The Hope Device

Preliminary Proposals

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2018

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DISCLAIMER

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EXECUTIVE SUMMARY

The requirement of the project is to make a useful product for a person with a disability so we have decided to make the two crutches one for the left leg and second for the right leg. In order to start with the project, we have found existing designs and then we have generated the requirements from the client description. After that, we have generated the engineering requirements which will present in our design. The Black Box model and the functional model have been developed as well in this report. Also, there are the development of the system level and the sub-system level designs. Few designs ideas have generated for the design and from these designs, the final design has selected using the Pugh chart and decision matrix. Final design selected from these two methods is two crutches one for the leg movement and second for the support of the body. CAD model has developed as well for the defined design and each part has separately developed in CAD model. The design has implemented in SolidWorks and it will not implement in actual because of body variations, as for each body this product has a different dimensions. Bill of material has provided for the design in order to understand the implementation phase and with the help of BOM, this model can implement as well.

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1 BACKGROUND

1.1 Introduction

Physical challenges and disabilities create complex, influential, dynamic, multidimensional barriers which reduce, limit and restrict the freedom of movement. Findings presented by the World Health Organization (WHO) have claimed that approximately over 15% in the global population remain affected with some forms of disabilities and 2% to 4% among them experience extreme challenges in carrying out every day routine tasks (453-460) [1]. The project examines how disability negatively affects human movement. It aims at developing effective crutches for the left and right legs used based on the body strength so as to enhance the mobility of the people with leg movement challenges.

1.2 Project Description

Making supporters for people who have foot paralysis or injured and they are not able to walk. The device will make them able to walk using their hands holding the two different supporters that hold their foot. Primary goals of the project focus on providing required physical, emotional and psychological support to men, women, and children who are affected by minor or major disabilities that have caused freedom of movement. Causes of disabilities may relate to the sustaining of injuries, age factors or decrease impacts such as paralysis.

The project seeks to eliminate dependence on wheelchairs by encouraging disabled people to engage in outdoor movements like normal persons to give them an enhanced opportunity to connect with members of their community.

Crutches device planned for innovative development under the Senior Design - I Project will facilitate and support people affected with disabilities caused by injuries or born with foot paralysis to stand on their feet strongly and firmly to take care of their personal needs,

requirements and expectations in their living, work and social environments with greater acceptance, dignity, respect, and honor.

1.3 Original System

There is no original system for the product we are developing.

> "This project involved the design of a completely new hope device system. There was no original system when this project began."

2 REQUIREMENTS

In this section requirements of the project will describe. Two types of requirements that are considering for the project. One is customer requirements which have provided by our client in the form of the project description and second is engineering requirements which have obtained from the customer requirements.

2.1 Customer Requirements (CRs)

Customer requirements are determined by the client. They provide the description of the project and the requirements. The following table indicates the requirements:

Table 1: Customer Requirements

Customer Requirements
1. Easy to use/Flexibility
2. Affordability
3. Light-Weight
4. Low physical strain
5. Comfort and convenience
6. Low repairs & maintenance costs
7.Quality performance
8.Durability
9. Aesthetic design
10. Indoor & outdoor operation suitability

The next section indicates the engineering requirements.

2.2 Engineering Requirements (ERs)

Engineering requirements are derived from the customer requirements. They comprise the technical requirements of the project. The requirements have targeted values. The engineering requirements are present in Table 2.

Table 2: Engineering Requirements

Engineering Requirements	Target Values
1. Costs under $150	$150
2. Weight	5 Kg
3. Lifting capability of user	5 Kg
4.Appropriate price for spare parts ($40)	$40
5.Maneuverability	The person should rotate and change leg positions.
6.Stability	Ensure firm movement
7.Minimum changes in regular crutches	3
8.Safety	The crutches must minimize accidents
9.Instant fitting and removal	The person wear and remove them at any time
10.Maintenance cost between ($50)	$50

The team met with the TA for Senior Design 1 class Mr. Jeremy and he recommended us with materials to use and he gave us some useful sites to find what we are looking for. He also advised us to use tolerances for each part such as for manufacturing to be less or more than $50. Then we got these values which are presented on the above table based on the research that conducted and the estimated cost for spare and manufacturing parts estimated based on the

material that we are using such as the aluminum and the foam that suits our needs. The testing procedures of each engineering requirement are present in the next section.

2.3 Testing Procedures (TPs)

Engineering requirements are the technical requirements which need to be tested and the process of testing for each requirement is present below. The testing procedure based on the on the SolidWorks Finite Element Analysis. Forces and weight will be added to the design.

1. Total Cost

   Cost of this product can test when all the items will purchase and then summing up the cost spent on the implementation of product to identify the total cost.

2. Weight

   It is a physical quantity and it can measure through weight scale, so testing of weight can be done by measuring the weight of product at the end.

3. Lifting Capability

   Capability to lift the product can test when it will implement, and when the user will lift the product and test it.

4. Appropriate price for spare parts

   Spare parts price can be determined in the market and see if the part available is lesser $40 or not.

5. Maneuverability

   The capability of holding the product easily and comfortably in the hands. This can test by holding the product in hand actually.

6. Stability

   Stability is an important factor to test which can test by applying the pressure to the product and see if it will topple over.

7. Minimum changes in regular crutches

   Minimum changes which can test the product when it will be in use and see if the device need to make any change.

8. Safety

   Safety is important because if the device is not safe to use then it will hurt the user so there must not be any sharp edges in it and must not topple over. So safety can test by touching all the sides of product and see if there is an edge that can hurt the user.

9. Instant fitting and Removal

   This can test by assembling the product and then disassemble it to see if it is quick or not.

10. Maintenance cost

    Maintenance cost is important for any device and for this device maintenance must not be over $50 and it can test by determining the maintenance it will require after wearing the product.

11. The equipment that are required are the spare parts for the crutches. The spare parts are obtained from the hardware outlets.
12. The testing of the crutches is done through the actual use by the physically challenges individuals. They have to offer feedback on the flexibility and comfortability of the crutches in order to adopt effective changes.

2.4 *House of Quality (HOQ)*

Information presented in the HOQ illustrates the performance quality and competitiveness of the crutches that we had proposed for development under the Senior Design - I with other brands that are currently marketed.

