchair would. One of the main aspects and probably the most important is to hold a child 2-3 years old safely. A wheelchair must provide proper fit and postural support. Customers expect something that will work correctly and won't have any problems in the near future, considering that they are expensive. Therefore, it has to satisfy security and durability standards. One of the main disadvantages is that children with cerebral palsy have impeded mobility, hence our design's ability to allow movement in various directions, enabling them to engage in more activities. Another important aspect is the time children spend on this type of equipment, needing a comfortable and pleasant seat or holder to spend long periods without discomfort. That is why our design needs to hold the child by giving a perfect fit without pain for a long time.

Safe for a 2-3-year-old kid	10
Easy to assemble/disassemble	7
Easy to store	6
Easy to move around	9
Comfortable	8
Low retail price	8
Low manufacturing cost	7

Table 2.1: Importance Chart

2.2.2 Objectives

- This project aims to have a secure product that can take more of the weight of an average of a 2/3-year-old child. The easy movement is also a crucial aspect for children to be able to do in their regular lives with the least amount of problems because of their mobility impairment. Also, an added attractive design will make kids feel comfortable when using the wheelchair. All of that for a low price thanks to the recycled, environmentally friendly, and very lightweight materials used.

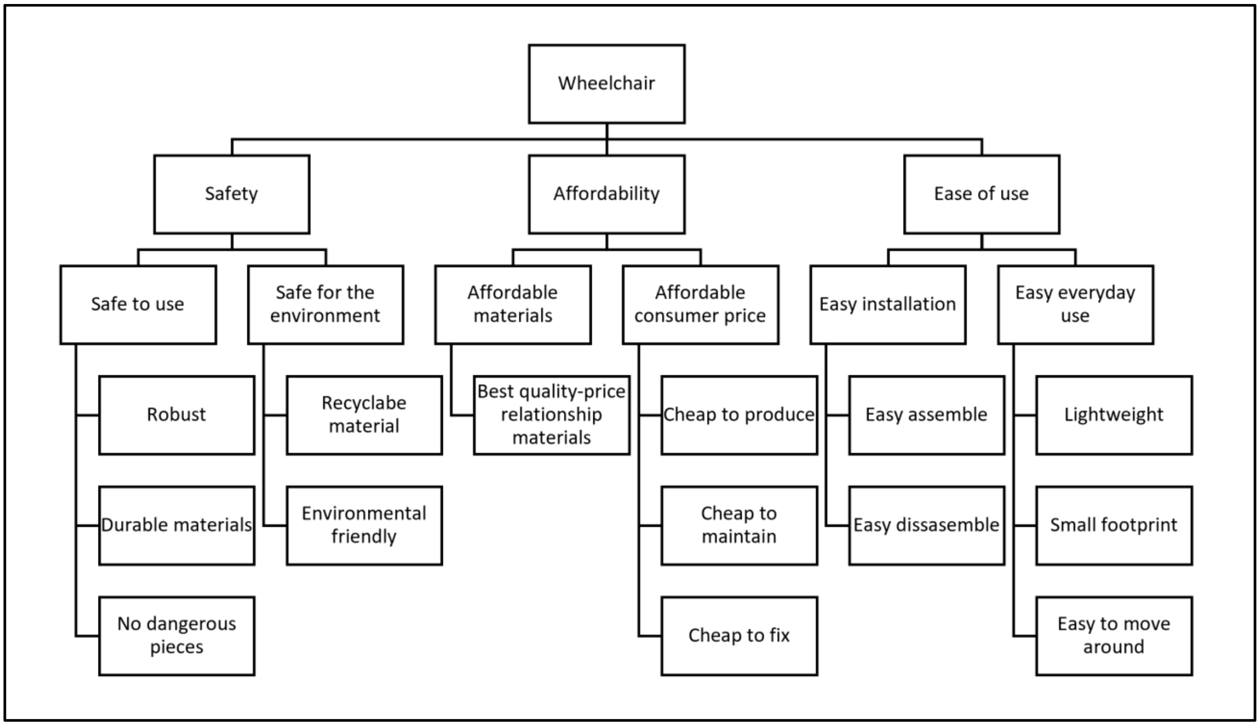


Figure 2.1: Objective tree.

2.2.3 Constraints

- Some of the constraints of this project are, for example, the amount of weight it can take. Our design is made from cardboard, which does not harm the environment while being a very portable solution. Based on that, it is clear that even though the minimum weight of 35 pounds is satisfied, there might be users that couldn't use the product in extraordinary circumstances. Another constraint is the development time of the project. Even though we have a very sturdy and useful design, we know that many improvements can add extra functionalities and improve the overall production quality. Another vital thing to consider is the safety of the user. A child with cerebral palsy can find danger on lots of simple things like sharp edges, small parts that can pose a choking hazard, among others. That is why we have to pay attention to the details to ensure optimal protection.

3 Solution

3.1 Solution 1

We wanted to make something robust with all the functionalities a standard wheelchair would provide for our first solution, but we wanted to do something different too. We started by brainstorming, and we gathered some features we thought we must have on our design, and then we also gathered some that we thought were innovative and exciting to have. We came up with a design that focused on the freedom of movement and comfort when using our product. We had a central arch intended to hold the child with a type of harness instead of a typical solid seat that feels very uncomfortable after a long period of use. The arch is connected to a horizontal 'U' shape to give extra support and divide the weight into four wheels making it sturdier. We can see how it was intended to be structured in Figures 3.1.1 and 3.1.2.

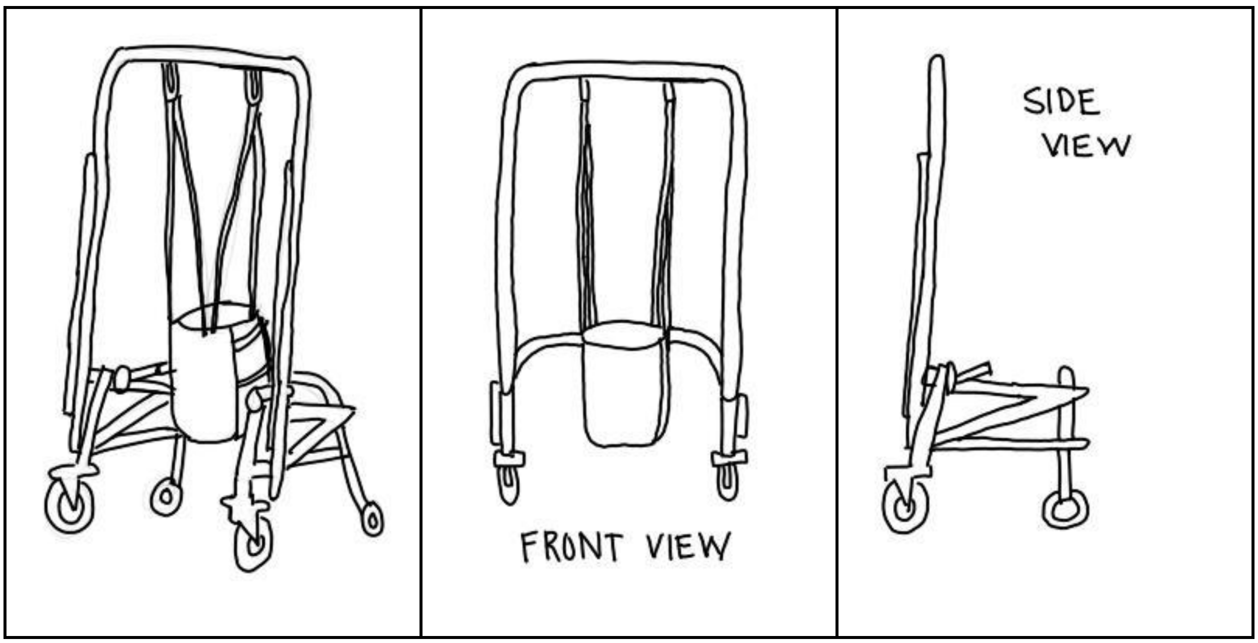


Figure 3.1.1: Rough sketches of our 1st design with different views.

