The Hope Device

Preliminary Proposals

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EXECUTIVE SUMMARY

This report has a product that will help the person with disabilities to support. As the requirement of project was to make a useful product for person with disability so we have decided to make the two crutches one for left leg and second for 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. Black Box model and functional model have developed as well in this paper. After that system level and sub-system level designs have found. Few designs ideas have generated for the design and from these designs 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 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 different dimension. 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.

ACKNOWLEDGEMENT

We would like to thank our client and advisor Dr. Sarah Oman for supporting us in this project. Because Dr. we may not be possible to finish this project. And we would to like the thank the Mechanical Engineering Department for giving us a chance to work on such a creative thing and provide us a platform on which we can make this product. We would like to thank NAU for giving us the chance to do some learning in our field.

TABLE OF CONTENTS

Table of Contents

1 BACKGROUND

1.1 Introduction

Physical challenges and disabilities create complex, influential, dynamic, multidimensional barriers which reduce, limit and restrict the freedom of movement. Disability refers to a physical or mental weakness or illness which reduces an individual's capacity to handle or manage simple tasks in their living or work environment. People affected with physical challenges and disabilities experience major changes physical, mental and psychological – which impact their quality of life by discouraging their abilities or capabilities to integrate and reintegrate into their societies. 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].

1.2 Project Description

Making supporters for people who has 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 holds their foot. Primary goals of the project focus on providing required physical, emotional and psychological support to men, women and children who are affected with 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 given 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 project description and second is engineering requirements which have obtained from the customer requirements.

2.1 Customer Requirements (CRs)

Customer requirements are the one provided to us by our client, as the client has provided us the description of project and from that description these requirements have captured. These requirements are basically the main points of project description provided by the client. Following table is showing the requirements.

Table 1: Customer Requirements

Customer Requirements
1. User-Friendly
2. Affordability
3. Light-Weight
4. Low physical strain
5. Increased comfort and convenience
6. Low repairs & maintenance costs
7.Quality performance
8.Durability
9. Aesthetic design
10. Indoor & outdoor operation suitability

Now move towards the engineering requirements.

2.2 Engineering Requirements (ERs)

Engineering requirements have devised from the customer requirements but these are the technical requirements about the project. In these requirements the targeted value has observed for each requirement and then mentioned in the table. Engineering requirements are present in table 2.

Table 2: Engineering Requirements

Engineering Requirements	Target Values
1.Total cost $150.	$150
2. Weight	5 Kg
3. Lifting capability of user	5 Kg
4.Appropriate price for spare parts ($40)	$40
5.Maneuverability	- (don't have any units)
6.Stability	- (don't have any units)
7.Minimum changes in regular crutches	3
8.Safety	- (don't have any units)
9.instant fitting and removal	- (don't have any units)
10.Maintenance cost between ($50)	$50

For the testing procedures of each engineering requirement move to 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.

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 then user will lift the product and test it.

4. Appropriate price for spare parts
   Spare parts price can determine through the market and see if the part available is lesser $40 or not.

5. Maneuverability
   Capability of holding the product easily and easy to adjust in the hands and comfortable as well. 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 on the product and see if it will topple over.

7. Minimum changes in regular crutches
   Minimum changes which can test in 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 be topple over. So safety can test by touching all the sides of product and see if there is any edge that can hurt the user.

9. Instant fitting and Removal
   This can test by assembling the product and then disassemble it so 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 determine the maintenance it will require after wearing the product.

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 of 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 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 not are producing the original product. Existing design means similar concepts which have implemented already and reason for searching these design is to take some help from them while implementing the project. Next thing is searching of 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. Research has done over the internet and few existing designs have found for the system level designs and few existing designs have found for the sub-system levels.

3.2 System Level

On 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 a 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 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 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 my not be comfortable.

Figure 3: Walker Crutches [4]

3.3 Functional Decomposition

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, bold black line is defined as the material in this model, 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 has 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.