Table 3: House of Quality

House of Quality (HoQ)												
Customer Requirement	**Weight**	**Engineering Requirement**	**Total cost $150**	**Device weight cannot exceed 5kg**	**User must be able to left 5 kg**	**Appropriate price for spare parts ($40)**	**Manuverability**	**Stability**	**Minimmum changes in regular crutches**	**Safety**	**instant fitting and removal**	**Maintenance cost between ($50)**
1. User-Friendly	3		9	9	9	6	9	6		9	9	6
2. Affordability	4			9	9	3	9		6			6
3. Light-Weight	5		6	9	9		9	9	6			
4. Low physical strain	4			9	6		9	9		9	9	
5. Increased comfort and convenience	5		3	6	9			9	6	9	9	
6. Low repairs & maintenance costs	5		6			9		6		9		9
7.Quality performance	4		9	9	9	9	9	9	9	9		
8.Durability	5		9	6		9	6	9	9	9		9
9. Aesthetic desiagn	3		9			3			6			3
10. Indoor & outdoor opreation suitability	4		9					9		9	9	
Absolute Technical Importance (ATI)			246	240	213	165	210	291	183	270	144	141
Relative Technical Importance (RTI)			3	4	5	8	6	1	7	2	9	10
Target ER values			$150	5	5	40						50
Unit			USD	kg	kg	USD						USD
Tolerances of Ers			±50	<5	<5	±10						±10

3 EXISTING DESIGNS

In this section, some of the existing designs will present. Existing designs are those which have implemented already and this can determine through the research. Existing design doesn't mean we are not producing the original product. Existing design means similar concepts which have implemented already and the reason for searching these designs is to take some help from them while implementing the project. Next thing is searching for existing designs for the subsystem level. There are few sub-system levels of the project, and their existing design will search as well to take the help in our project.

3.1 Design Research

Information and knowledge gained from existing designs and product features of the assistive devices that are marketed under various internal brands, in countries all over the world, will be effectively used for making our prototypes more suitable, perfect and satisfactory. The research was done over the internet and few existing designs have been found for the system level designs and also the sub-system levels. The research is important in determining the actual requirements for developing the stretcher assistive devices. Also, the data from the research offers a good explanation of the desires of the individuals who have immobility challenges. For example, they require assistive equipment that is flexible, durable, affordable, and also comfortable.

3.2 System Level

On a system level, we have determined few concepts which are related to our project and these design concepts can help us in actually implementing the project. Existing designs which have found are:

- Underarm Crutches

- Exoskeleton
- Walker Crutches

3.2.1 Existing Design #1: Underarm Crutches

Crutches are good for people who like using underarm crutches. This is because they are designed in order to compensate for the advantages of Forearm crutches. The disadvantage to using underarm crutches and crutches, in general, is that they rely on the strength of the user to use them correctly and they can be difficult to use in rainy or snowy weather.

Figure 1: Underarm Crutches [2]

3.2.2 Existing Design #2: Exoskeleton

The Exoskeleton is a work in progress device that is being developed at North Carolina State/University of North Carolina-Chapel Hill Department of Biomedical Engineering. They believe that this will help people with paralysis, or trouble walking, overcome their disability. The current version of the device has resulted in an additional benefit of reducing the amount of energy required when using the device by seven percent. Another advantage is the light-weight aspect of the device, as it feels about the same as wearing a loafer on your foot. The biggest

disadvantage of this device is that it is not fully tested, and the results are inconclusive for the time being.

Figure 2: Exoskeleton [3]

3.2.3 Existing Design #3: Walker Crutches

The Walker Crutches or two-wheeled walker offers the benefits of using wheels to make walking smoother as well as a seat for you to sit on when you are tired. This device makes it easier to go long distances when walking because of how much easier it is to use. Less strength is required for its use. This device has some drawbacks though. This device is difficult to use for some people who stand at full height, the wheels can spin out of control which can cause accidents, and the seat may not be comfortable.

Figure 3: Walker Crutches [4]

3.3 Functional Decomposition

The functional decomposition illustrates the effectiveness of the proposed models in enhancing the mobility of the disabled individuals. There are two effective and efficient models which are the Black Box Model and the Functional Model. The Black Box Model presents material, function and flow of the project. It also has the aim of enhancing the performance of the device, in order to enhance the mobility of the individuals with paralysis. The Functional Model illustrates the Black Box Model.

3.3.1 Black Box Model

The Black Box model shown below in Figure 4 was created to imply the fundamental capability of disabled people who can walk normally by our proposed design. In this Black Box, the bold black line is defined as the material in this model; a thin line is used to state the energy for this model, and spotted line to identify the signal. The importance of this model is to show the functionalism of this device keeping in mind to reach the goal which is making disabled people who have paralysis to walk as normal people. We appropriated the fundamental elements of the

hope device by making this model and can be comprehended when having the budget and data sources.

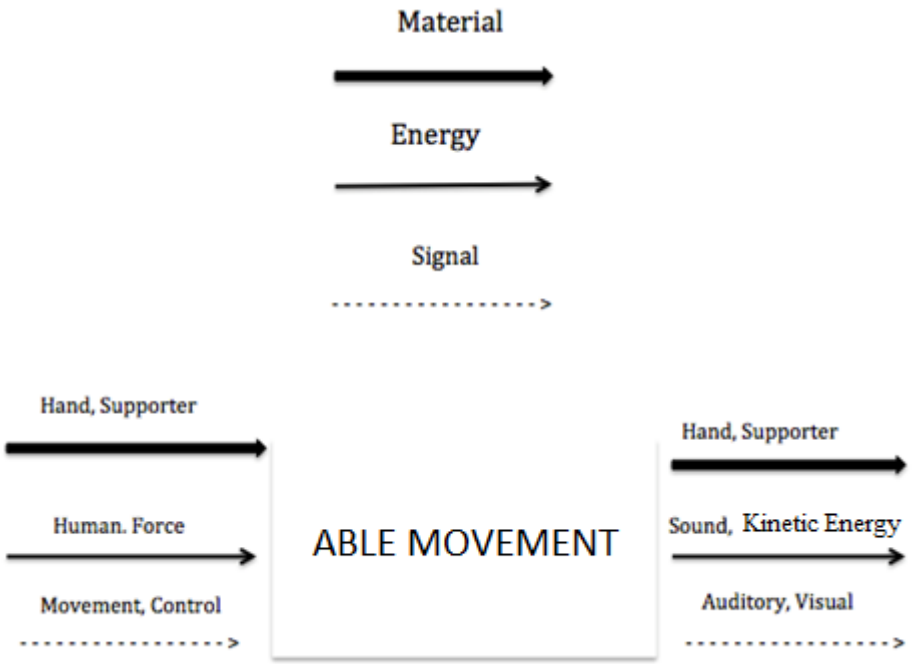

Figure 4: Black Box Model

3.3.2 Functional Model

The hypothesized Functional Model shows the complete working of any project, as it has the main function, material, energy, and sound. The functional demonstrates the flows and main functions for the hope device. Hypothesized Functional Model indicates sub-functions, functions and flows that the hope device contains. The main function used in the Black Box model is Able Movement, which can be designated as the final function of the hope device. This function related to customer needs in one way or another. The functional model is important as the team learns how to divide product into functions and flows that are more accessible to the customer

needs. Figure 5 indicates the relationships of various items and concepts in the Functional Model.