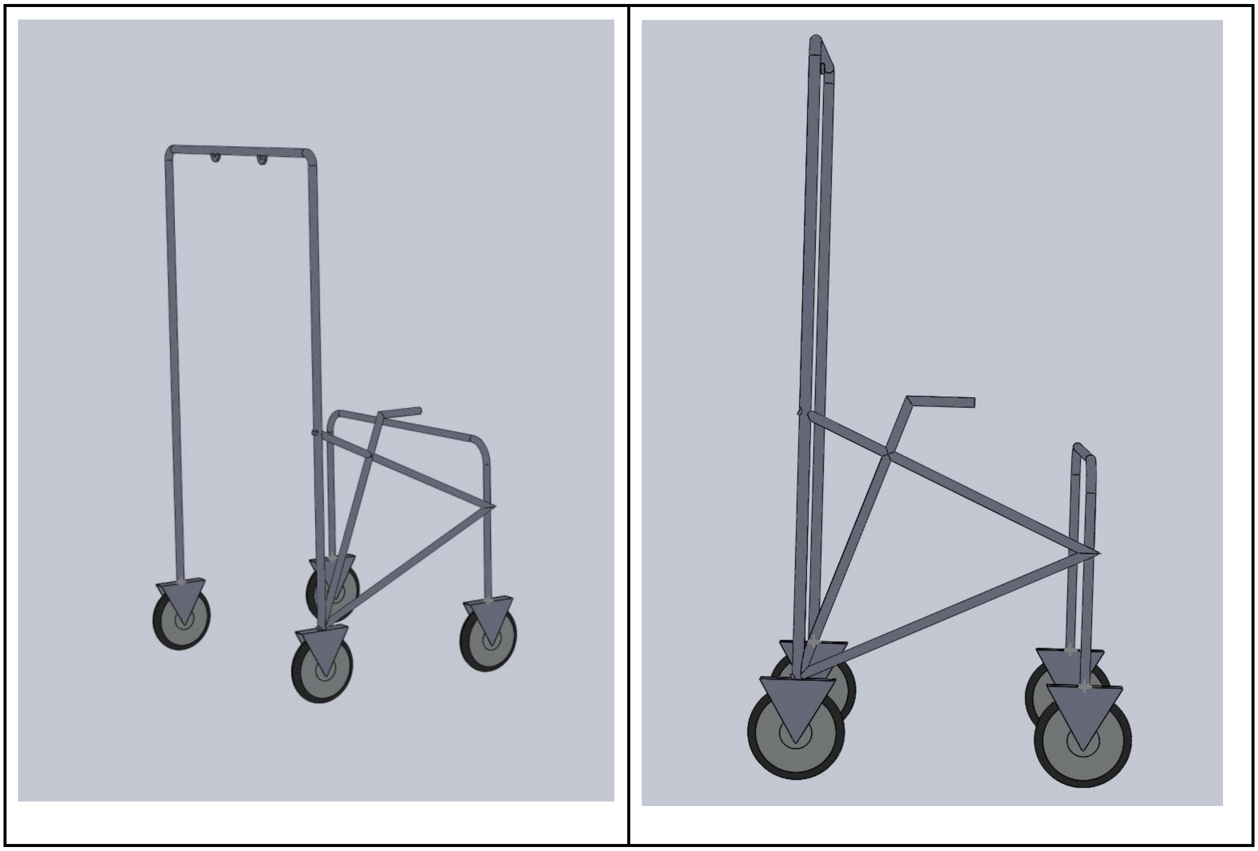


Figure 3.1.2: SolidWorks build of our 1st design.

In the end, we found that we could structure everything more efficiently, having almost all the same functions covered in a different form factor. We also found that the big arc would be an accessibility problem when going into small places. That is why we came up with solution two, a design that evolves from the first and makes everything easier.

3.2 Solution 2

For our second solution, our approach was to make a simpler cerebral palsy walker design that was able to be used as a walker and a chair, depending on what the user requires. The frame is simple with the front half slanted for a maximum balance of the walker. For this walker, there is a built-in chair located on the back of the frame that can be easily pulled down for the user to sit on. The walker also has 2 sets of handlebars, one in the front for the user to use and one in the back for a parent/caretaker to push when the user is sitting down. When the user sits down on the chair, 2 foldable footrests can be folded inward for the user to relax their feet on. At the end of each leg, there are wheels that help the user move around either in the walker position or chair position.

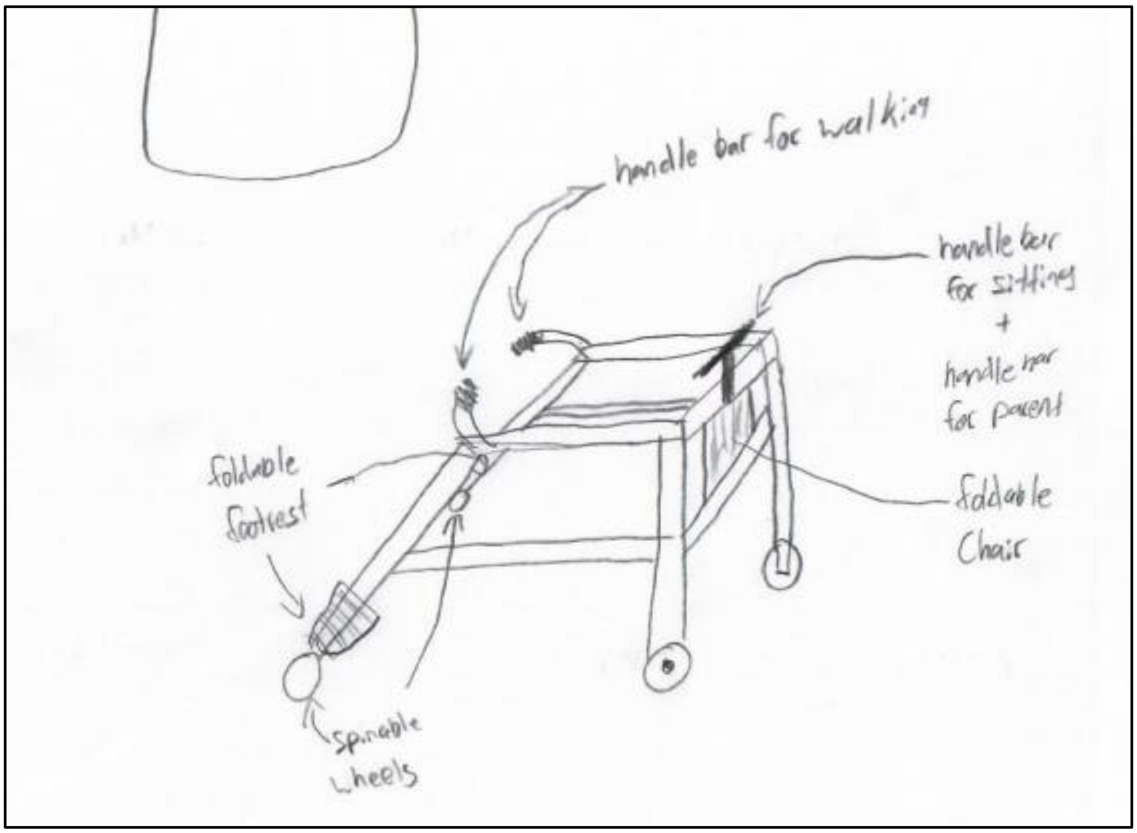


Figure 3.2.1: Rough sketch of our 2nd design.

We did not choose this design as we found that the frame did not have enough structural support to support the user. For the chair component, it was only held and attached to the backside of the frame, which would collapse very easily making us not use this design. Also, the front half of the walker could break as all the weight is being forced into 2 small handlebars from the user in the front half of the walker which could break the frame. Additionally, the user would not be able to reach the foldable footrest as they would need a parent or caretaker to help them fold and use it, as well as the chair component.

3.3 Final Solution

For our final solution, we came up with an improved design based on our second solution, which will let the user be able to easily convert the walker into a chair. The user would be strapped into a harness which would let them be able to walk around, but also be able to sit down at any time. This design is lightweight and compact as we used aluminum in SolidWorks and cardboard in the real prototype, so it can be portable and easy to use.

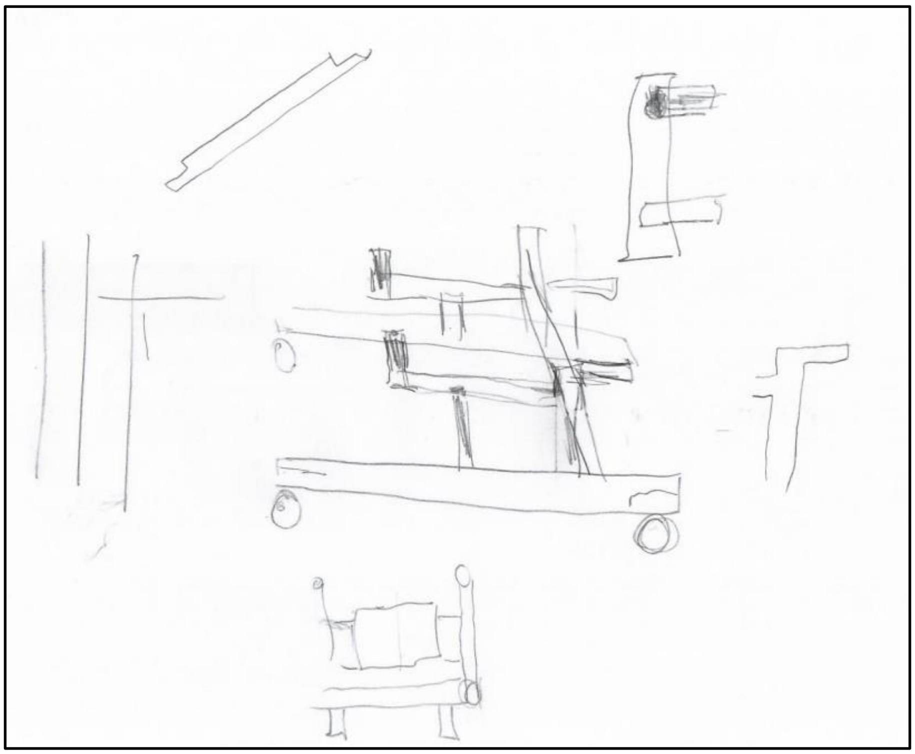


Figure 3.3.1: Rough Sketch of our final design

Figure 3.3.2: Images of the final design to scale (Multiple Views).

The reason why we chose this solution over the other solutions is that this design offered a more simple and reliable structural support system that would be able to support the user. The main base was made from one part giving it lots of structural support when compared to the first and second solutions. All the main components connect into the base which behaves as the main hub. This provides a secure fit for all the pieces as well as making it more compact and allowing it to be stored in small places. Having the wheels connected to the base rather than each leg from previous solutions would also increase the amount of durability and strength to the overall frame. This design had an overall better seating arrangement as we used a harness system which adds even more safety and security for the child when the chair is in use. The handle system was also more reliable when compared to the other solutions. The handles would bend towards the user on an angle to ensure that they can reach easily. Also, it has padding on the handles and arms for comfort for the child, unlike the other solutions.