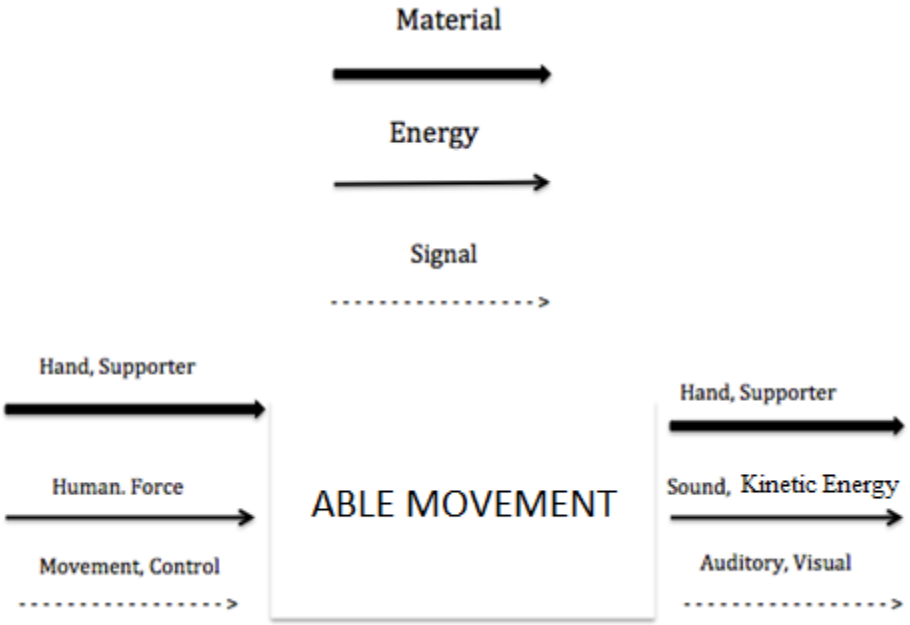

Figure 4: Black Box Model

3.3.2 Functional Model/Work-Process Diagram/Hierarchical Task Analysis

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 for the hope device. This function related to customer needs in way or another. Functional model is important as the team learned how to divide product into functions and flows that are more accessible to the customer needs.

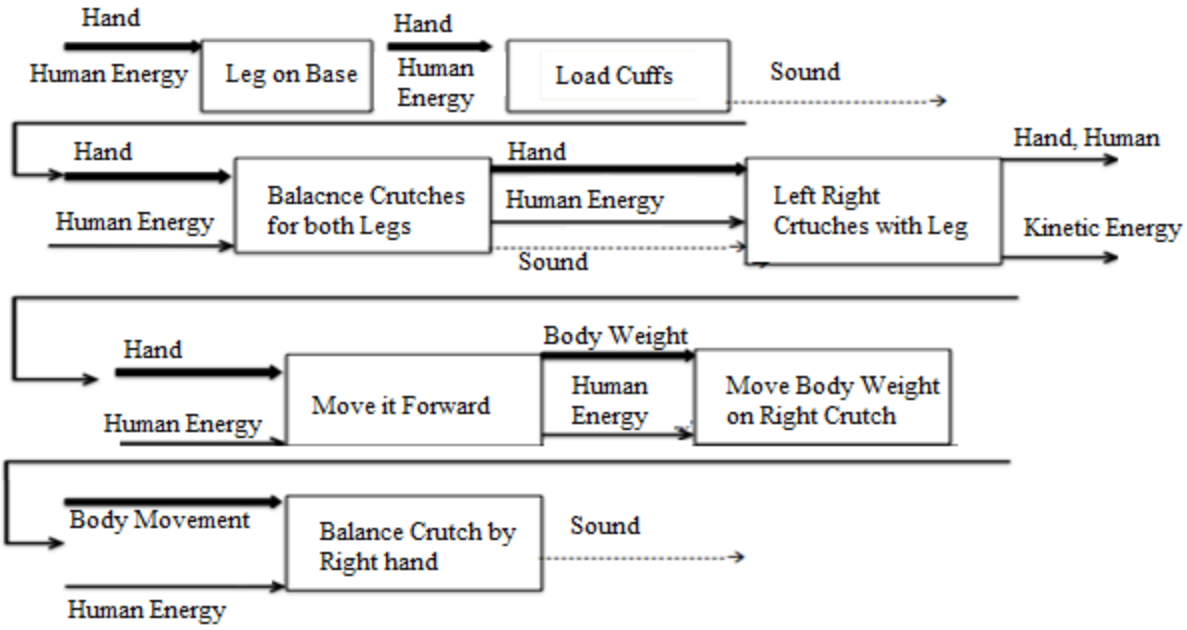

Figure 5: Hypothesized Functional Model

3.4 Subsystem Level

In sub-system level there are three sub-system 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 provide 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. Holder can make from any material, but the steel holder is strong and able to bear lot of pressure apply by the user as showing below in the figure.