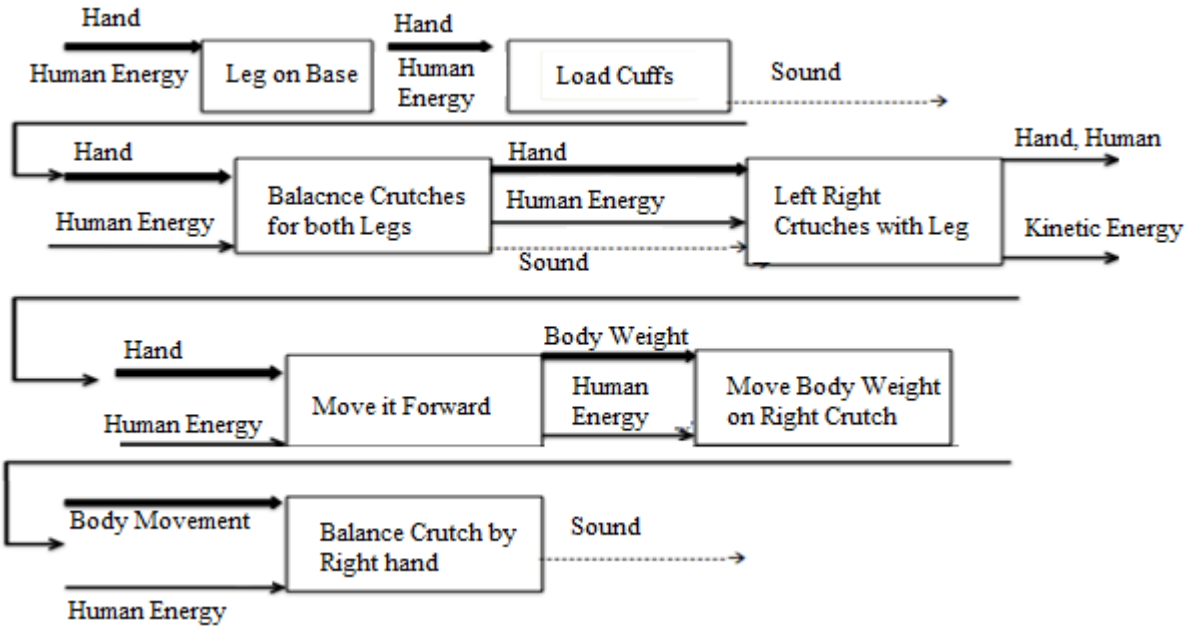

Figure 5: Hypothesized Functional Model

3.4 Subsystem Level

In sub-system level, there are three sub-systems considering in the report. The basic sub-systems that are considering here are:

- Holder
- Legged supports
- Base

3.4.1 Subsystem #1: Holder

Holder is the main thing in our project which provides the support to carry the crutch. Hand will insert into the holder and user will able to get the support from it. Three existing designs have found for the holder which have presented below.

3.4.1.1 Existing Design #1: Steel Holder

Steel holder is an already available and can utilize in our project as well. The holder can make from any material, but the steel holder is strong and able to bear a lot of pressure applied by the user as show in the figure below.

Figure 6: Steel Holder [5]

3.4.1.2 Existing Design #2: Wooden Holder

Another existing design is the wooden holder which can also be used in our project. Wooden holder is strong and heavier as well but it can use in our product because it has the capability to bear the pressure as well.

Figure 7: Wooden Holder [6]

3.4.1.3 Existing Design #3: Plastic Holder

Another existing design available for the holder is the plastic holder. Plastic holders are lightweight and can bear only a limited weight but still can use in our project. The holders are affordable to acquire and they enhance the comfort level of the person as they are soft in texture. Also, they are not affected by frequent weather changes as they are not good conductors of the environmental heat. Therefore, they are comfortable in both hot and cold weather conditions.

Figure 8: Plastic Holder [7]

3.4.2 Subsystem #2: Legged Supports

Legged support is another sub-system level which will cover the leg and carry the load of the body.

3.4.2.1 Existing Design #1: Round Legged Support

Round legged support is an existing design of our project. In this design, the covering of leg will be done by the round shape support and it can be used in our project as well. It is showing below in the figure. The support improves the stability of the device and the comfort of the user.

Figure 9: Round Legged Support [8]

3.4.2.2 Existing Design #2: Square Legged Support

Another existing design is the square legged support which can use in our project. Square legged support can hold the legs easily as well. As a result, there is stability and firm connection between the legs of the person and the assistive device.

Figure 10: Square Legged Support [9]

3.4.2.3 Existing Design #3: Open Ended Legged Support

Open-ended legged support can also use in our project for holding the legs but it will have the open end which will not be able to carry the leg easily. It is also showing in Figure 11.

Figure 11: Open Ended Legged Support [10]

3.4.3 Subsystem #3: Base

The base is another sub-system of our project which can be in any form and it provides the support to the legs as well and also to the product.

3.4.3.1 Existing Design #1: Steel Base

An existing design for the base is available which can use in our project as well. The steel base is strong and capable of holding the complete weight of use and device as shown below in the image.

Figure 12: Steel Base [11]

3.4.3.2 Existing Design #2: Wooden Base

Wooden base can also use in our project and it is already built as well. Wooden is also strong base and can easily bear the weight of user and product as well.

Figure 13: Wooden Base [12]

3.4.3.3 Existing Design #3: Aluminum Base

Aluminum base is already available and it is also strong and has the capacity to carry the load as well. This base can also use in our project as it showing below in the figure 14. The base enhances the stability of the assistive device during movement.