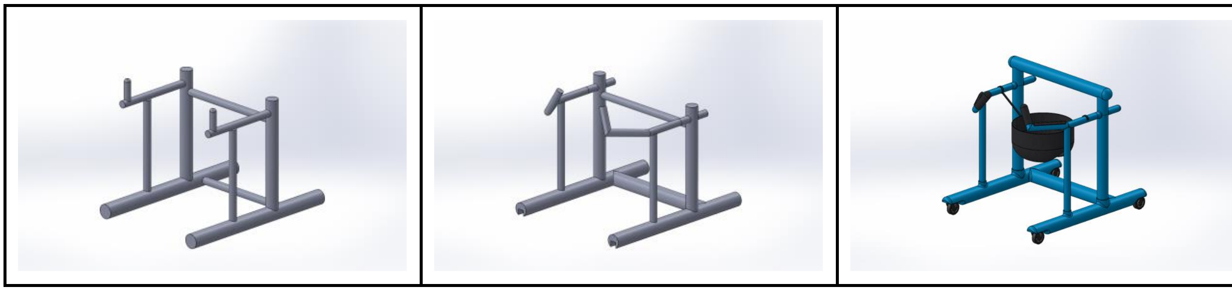
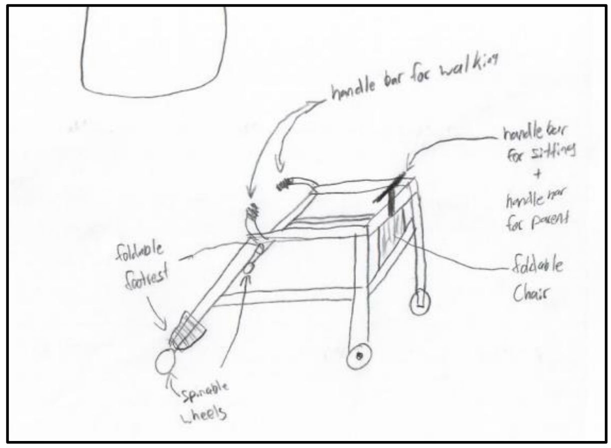


Figure 3.3.3: Iterative Process of Final Solution.

Solution 1

Has arch intended for a harness to support the user. Lacks structural support and stability. Very tall which can cause accessibility problems.



Solution 2

Small condense frame with curved handlebars. Lacks structural support for the chair. Footrest is unnecessary.

Solution 3 (Final)

Easily convertible from walker to chair. Handle Grips and arm rest for comfort. Overall better structural support.

Table 3.3.1: Comparing the 3 different solutions.

Design criteria / Weighting factor / Alternatives	Use of standard parts	Safe	Simplicity and maintenance	Durability	Public acceptance	Reliability	Cost to develop	Cost to buyer	Performance	Sum
	0.05	0.16	0.11	0.11	0.10	0.13	0.10	0.13	0.11	1.0
Solution 1	4 / 0.2	7 / 1.12	6 / 0.66	8 / 0.88	8 / 0.8	6 / 0.78	5 / 0.5	5 / 0.65	6 / 0.66	6.25
Solution 2	7 / 0.35	8 / 1.28	8 / 0.88	9 / 0.99	8 / 0.8	7 / 0.91	7 / 0.7	6 / 0.68	8 / 0.88	7.47
Solution 3	8 / 0.4	9 / 1.44	9 / 0.99	9 / 0.99	8 / 0.8	9 / 1.17	7 / 0.7	8 / 1.04	10 / 1.1	8.63

Table 3.3.2: Decision Matrix comparing all 3 solutions

3.3.1 Components

The base of the walker acts as the main structural support for the entire design. It is where all the other components join together to form the walker. The top support on the walker joins with the two arm components, by preventing them from moving around. The left and right arm components is where the user would hold onto when using the walker. Each arm piece has two straight poles that will be able to lock into a connector, which is built into the base. On each arm, there are two arm covers that help cushion the user's arms when holding onto the arms. There are also two hand covers to help the user to grip onto as well as provide comfort. The harness/chair provides support and security that prevents the user from falling out of the walker. There are four wheels that allow the walker to move around smoothly. In the wheels, there is a part called the wheel hub, which connects the wheel and bracket, allowing the wheel to spin around. There are two front-wheel brackets that attach on the underside side of the base, which allow the wheels to swivel around to help the user go in any direction they want. There are also two back wheel brackets that attach to the underside of the base and are stationary to help with movement. We have a total of sixteen-wheel screws that attach the two different wheel brackets to the base of the walker to keep them secure. In the following figures, you will see the sketches of the following components that provide images and dimensions.

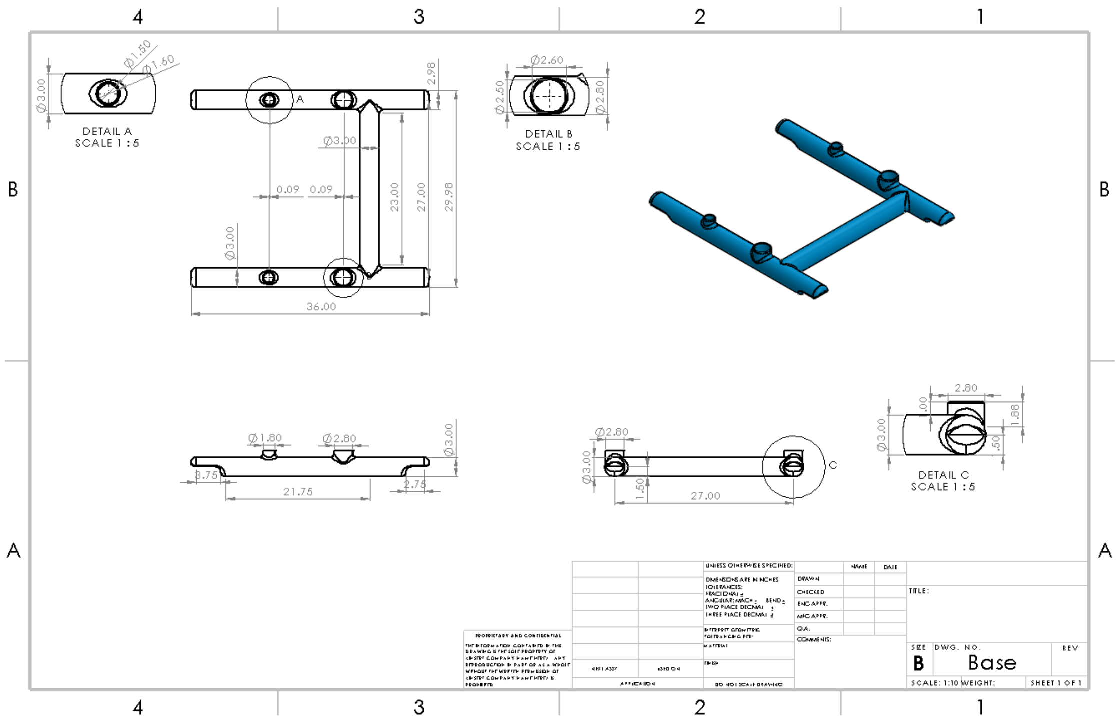


Figure 3.4.1: The sketch and dimensions of the base of the walker.

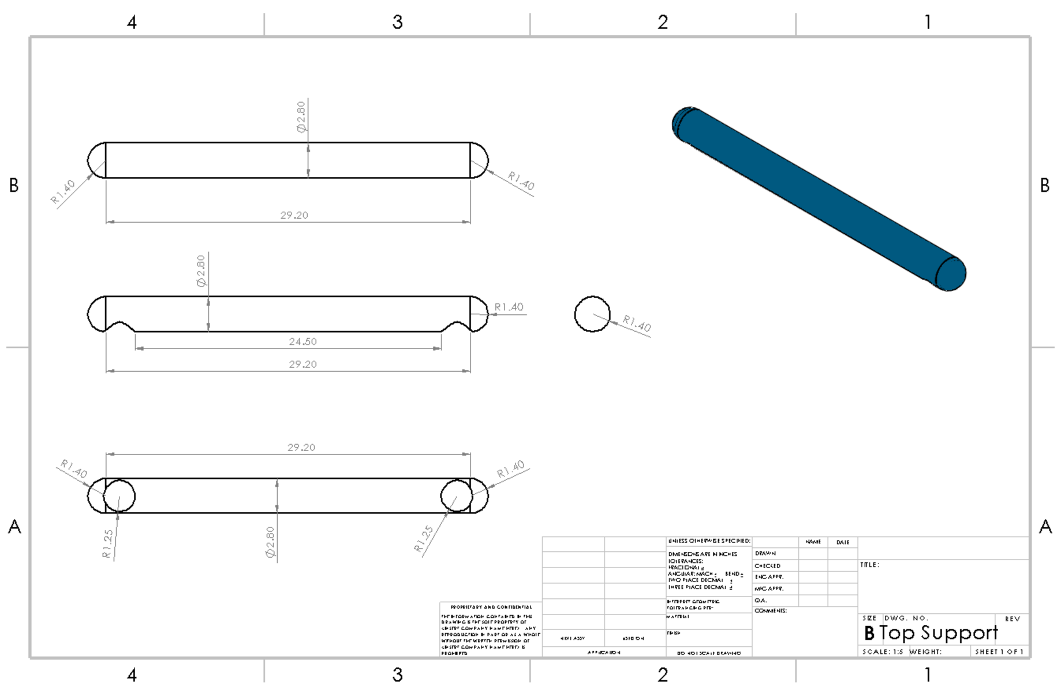


Figure 3.4.2: The sketch and dimensions of the top support.