Figure 6: Steel Holder [5]

3.4.1.2 Existing Design #2: Wooden Holder

Another existing related to holder is wooden holder which can also use 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 plastic holder. Plastic holders are light weight and can bear only a limited weight but still can use in our project.

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 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 use in our project as well. It is showing below in the figure.

Figure 9: Round Legged Support [8]

3.4.2.2 Existing Design #2: Square Legged Support

Another existing design is square legged support which can use in our project. Square legged support can hold the legs easily as well.

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 the figure 11.

Figure 11: Open Ended Legged Support [10]

3.4.3 Subsystem #3: Base

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. Steel base is strong and capable of holding the complete weight of use and device as showing 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 have the capacity to carry the load as well. This base can also use in our project as it showing below in the figure 14.

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.

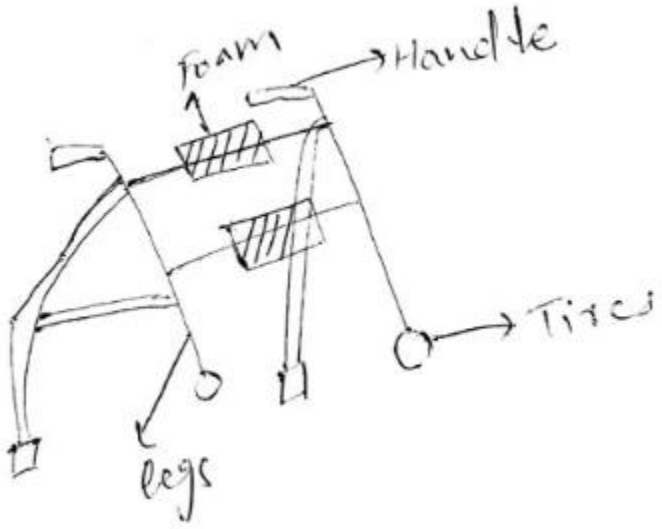

Figure 15: Design 1

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.

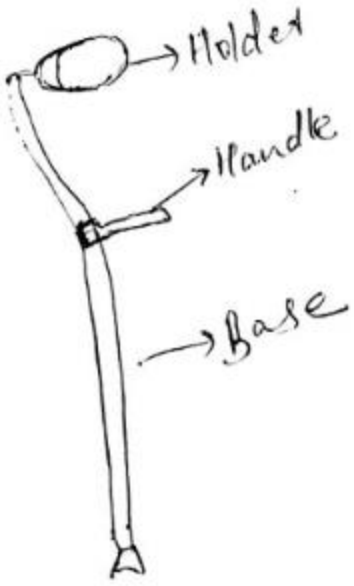

Figure 16: Design 2

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.

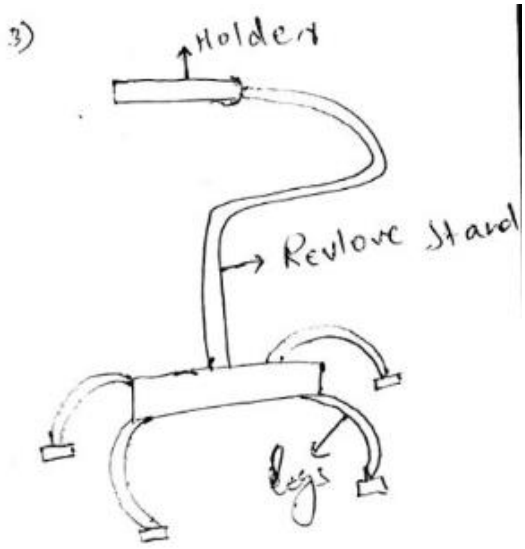

Figure 17: Design 3

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.

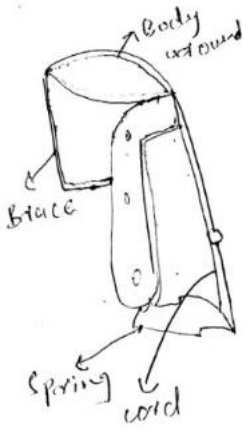

Figure 18: Design 4

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.