Figure 14: Aluminum Base [13]

4 DESIGNS CONSIDERED

Few design ideas have generated for the project in order to select the final product. These designs are showing below.

4.1 Design # 1: Two Wheeled Walker

The rolling mobility walker, or two-wheeled walker offers the benefits of using wheels to make walking smoother as well as a seat for you to sit on when you are tired. This device makes it easier to go long distances when walking because of how much easier it is to use. Less strength is required for its use. This device has some drawbacks though. This device is difficult to use for some people who stand at full height, the wheels can spin out of control which can cause accidents, and the seat my not be comfortable.

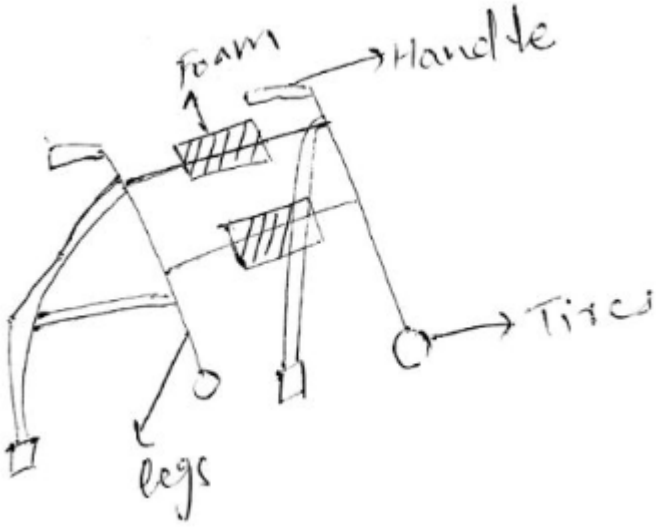

Figure 15: Design 1

4.2 Design # 2: Forearm Walker

Forearm crutches are a good alternative for people who do not like using underarm crutches. This is because they are designed in order to compensate for the disadvantages of underarm crutches. They provide a more ergonomic position of the hand and wrist, they allow

for improved agility and walking speed, they are easier and safer to use when ascending and descending stairs, and they allow for a variety of walking styles. The disadvantage to using forearm crutches, and crutches in general is that they rely on the strength of the user to use them correctly and they can be difficult to use in rainy or snowy weather.

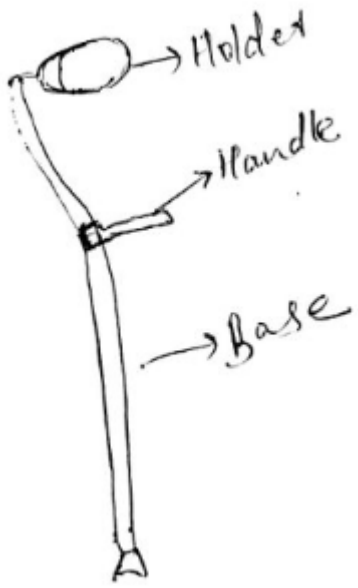

Figure 16: Design 2

4.3 Design # 3: Quad Cane Walker

The quad cane has been around for a while now. They offer many benefits to walking and those who have a difficult time doing so. Some of the benefits include: reducing knee, ankle, hips and spine stress, they strengthen muscles that support the spine, and it helps the upper body muscles to put off stress in wrists, forearms, hands, shoulders and elbows as well as in the neck. Quad canes do have their disadvantages though. Some of these include: getting stuck in the cracks of the pavement and repetitive strain can become a problem after using the cane too much.

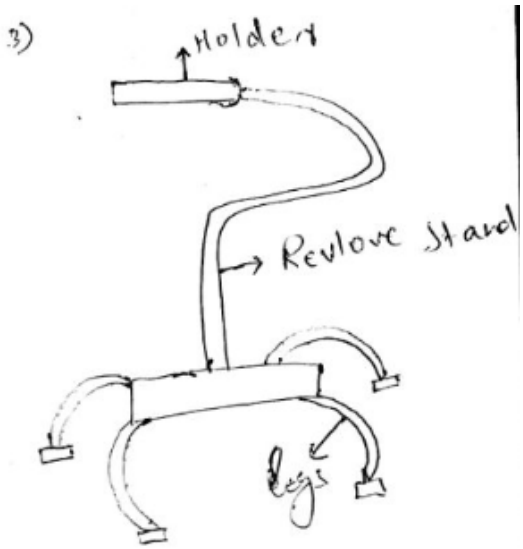

Figure 17: Design 3

4.4 Design # 4: Add-on Exoskeleton

The Add-on Exoskeleton is a work in progress device that is being developed at North Carolina State/University of North Carolina-Chapel Hill Department of Biomedical Engineering. They believe that this will help people with paralysis, or trouble walking, overcome their disability. The current version of the device has resulted in an additional benefit of reducing the amount of energy required when using to device by seven percent. Another advantage is the light-weight aspect of the device, as it feels about the same as wearing a loafer on your foot. The biggest disadvantage to this device is that it is not fully tested, and the results are inconclusive for the time being.

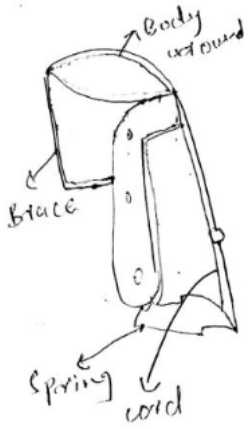

Figure 18: Design 4

4.5 Design # 5: Rebound Crutch

Underarm crutches have been around for over a hundred years for the purposes of helping people to walk. However, they have not always provided the best option for walking. The underarm rebound crutch is a design that has many benefits. They are easy to use, they provide improved comfort over the traditional crutch design, they improve the posture of the user, and they allow for a variety of walking styles. The cons of using underarm crutches are that they can cause armpits to be rubbed raw and they can cause major wrist pain.

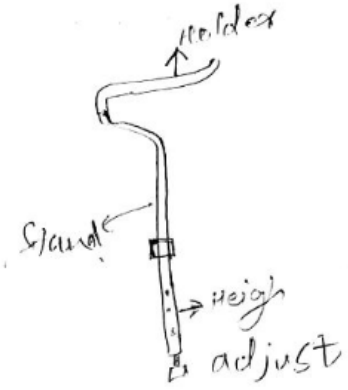

Figure 19: Design 5

4.6 Design # 6: Walking Frame

The walking frame is a relatively new form of technology that is based on the classic rolling walker. This device offers many benefits to those who are having difficulties walking or they cannot walk at all. It is designed with adjustable height handles and supportive mechanisms, which help relieve stress and pain in the back. Other beneficial aspects of its design include a foldable support, wheels, and moveable handles so that the user can use it as comfortably as possible. The biggest disadvantage is the cost, and that is because it is at the upper limits of what is affordable, and most people would prefer a cheaper option.