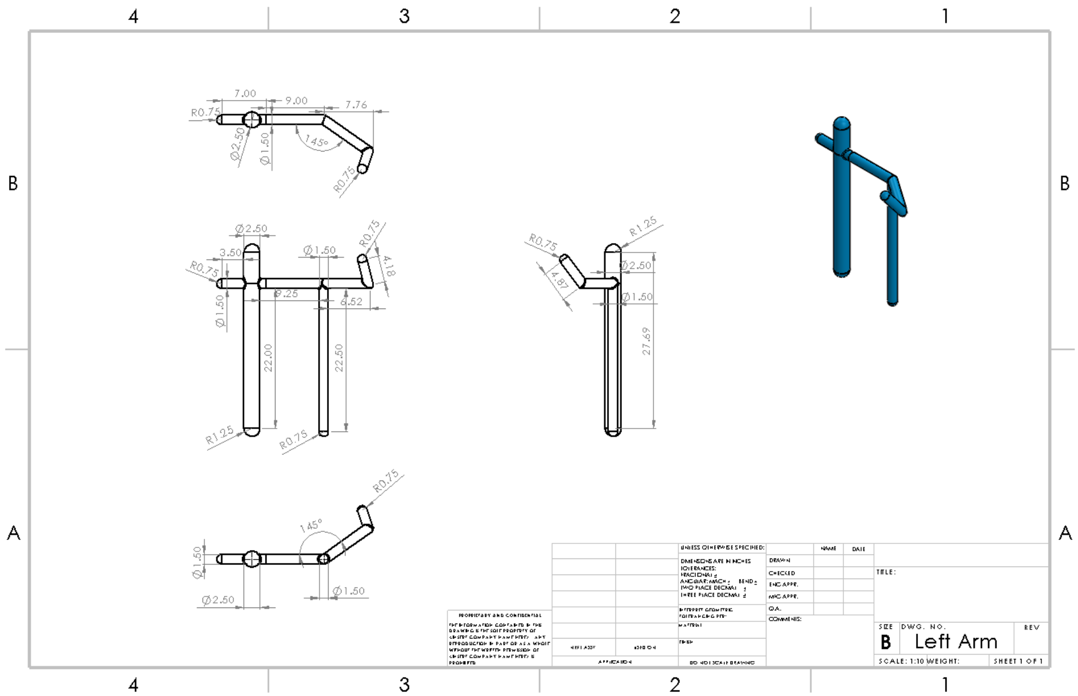


Figure 3.4.3: The sketch and dimensions of the left arm.

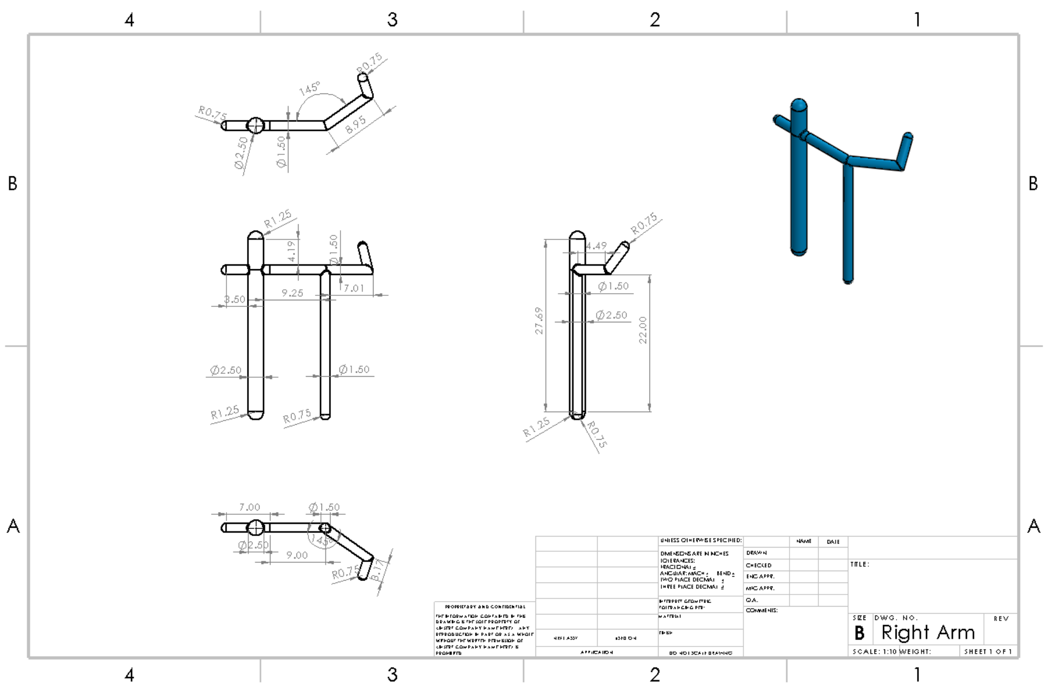


Figure 3.4.4: The sketch and dimensions of the right arm.

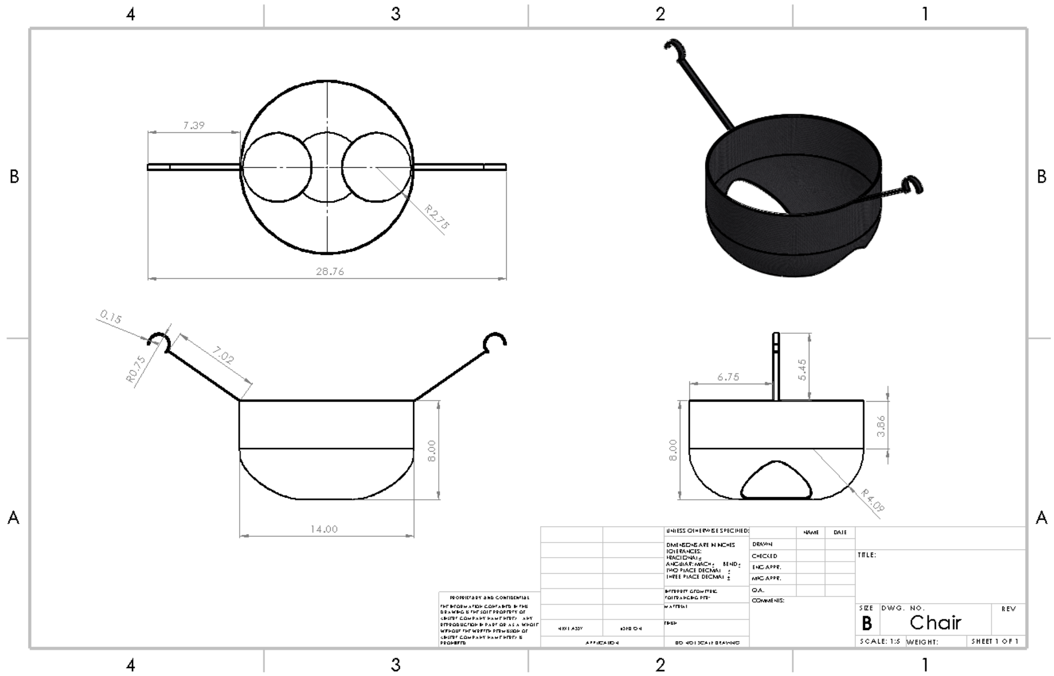


Figure 3.4.5: The sketch and dimensions of the chair/harness.

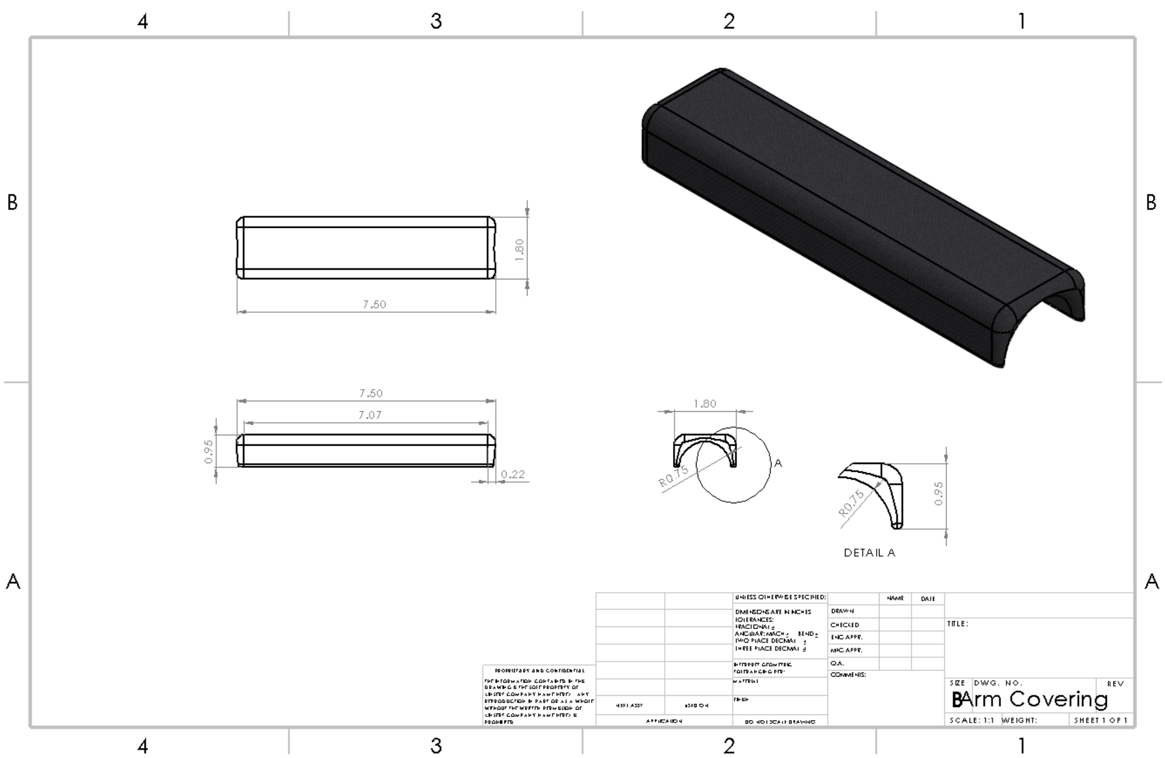


Figure 3.4.6: The sketch and dimensions of the arm covering of the handlebars.