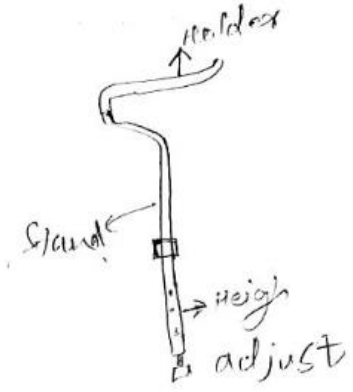

Figure 19: Design 5

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.

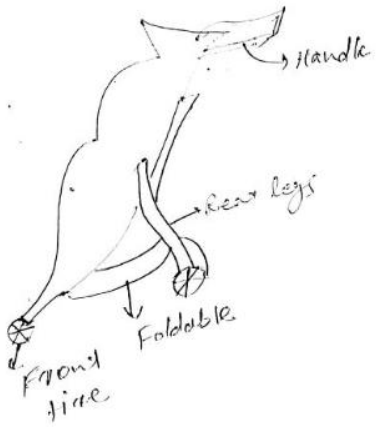

Figure 20: Design 6

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.

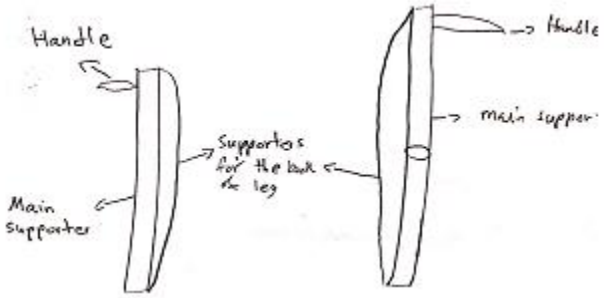

Figure 21: Design 7

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.

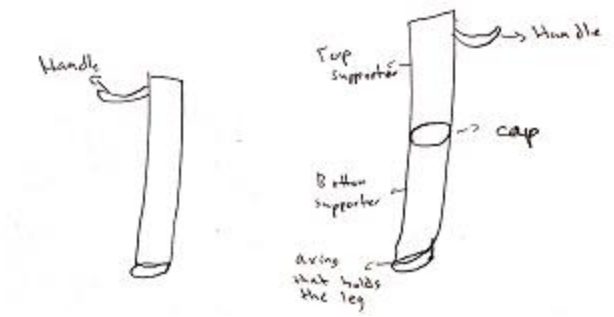

Figure 22: Design 8

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.

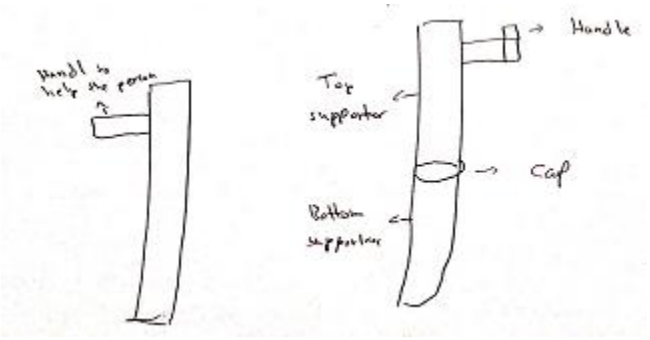

Figure 23: Design 9

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 and then final design will obtain.

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=40	6x7=42	2x6=12	7x5=35	7x4=28	5x3=15	5x2=10	2x1=2	184
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.

5.2 Design Description

The group decided to make supporters for people who has 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 crutches (Attached to legs) that holds their foot. So, the person who is using it has to be strong to be able to lift his whole body weight by his hands.