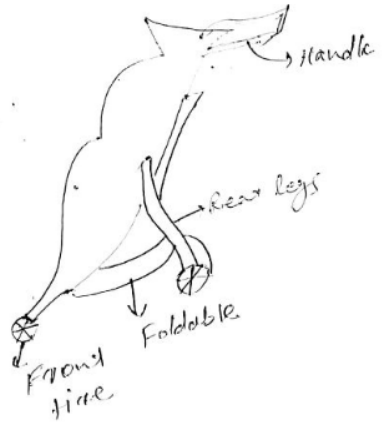

Figure 20: Design 6

4.7 Design # 7: Swap Design

In this design the concept is showing that a handle with the main support, and a support is showing around for making it strong.

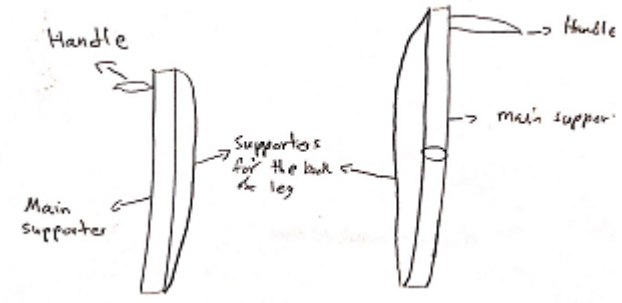

Figure 21: Design 7

4.8 Design # 8: Handle and Cap Stand

The design is showing in the figure in which the idea is to keep the stand straight and holding it up.

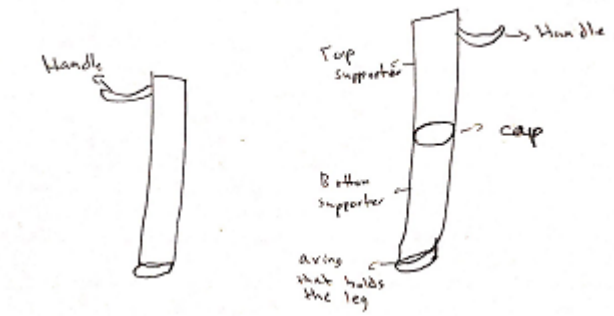

Figure 22: Design 8

4.9 Design # 9: Double Cap stand Design

It is similar to the above design but it has two different caps to support the legs as it showing below.

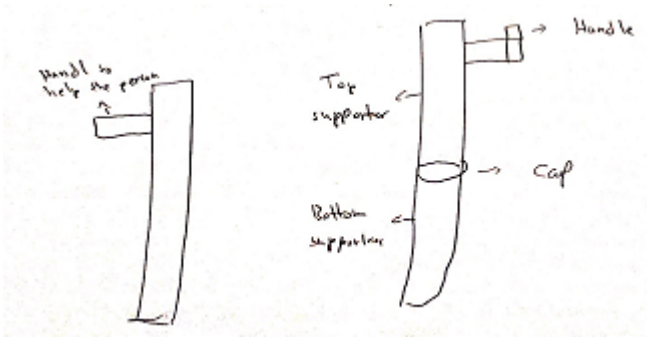

Figure 23: Design 9

4.10 Design # 10: Two Legged Design

The idea is that there are two legs support and both supports are different from each other. According to the current design one leg will have three caps to hold the leg and second will have the two cups to hold the leg. The idea is showing below in the figure.

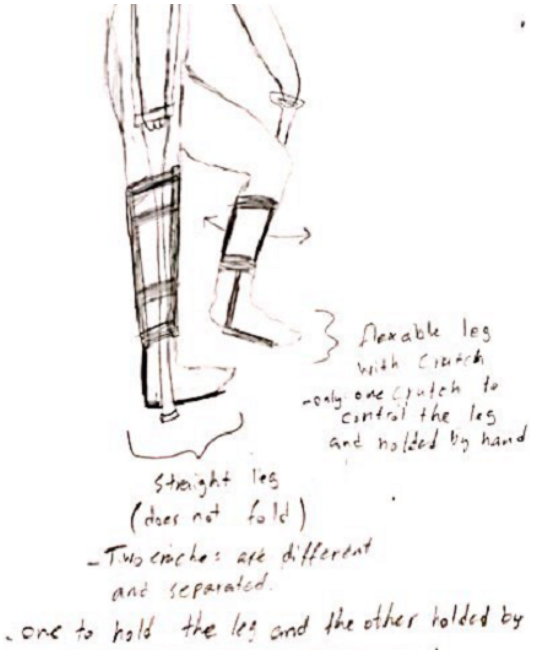

Figure 24: Design 10

5 DESIGN SELECTED – First Semester

For selection of any design there are difference methods which have to use in order to select the final design. Reason for using these methods is that these methods evaluate the design according to the requirements of clients and without the evaluation of design it is difficult to select the design which fulfill all the requirements. That's why different methods use for selection of final design and in this section these methods will apply to the generated design and select the final design.

5.1 Rationale for Design Selection

In order to select the final design, we have utilized two different methods, from these two methods the final design has obtained. These two methods are:

- Pugh Chart
- Decision Matrix

5.1.1 Pugh Chart

The Pugh chart is the tool that analysis the designs below which are manual method, morph concept and bio inspired design. Pugh chart is important tool for designing project as it points the importance of sum the criteria for each design and analyzing each one. It also gives the team members the insight to analysis the application of the criteria for the three designs in this Pugh chart.

Table 4: Pugh Chart

10 Designs	Weight	Design # 1:	Design # 2	Datum Design	Design # 3	Design # 4	Design # 5	Design # 6	Design # 7	Design # 8	Design # 9	Design # 10
Cost	8	+	+	D	-	+	-	-	-	+	+	+
Durable	7		+	D	+	-	+		+	+	+	+
Aesthetics Design	6	-		D	+	+	-	-		+	-	+
Affordable	5	+	+	D	-	+	-		-	-	-	+
Safety	4	+	-	D	+	S	-	+	-	+		+
Stable	3	+	+	D	+	-	+	-		+	-	+
Low Physical Strain	2	-	+	D	+	+	-	-	-	+		+
Light-Weight	1	-	-	D	-	-	+	-	-	+	+	+
Pluses		4	5	-	5	4	3	1	2	7	2	8
Minus		3	2	-	3	3	5	5	4	1	4	0

Pugh chart has produced top three designs which will take into decision matrix which are designs 2,8 and 10 then final design will obtain based on the decision matrix calculations and results. The

Pugh Chart ensures that the details of the final design adhere to all set criteria and in appropriate levels. For example, the final design must have the highest standards of safety and durability. Also, the design should be aesthetically appealing and affordable to purchase and maintain.