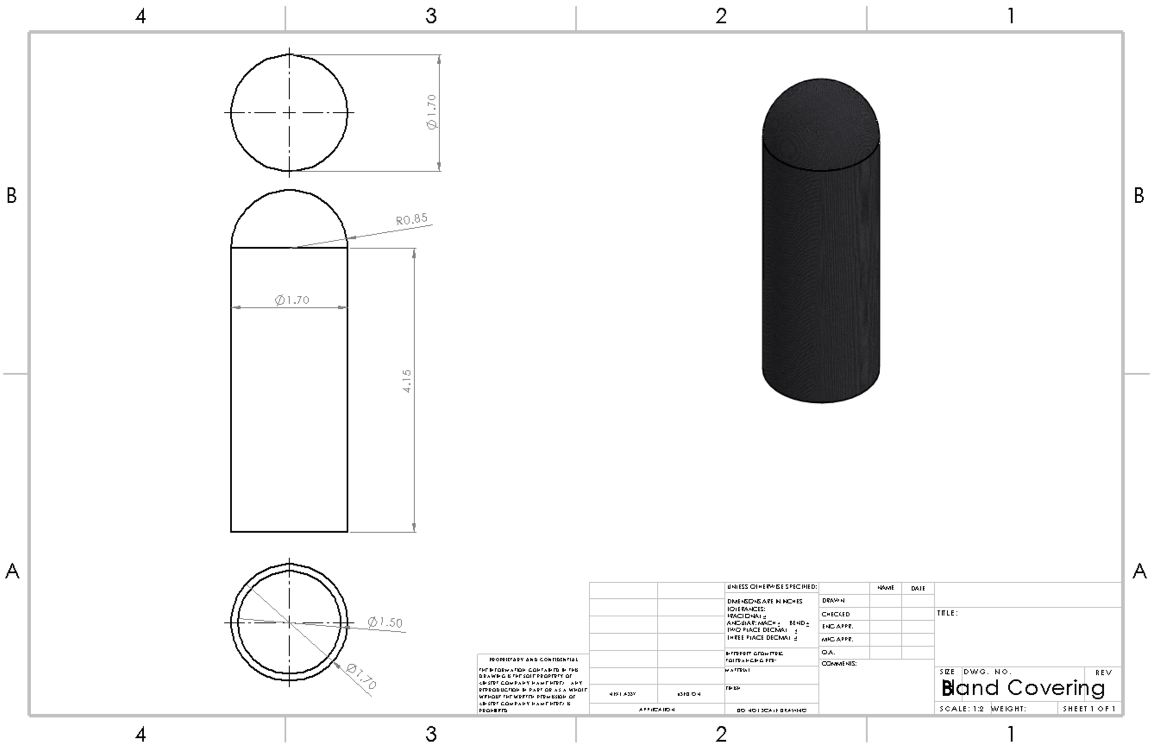


Figure 3.4.7: The sketch and dimensions of the band covering of the handlebars.

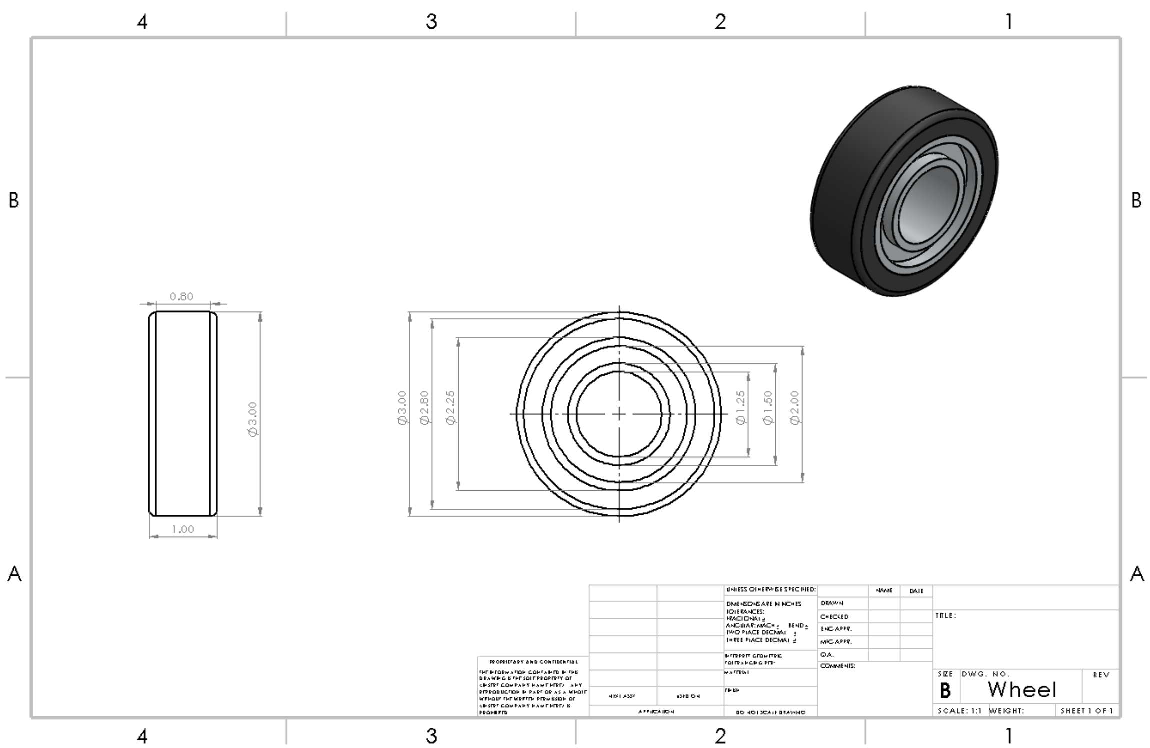


Figure 3.4.8: The sketch and dimensions of the wheel.

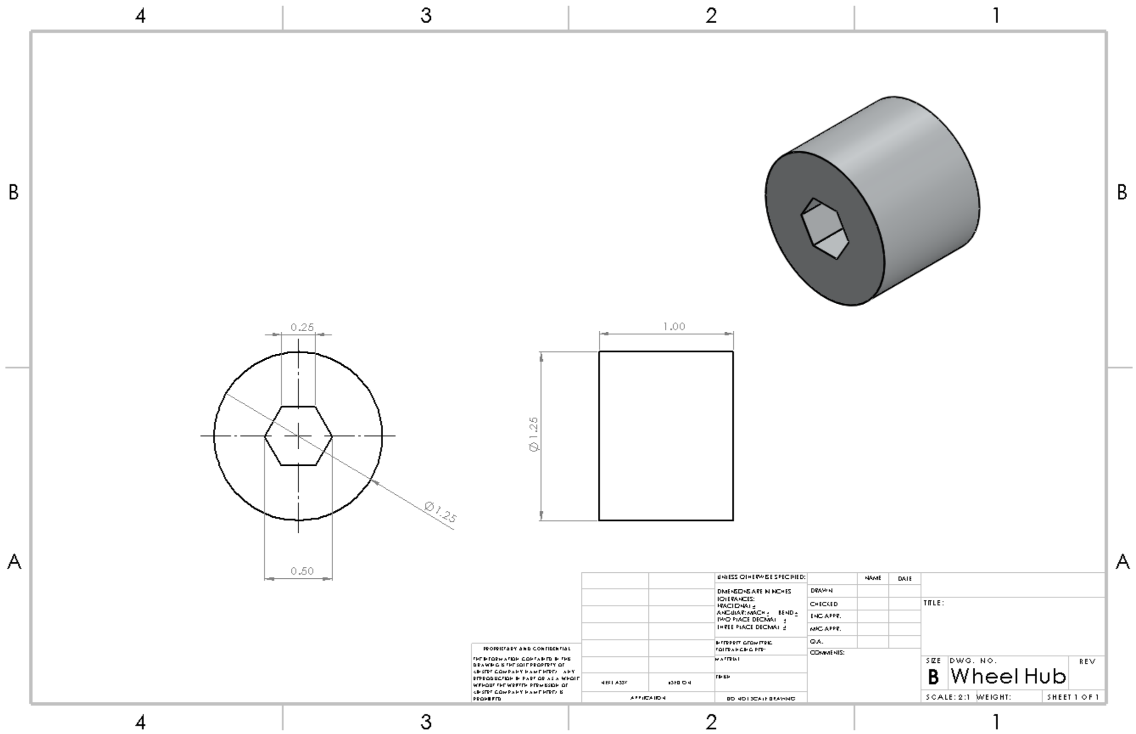


Figure 3.4.9: The sketch and dimensions of the wheel hub.