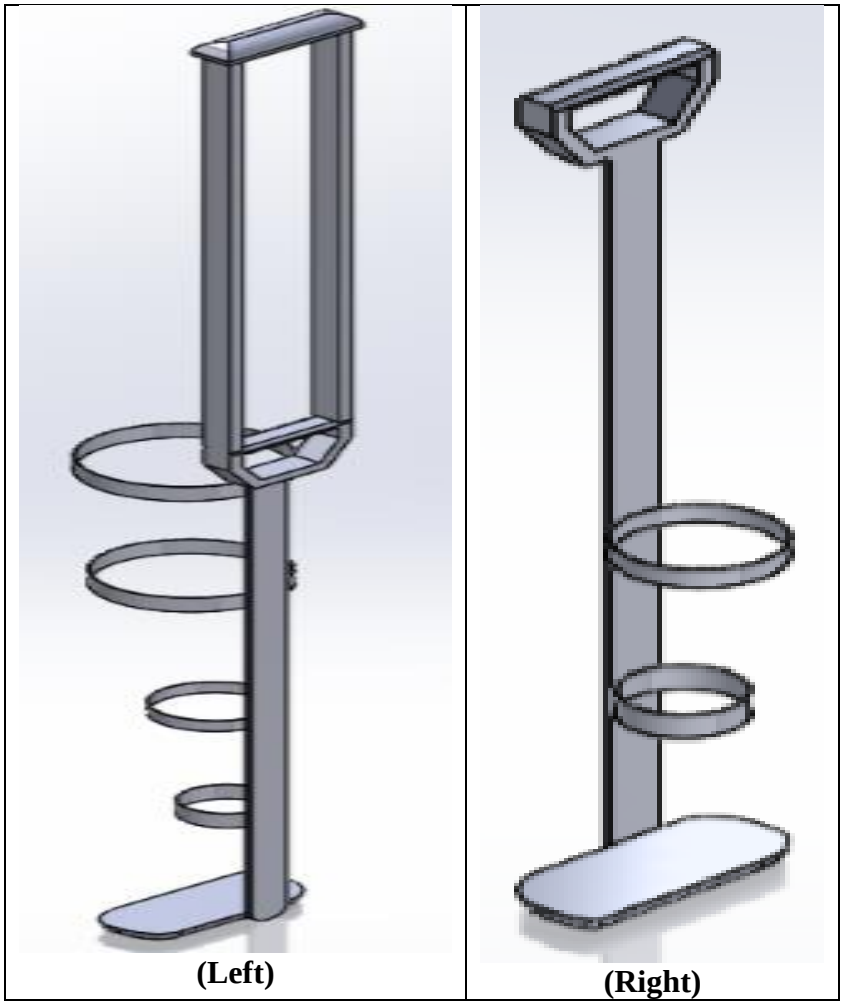

Figure 25: Assistive Device under Senior Design Project – I Prototype Development

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 has eliminated the need for attaching any mechanical devices' 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 forearms and 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

So the implementation of this design can possible to do using the following bill of material that will explain 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 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