5.1.2 Decision Matrix

The decision matrix was done by taking top three designs from Pugh chart. In decision matrix each design will evaluate on the requirement and each design will get some marks out of 8 and that marks will multiply with weightage. Sum up all the values to see which design has obtained maximum marks. And that design will be the final design.

Table 5: Decision Matrix

Decision Matrix	**Cost**	**Durable**	**Aesthetics Design**	**Affordable**	**Safety**	**Stable**	**Low physical Strain**	**Light –Weight**	**Total**
Weight	8	7	6	5	4	3	2	1	
Design # 2	6x8=48	6x7=42	2x6=12	7x5=35	7x4=28	5x3=15	5x2=10	2x1=2	192

Design # 8	7x8=56	6x7=42	4x6=24	7x5=35	7x4=28	5x3=15	5x2=10	3x1=3	210
Design # 10	8x8=64	5x7=35	5x6=30	7x5=35	6x4=24	6x3=18	7x2=14	5x1=5	225

From the decision matrix final design has obtained is design # 10 which is two legged support walker. The design has the highest score and, therefore, indicates satisfactory adherence to the important criterion and characteristics of the assistive device. Therefore, the project uses the design #10 that entails the development of the two legged support walker.

5.2 Design Description

The group decided to make supporters for people who have challenges of walking due to foot paralysis or injuries. The device enhances mobility by enabling the hands to hold the two different crutches that are attached to legs. So, the person who is using the assistive device has to be strong enough to lift the whole body weight using hands.

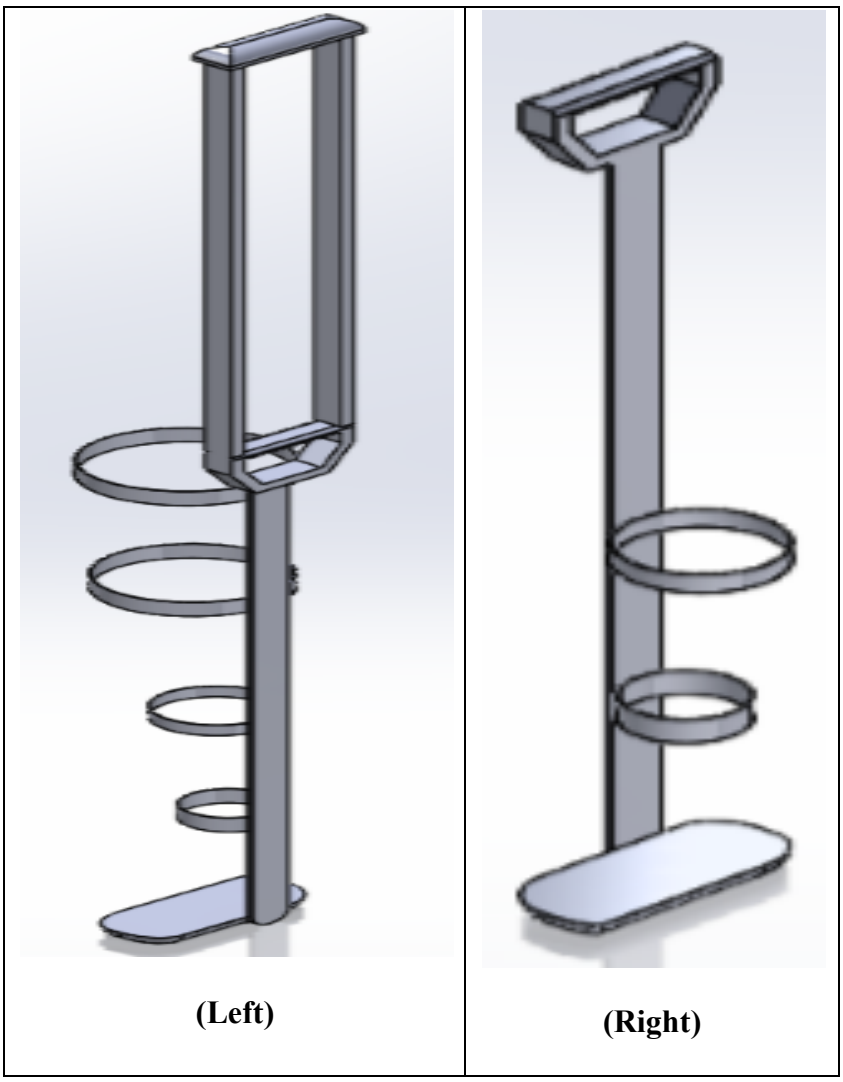

Figure 25: Assistive Device under Senior Design Project – I Prototype Development

Several Key Success Factors (KSFs), were taken into consideration in making the final selections of both the Left Crutch and the Right Crutch. Following are some of the most important technical features, which make these crutches most suitable, convenient and useful:

- Crutches work with users' physical strengths and powers, which have eliminated the need for attaching any mechanical support.

- Lack of built-in mechanical instruments, tools and applications have enabled them to remain light-weight, which does not cause any stress or strain even when the device users remain on their support for prolonged duration.

- Foot-rest flat base helps users to reduce impacts of bearing total body weight under the supports of the forearms and the armpits.

- Simplicity of the design allows users to wear and remove the device dozens of times according to their needs, demands, and requirements without the least efforts, strains and stress.

- Crutches made with simple engineering technology applications provide safe and secured manual user support, which makes them quite inexpensive.

- Absence of mechanical devices or moving parts, make these crutches very durable while eliminating expensive repairs, maintenance and repurchase costs or expenditures.

The Assistive Device under the prototype development contains a set of 2 Crutches, which could fit both the left and the right leg of the physically challenged person. The crutches have been designed with a flat base at the bottom for foot rest, which provides added comfort, support and convenience to the users in minimizing, reducing and eliminating physical exertions while walking around with the device.