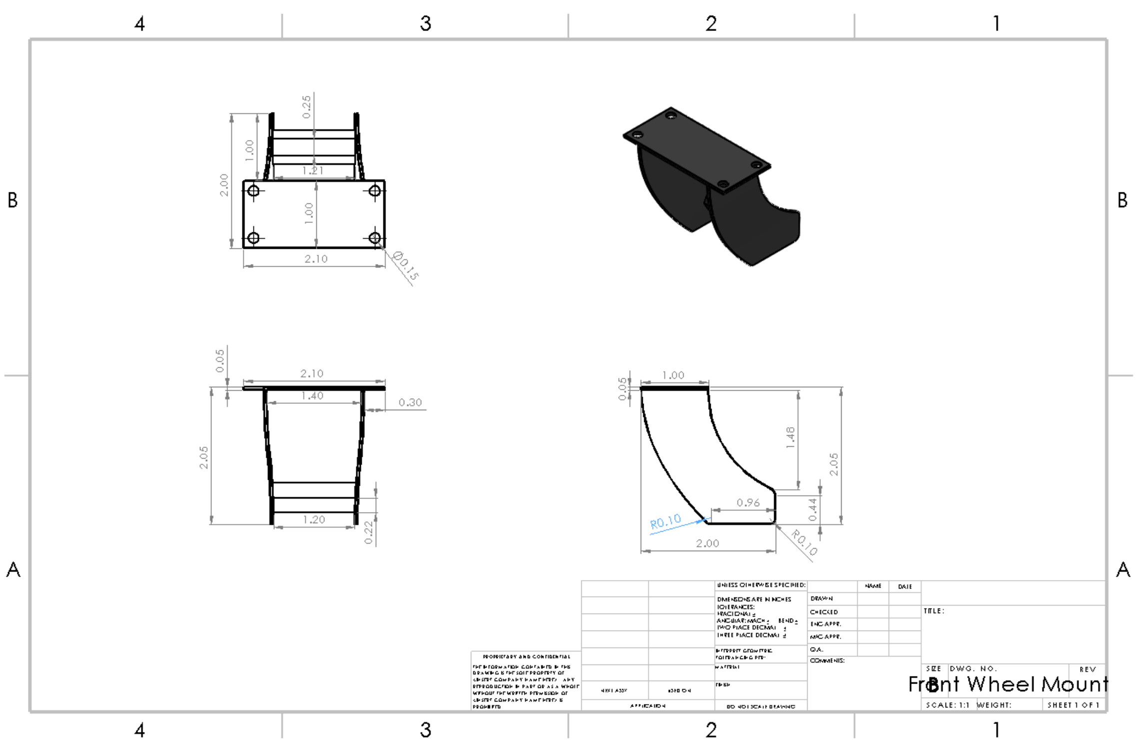


Figure 3.4.10: The sketch and dimensions of the front-wheel mount.

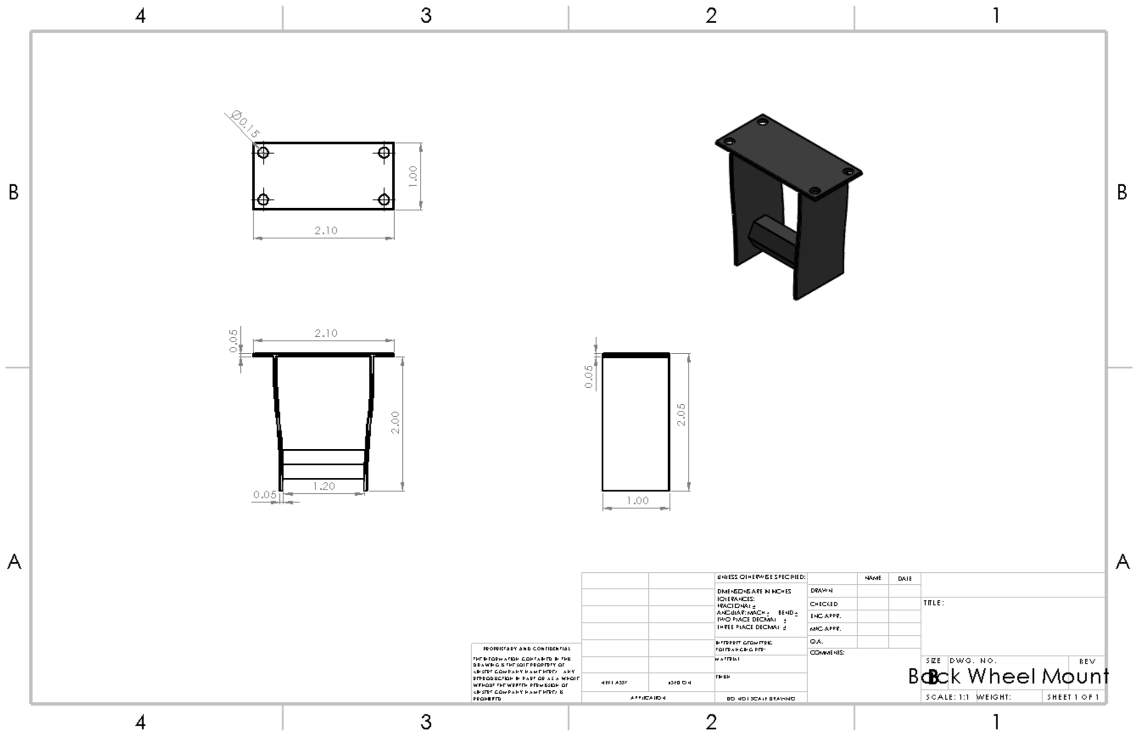


Figure 3.4.11: The sketch and dimensions of the back-wheel mount.

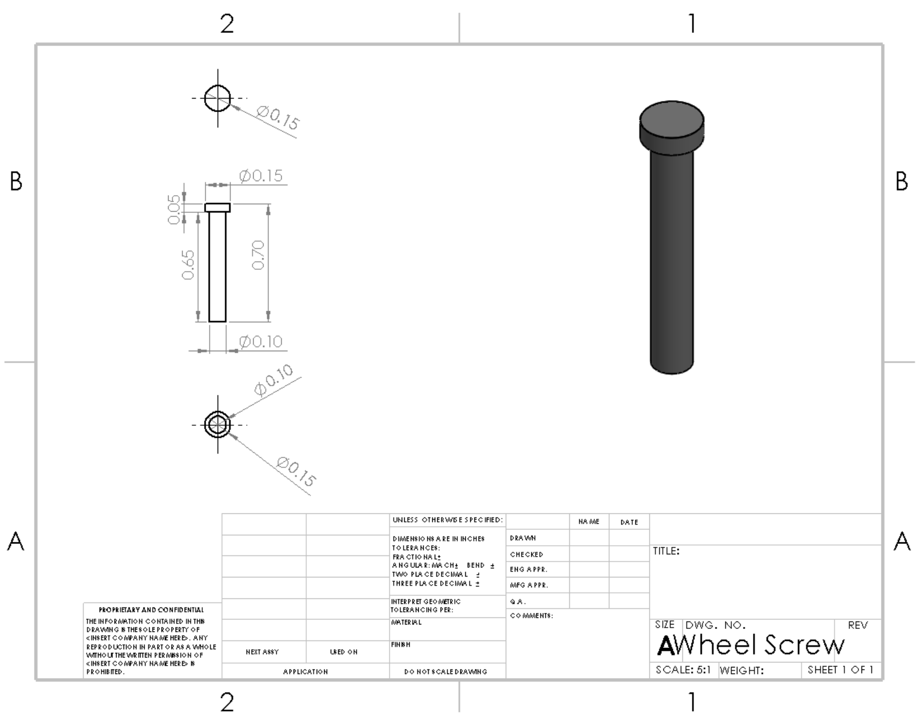


Figure 3.4.12: The sketch and dimensions of the wheel screws.

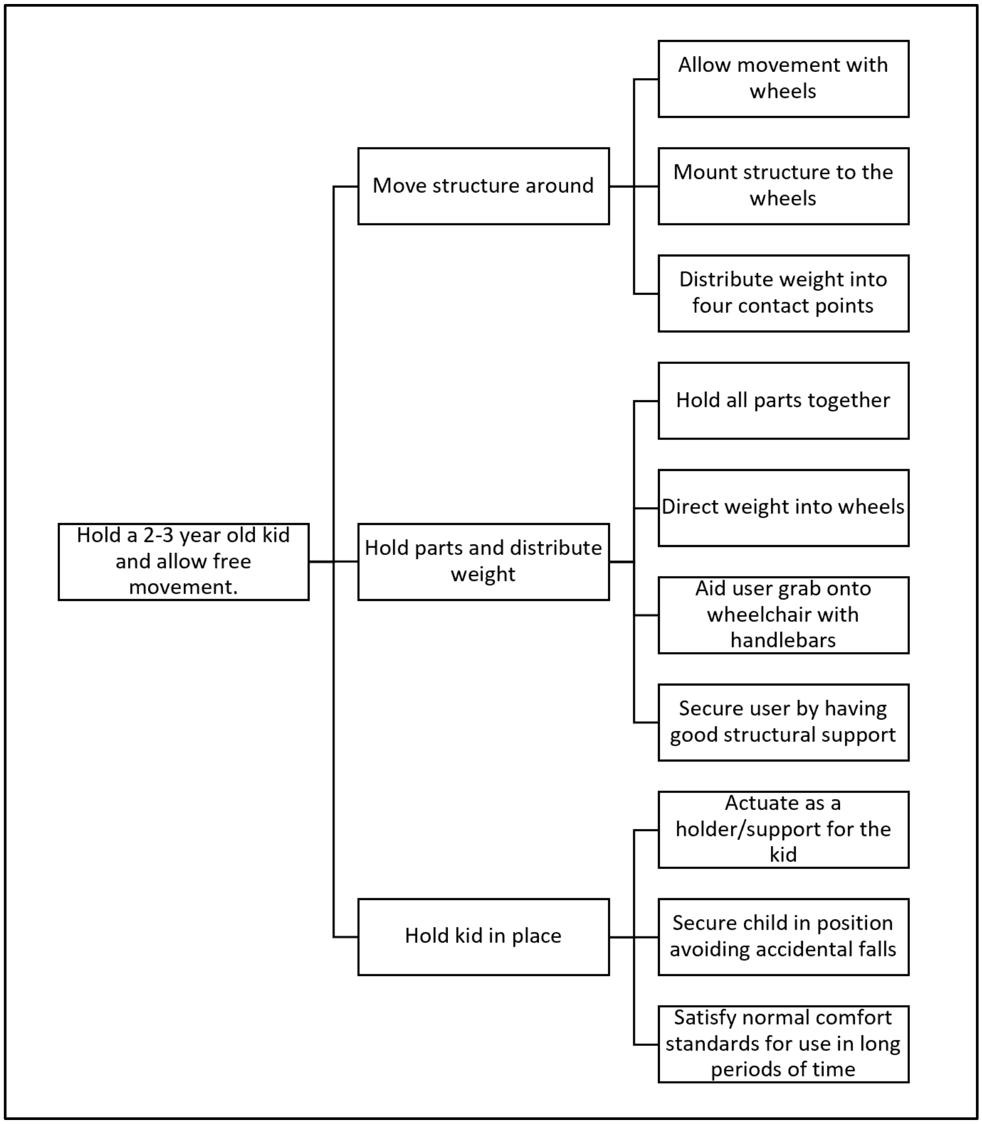
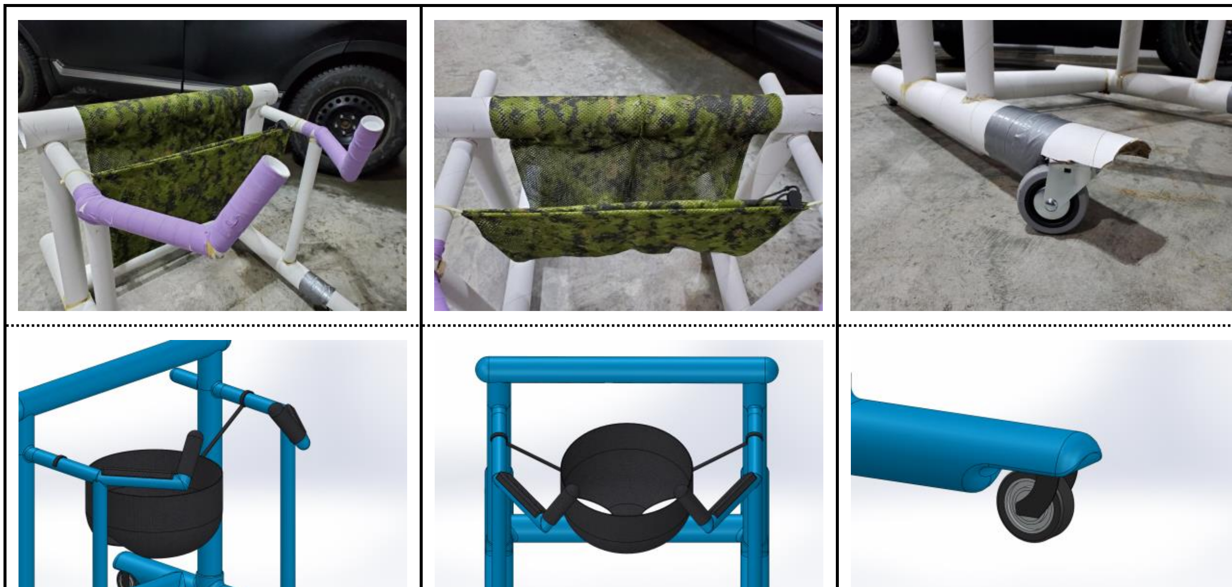


Figure 3.5: Function Tree.

3.3.2 Features

The features for our final design is that it is lightweight, compact, and portable, allowing it to be stored and used with ease. With this design, the cerebral palsy walker has four wheels, where the front wheels can swivel around allowing the user to go in any direction they please. On the side of the arms, we have padding for the handles and arm placements for comfortable usage for the user. With our seat, we are instead using a harness system, allowing the user to be securely attached to the chair, instead of having them sit on a normal seat. It will also allow them to sit in the harness but can move at the same time. The harness would be adjustable for any kind of child who uses it.



Handgrip & Arm placements (Padding)	Harness System (Seat)	Wheels (Front Wheels Swivel)

Figure 3.6: Showing the final design features.

3.3.3 Environmental, Societal, Safety, and Economic Considerations

When designing our cerebral palsy walker for a child, we took into consideration for the walker to make sure that it was environmentally friendly, safe to use, and inexpensive. We also wanted to take into consideration what materials were used when designing and constructing the final design.

For environmental considerations, we built our SolidWorks version of the final design out of aluminum 6061 alloy. This is one of the most common types of aluminum around the world, which is very lightweight, durable, and strong. We used aluminum for the frame of the design because it is sustainable, can be recycled multiple times, and can be melted down to use for other purposes without losing quality. The process can be repeated over and over as recycling aluminum saves around 95% of the energy needed to make the metal from raw materials [5].

With our real-life prototype, we constructed the entire frame out of all cardboard, which can be recycled very easily and be used for other purposes. We used LePage Multi-Purpose White Glue, which is a versatile, general-purpose glue that is water-based and non-toxic making it safe to use [6].

For safety considerations, the entire frame for the final design on the SolidWorks version, as well as the cardboard version, have no sharp edges to prevent the user from getting any kind of cuts or scrapes. Both versions use tube shape pieces to further improve the smooth surfaces as well as provide extra structural support to the entire frame. We added padding to the handles and arm placement to provide a comfortable surface that the user will be in contact with. Additionally, we chose to go with a harness kind of seat that would further protect the user by safely securing them in the harness, unlike a normal seat. The harness would be made out of some fabric to ensure that the user is comfortable when using the walker.

For economic considerations, we chose to build the mainframe out of aluminum 6061 alloy in our SolidWorks version rather than other kinds of metals. This is because aluminum is far more cheaper than other metals such as titanium that can do almost the exact same thing and is more common to find. With our real prototype, we built the mainframe out of cardboard tubes which are very cheap and can be very durable if used right. In total, we spent a little over $40.00 on all the necessary supplies to build our prototype. This includes cardboard tubes, wheels, glue, and tools. Both versions have a measurement of 35 X 31.5 X 30 inches which allows a child to easily fit and be able to use the walker.

3.3.4 Limitations

The limitations for the final design is that we had to build our real cerebral palsy walker out of all cardboard, which makes it less durable than something made out of wood or metal. By using stronger materials, it would provide better structural support around the entire frame when in use. Also, the real prototype is not weather resistant. If the real prototype sits in the rain or any wet conditions, it will lose durability. The design is adjustable, but it requires you to change the sidearm components for certain heights. This can cost more money as the child grows.

4 Team Work

4.1 Meeting 1

Time: November 14, 2020, 1:00pm to 3:00pm

Agenda: Designing Possible Solutions for Cerebral Palsy Walker

Team Member	Current Task	Completion State	Next Task
Luka	Coming up with Solutions	50%	Continuing to look for other solutions
Toma	Coming up with Solutions	50%	Starting report/research
Emiliano	Coming up with Solutions	50%	Design/Building 1st solution

4.2 Meeting 2

Time: November 16, 2020, 5:00pm to 6:30pm

Agenda: Discussing the designs

Team Member	Current Task	Completion State	Next Task
Luka	Coming up with Solutions	80%	Build an iteration of the final design on SolidWorks
Toma	Designing 2nd Solution	90%	Starting report/research
Emiliano	Designing 1st Solution	70%	Build 1st solution on SolidWorks

4.3 Meeting 3

Time: November 20, 2020, 2:00pm to 3:45pm

Agenda: Start Research/Report, continue to build prototypes on SolidWorks

Team Member	Current Task	Completion State	Next Task
Luka	Finish building the first iteration of the final solution	95%	Start the final iteration of the final design
Toma	Researching and writing report	30%	Continue to research and write the report
Emiliano	Finish building first solution on SolidWorks	85%	Start writing the Design Problem

4.4 Meeting 4

Time: November 22, 2020, 4:00pm to 6:20pm

Agenda: Talk about the final design, discuss how to build real-life prototype

Team Member	Current Task	Completion State	Next Task
Luka	Finishing the final solution design on SolidWorks	95%	Building Real-Life Prototype
Toma	Continuing to research and write report	60%	Building Real-Life Prototype
Emiliano	Working on various charts and tables	60%	Researching for the report

4.5 Meeting 5

Time: November 28, 2020, 1:00pm to 2:30pm

Agenda: Talking about and finishing the report

Team Member	Current Task	Completion State	Next Task
Luka	Create Sketches for final design and help finish the report	85%	Record testing of Real-Life Prototype
Toma	Finishing Report	89%	Record testing of Real-Life Prototype
Emiliano	Start making Exploded/Collapse Video	60%	Start making PowerPoint

4.6 Meeting 6

Time: November 29, 2020, 1:00pm to 2:30pm

Agenda: Finishing PowerPoint video

Team Member	Current Task	Completion State	Next Task
Luka	Making PowerPoint Video	40%	Hand in Project 3
Toma	Making PowerPoint Video	40%	Hand in Project 3
Emiliano	Making PowerPoint Video	40%	Hand in Project 3

5 Conclusion and Future Work

In conclusion, we achieved plenty of considerable designs on how to create a cerebral palsy walker. First off, we came up with a couple of designs that could be used to make the best possible cerebral palsy walker that can also be used as a chair, while following all the constraints. Our objective was to build and assemble a prototype of a cerebral palsy walker on the program SolidWorks from the sketches we came up with. After completing the virtual prototype, we had to build and assemble a simple, lightweight cerebral palsy walker made from cardboard, that can be used by children who have cerebral palsy while being cheap, accessible, and sustainable.