5.2.1 Left Crutch

Disabled and the physically challenged persons who are using the Left Crutch are users who are required to take the major load of their physical weight from being transformed onto the device. To facilitate their needs, requirements and expectations, the Left Crutch has been designed with the following technical features:

- Hand Grip &
- Crutch Pad

By supporting body weight on the Crutch Pad and reducing additional load through strong Hand Grip, users are able to maintain their leg position without flexing it. Due to substantial distribution of body weight through both Hand Grip and Crutch Pad, device users are able to enjoy prolonged outdoor walking or moving around in the indoor environment such as climbing-up or down long staircases without any strain, discomfort, inconvenience and exhaustion. However, the Left Crutch device users are required to be in strong physical fitness with good amount of stamina and strength as they need to continuously maintain their body load under their arm pit and the hand that rests on the Crutch Pad. Foot-rest flat base provides ideal and critical support in reducing weight bearing problems and challenges.

5.2.2 Right Crutch

The design for the Right Crutch, had been significantly modified for the purpose of allowing the disabled and the physically challenged persons to flex their legs. Leg flexing is supported and facilitated by the following device features:

- Shin &

- Calf

The device users are provided with Hand Grip, which enables them to maintain their postures and memorability while moving around in the outdoor or the indoor environment. Hand Grip, provides added safety and security while also serving to assist device users in significantly reducing excess body loads onto the crutch.

6 PROPOSED DESIGN

In this section we are going to explain about the proposed design with all the details that will use to implement the design. First of divide the parts into sub-parts as:

- Cuff 1
- Cuff 2
- Cuff 3
- Cuff 4
- Handgrip
- Lower Stick
- Upper Stick underarm

Above sub-parts are for the hope device in left, now the hope device for right side have divided into sub-parts as:

- Cuff 1
- Cuff 2
- Lower Stick
- Upper stick hand gripped
- Handgrip

Cuffs hold the device with the leg. There are different sizes based on where will be attached. The handgrip is basically the main part to hold and control the device. The lower sticks and the upper

sticks are connected to each other to adjust the length of the device and it is attached with the cuffs and hold the leg. The upper stick underarm and the upper stick hand grip are to balance the body on the device and to help controlling the device.

So the implementation of this design can possible to do using the bill of material that found in appendices explaining the material which are going to use for each part.

6.1 Bill of Materials

Bill of materials is present in the Appendix A and in the table all the material that will use for the implementation and their dimensions have presented as well. This BOM will use for the implementation and each material will purchase according to the given bill of material.

6.2 Manufacturing

The team will implement the design in SolidWorks but the process of manufacturing is presenting in this section. First of all, this product will implement in the following way:

- Cuffs will develop at first with rubber to make the comfortable grip.
- Stick will develop with the Aluminum.
- Handgrips will make with aluminum and cover with the foam to provide the lightweight and durability of the device.

For manufacturing this product size of aluminum sheet is 0.35 as it is strong and flexible for the person with disabilities. And the process of manufacturing can be done as:

- Take the aluminum sheet and cut down the sheet to the size of 23 inches to make the lower stick.
- Cut the sheet in two angles form to make the underarm stick.

- Put the grip over the underarm stick
- Take the rubber pad and rotate it to make different cuffs.
- Attach the cuffs on the stick using the nuts.

6.3 Design Changes

Before the final implementation in CAD we have decided to make two crutches, one is for left and one is for right leg. Both crutches have different shape. Left crutch is the main crutch which will provide the movement support and right crutch will be the on which person with disability will stand and take the support for forward movement. This design idea has been decided from the start but the basic changes we have done in the design are:

- We have decided to make four cuffs for left crutch, whereas we have decided already to make three crutches but this change made in the design before the final implementation.
- Secondly we have decided to put the left crutch long and it will reach to the underarm for supporting purpose. Before that we have decided to make the left crutch length same as right one but this has changed.

These are the two basic changes we have made for the final design.

7 CONCLUSION

This project was assigned by the client to make such a useful thing that will help the persons with disabilities. Therefore, we have decided to make crutches for supporting persons with disability in their movement. Those people who cannot able to move without any support can use the crutches we have implemented in this project. For this project we have decided to make two crutches one for left leg and second for right leg. The design idea has selected on the basis of Pugh chart and Decision Matrix. We have decided to implement the CAD design in SolidWorks and this design will not implement.

8 References

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9 APPENDICES

9.1 APPENDIX A: Bill of Materials

Item #	Part Name	Qty	Decryption	Function	Material	Manufacturing Process	Dimension	Cost	Store
1	Cuffs	6	Covering the leg	It will cover the leg properly and hold it	Rubber	Chemical Formation	R 1.5 in, R 2 in	$60	https://www.grainger.com/
2	Hand Grip	2	Hold the item	Hold by the hand or underarm to support	Foam	Foaming	6 x 10 in	$30	https://www.grainger.com/
3	Lower stick	2	Stick for support	Support the legs and hold the cuffs as well	Aluminum	Aluminum Molding Process	23 in	$70	https://www.grainger.com/
4	Underarm Holder	1	Provide support	Provide the support through the underarms	Aluminum	Aluminum Molding Process	21.78 in	$50	https://www.grainger.com/

9.2 APPENDIX B: CAD Model with Exploded View

CAD model has implemented for each part to explicitly show the dimensions and shape of each part.

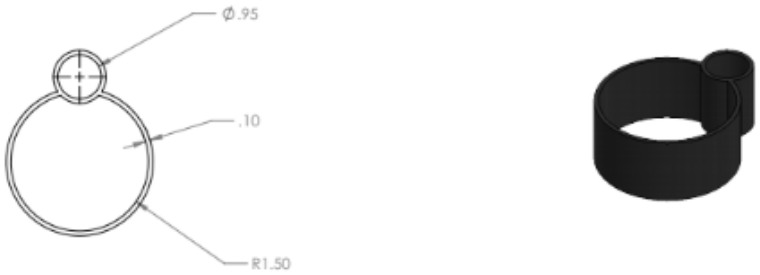

Figure 26: Cuff 1

Figure 27: Cuff 2

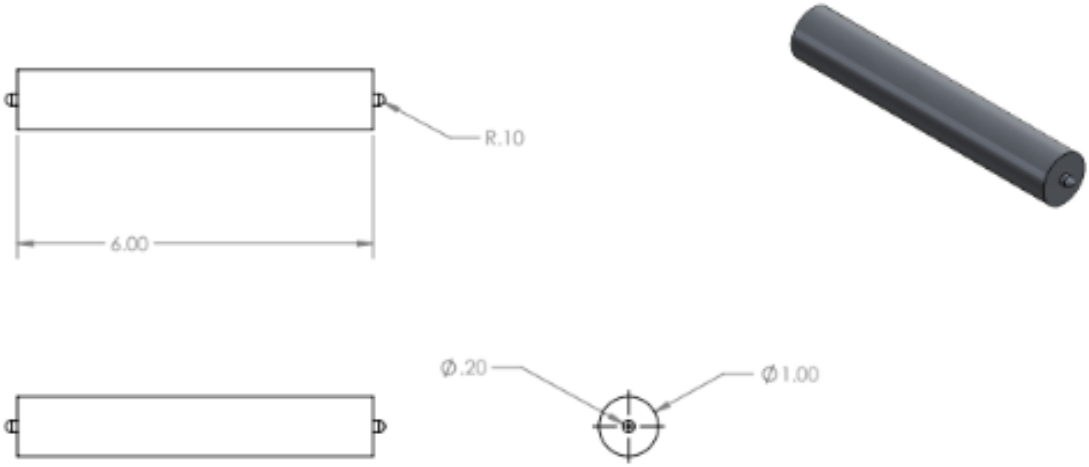

Figure 28: Hand Grip

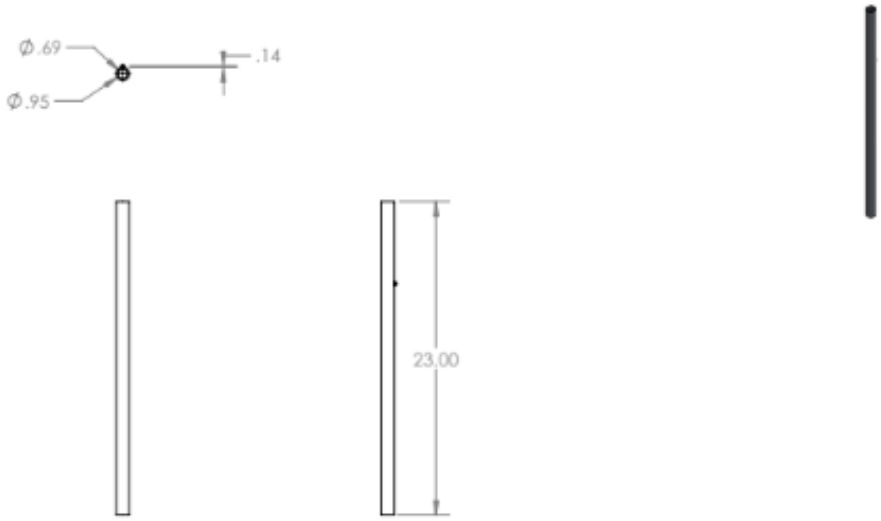

Figure 29: Lower stick

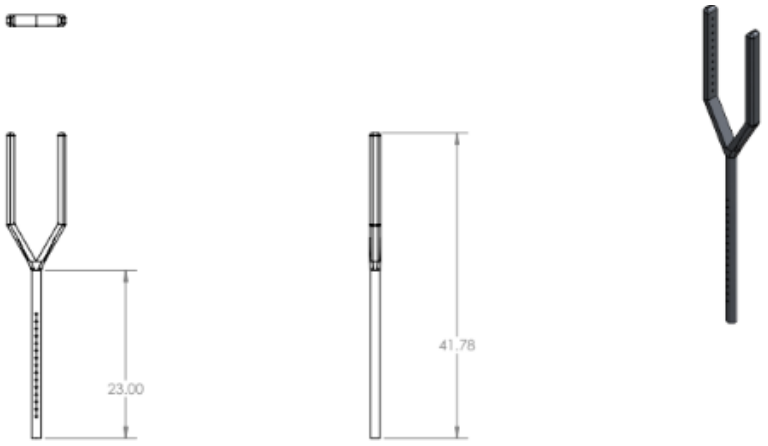

Figure 30: Upper Stick Grip

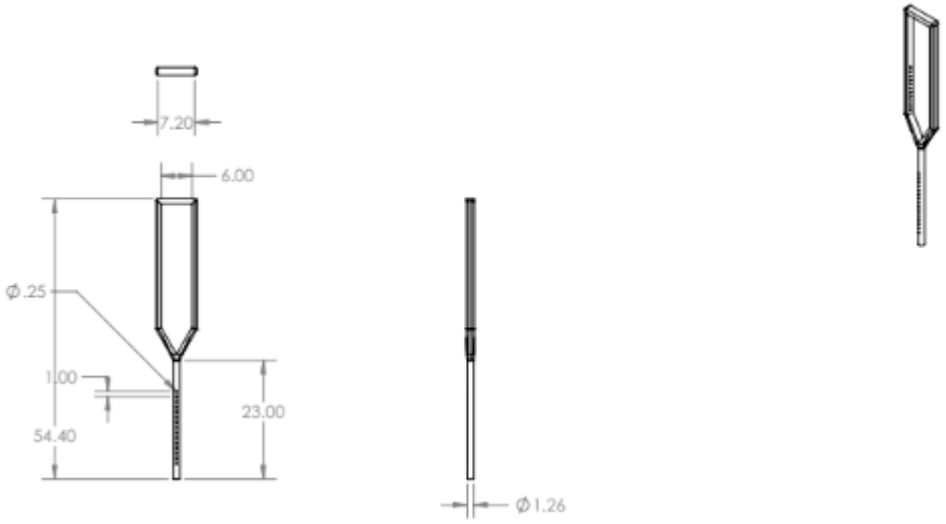

Figure 31: Upper stick hand under arm

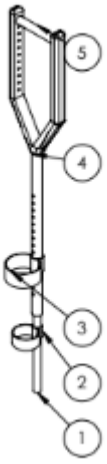

Figure 32: Right Crutch

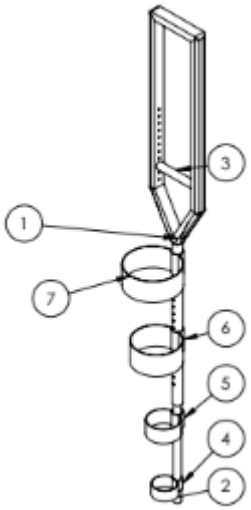

Figure 33: Left Crutch