From our research, we found out that people with cerebral palsy can suffer many aspects of everyday life. People with cerebral palsy have to take additional time to do certain activities when compared to others who may be able to do more quickly and easily. These people will also have to be supervised by a parent and/or caretakers to maintain maximum safety. Many of these individuals can have problems with their chair or walker, as they can be very bulky and heavy, causing the user to slow down. It can also be very expensive to repair and to adjust if there are any problems with the chair/walker [7]. By having a simple, lightweight, and robust cerebral palsy walker that can be used also as a chair, which can help these individuals immensely.

From researching the importance and the need for cerebral palsy walkers/chairs, we developed 3 different, yet similar designs with each one having its advantages and disadvantages. Our first design was more focused on the freedom of movement and comfort for the user. The design had a central arch that had the purpose to support the child with a type of harness that would act also as a seat. We soon found out that the arch would cause accessibility problems when going through small spaces. This design was tall and large, which could be condensed down to help make this design more accessible. For our second design, it was a simple, lightweight design, having 2 handlebars in the front for the user to hold on to, a folding chair in the back if the user needs to sit down and 2 foldable footrests for the user to rest their feet on. When designing this solution, we found out this design was not structurally supported as it would collapse on itself. As the user holds onto the handlebars, they would apply a force onto the handlebars, which would cause the walker to start caving in on itself. The built-in chair also has the same problem as it could not fully support the user, because it was only attached to the backside of the walker. Finally, the user would have a hard time trying to reach the footrest as they would need a parent or caretaker to help them use this feature.

In the final design, we achieved all our functions, objectives, and constraints that we listed in our design problem. Our final solution was designed on SolidWorks and was out of aluminum, while the real-life prototype was built out of cardboard tubes. Both aluminum and cardboard materials are affordable, highly recyclable, lightweight, and durable. It has structural support all around the design to make sure that the child is safe and can withhold a 2-3-year-old child. The real-life prototype can also sustain 35lbs or more. The edges of each part are smooth with no sharp edges to prevent a child from getting potential cuts and scrapes, as well as all the surfaces, are sealed to prevent outside materials from getting inside the design. Additionally, both the SolidWorks and real-life prototype designs can be easily assembled and can convert from a walker to chair depending on what the user requires.

For future improvements for the final design, we would add telescopic pieces in the arms and the base of the design in order to adjust the width and height. This will help users and save them money as the design would be able to change heights depending on how tall the user is, as well as the width size for users big or small. To further improve the design, we change the chair into a harness, which provides more safety and security for children when in use. We would also add a variety of different colours for children to choose from, allowing them to be personalizable. Finally, we would test different types of weather coating to further protect the design from corroding and making it weather resistant.

6 References

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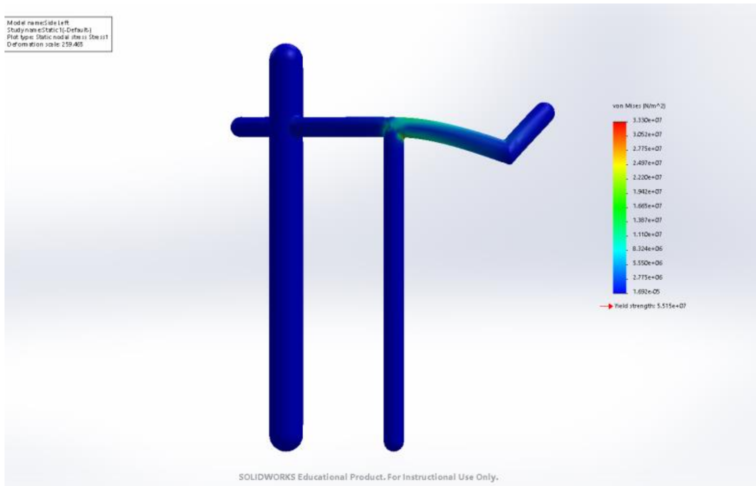
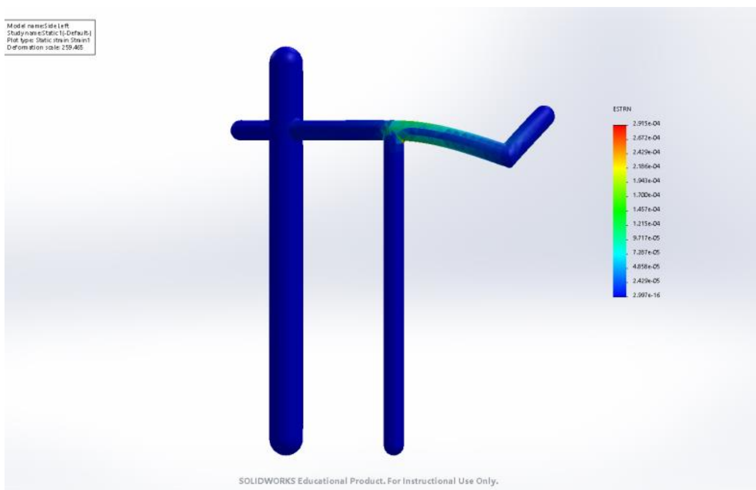
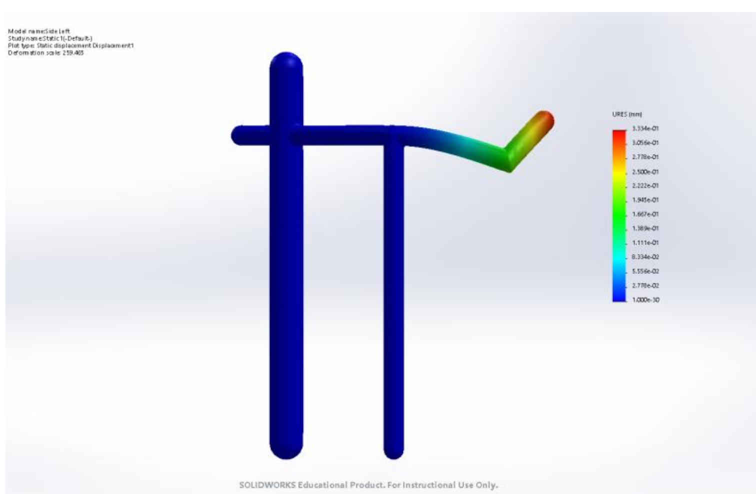
7 Appendix

Below, you will see some additional photos that we took for the cerebral palsy walker.

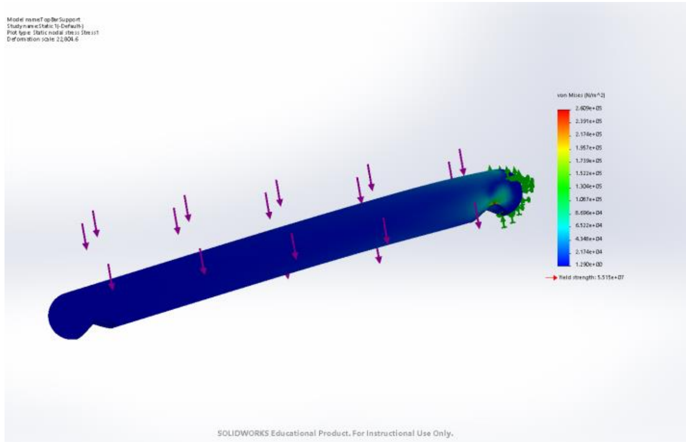
Stress, Strain, Displacement Analysis for Arm Component.

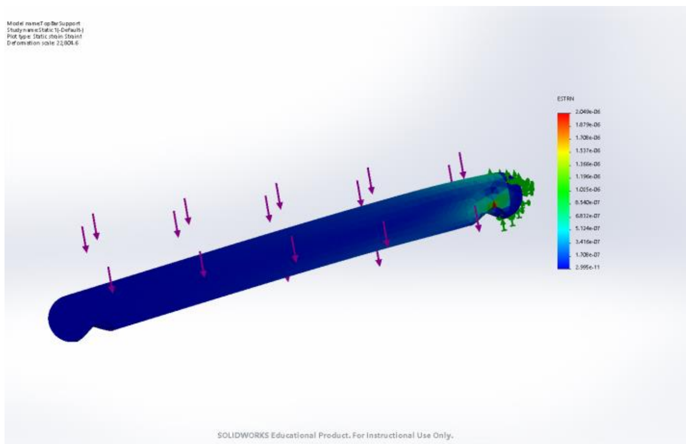


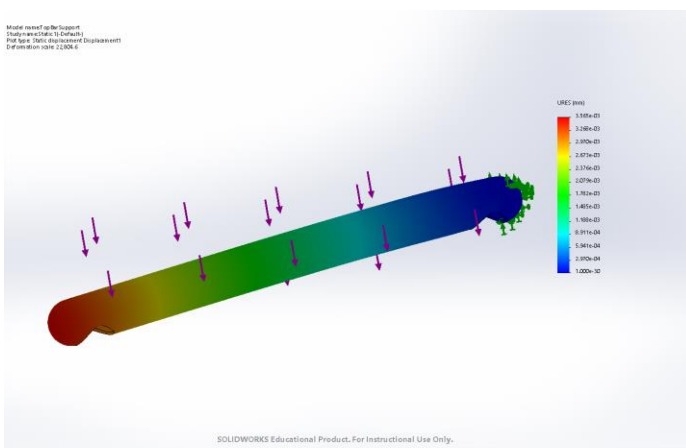




Stress, Strain, Displacement Analysis for Top Support.







Photos of building process of real prototype.