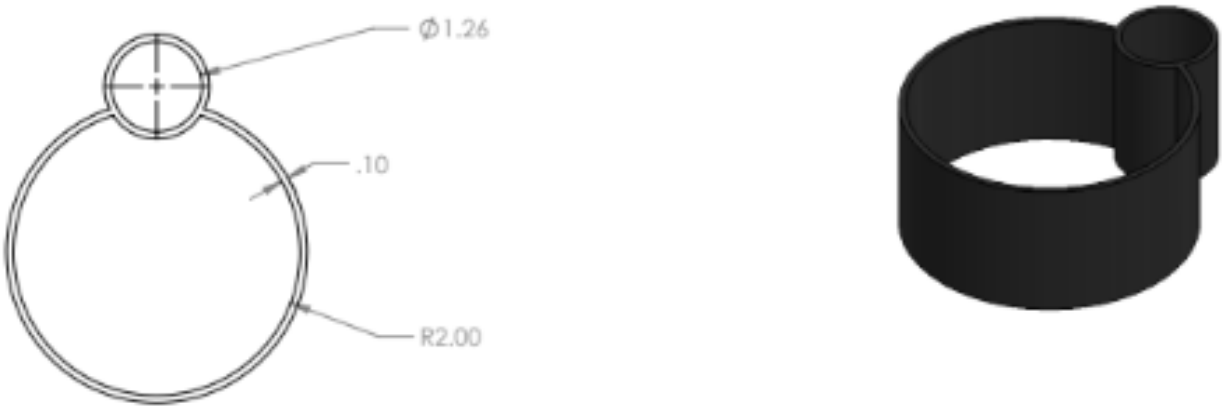

Figure 27: Cuff 2

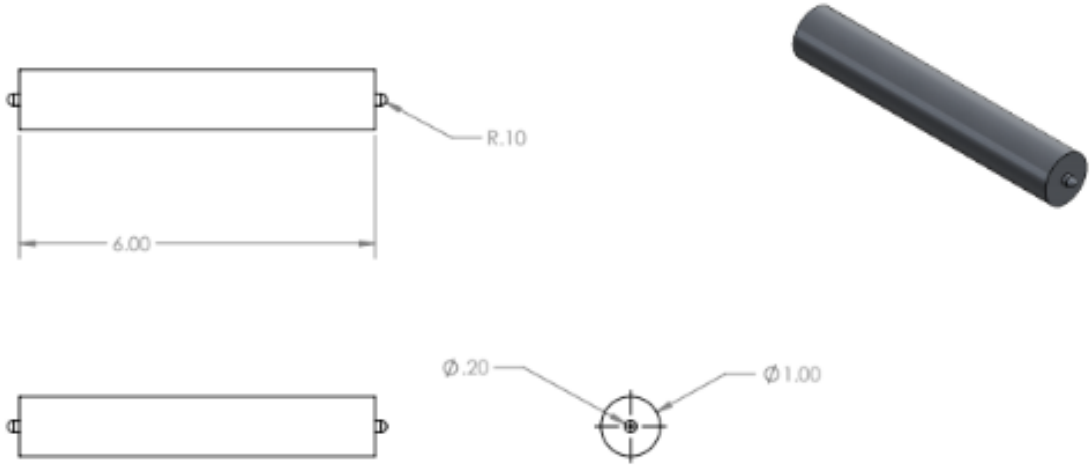

Figure 28: Hand Grip

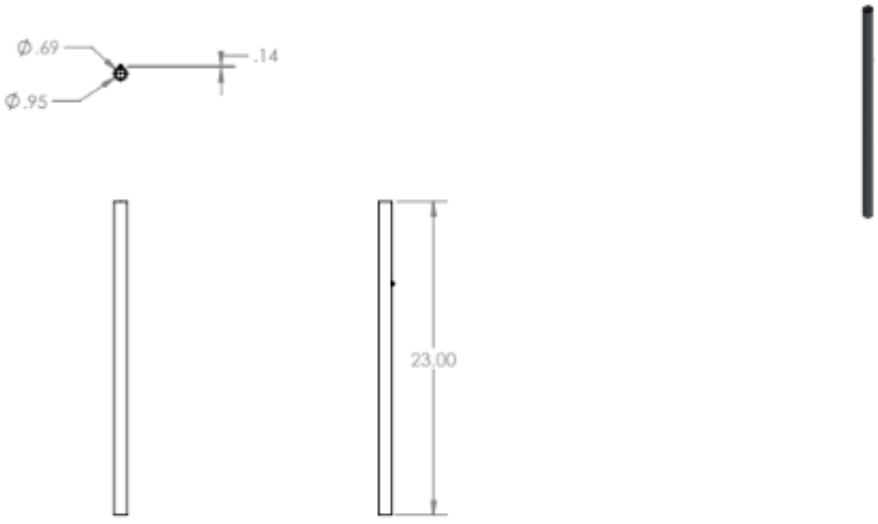

Figure 29: Lower stick

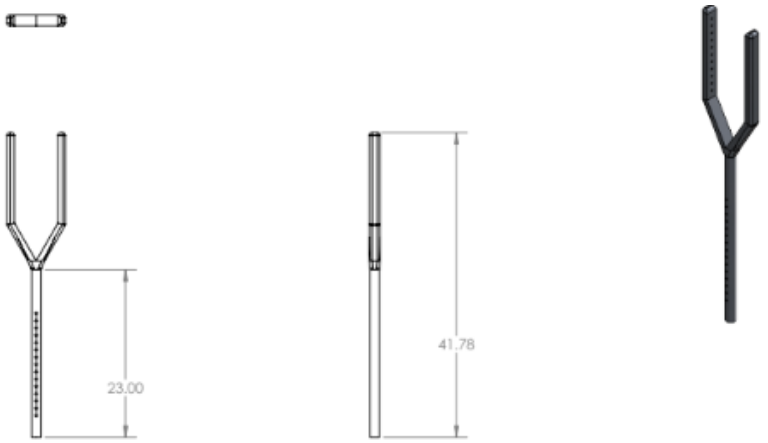

Figure 30: Upper Stick Grip

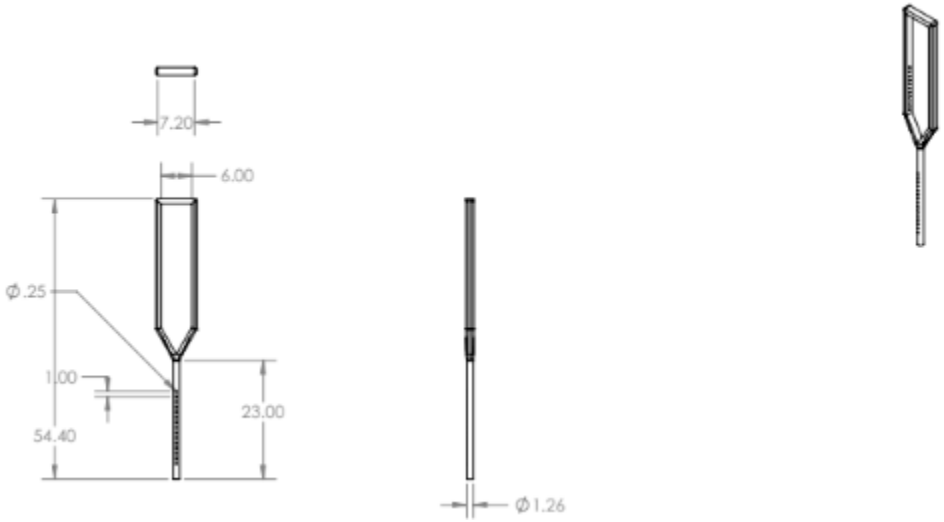

Figure 31: Upper stick hand under arm

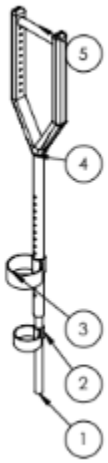

Figure 32: Right Crutch

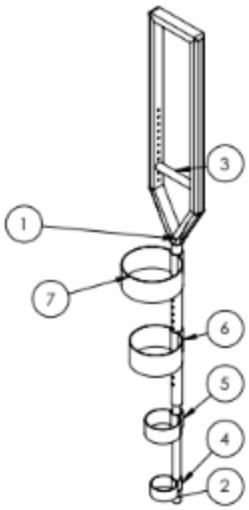

Figure 33: Left Crutch

7 IMPLEMENTATION

In this section all the implementation details will provide as we will be going to implement the design in Solid Work.

7.1 Manufacturing

We 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.
- Hand grips will make with aluminum and cover with the foam to provide

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.

7.2 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 has decided from the start but the basic changes we have done in the design are:

- We have decided to make Four cuff's for left crutch, whereas we have decided already to make three crutches but this change has 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 in the final design.

8 TESTING

We cannot test this device until it will manufacture but the problem in manufacturing is that each person has different length and different size therefore it is not possible for this device to implement in real that's why it cannot test in reality. This device will limit to the CAD design only which has developed in SolidWorks. In SolidWorks this device can test by applying an external force on the clutch and rotate the clutch to see if it will become balance.

9 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.

9.1 Contributors to Project Success

This project has implemented with the help of client and our advisor who helped us many times when we stuck into the project. At the same time team efforts cannot neglect, because whole team has played their tragic role in the completion of project. All team members were excited to work on this project when it has started and put their full efforts, worked day and night to finish the project on time. Each member helped each other and didn't let down anyone while working on the project. It was difficult task to do but with the great efforts of team the project has possible to become successful.

Team members have played their role in the success of project. Client helped us in selection of final design, advisor helped us during the difficult times when we didn't found any solution. Advisor brought us solution to our problems.

9.2 Opportunities/areas for improvement

There are some areas in the project we can further improve in future. As we didn't implement this project because of the reason that size of device is fixed and can't be use for anyone of different length parameters and it is not possible for us to make the product with one single length because it will not use for anyone else. So the improvement which can make in this design is to make the generic size of crutches that will automatically adjust with the body. Flexible cuffs that will fit in the leg of different diameters. Length of crutches will be varied so that any person with disability can wear this product. This improvement can make possible to develop this design. Only this is the improvement which is needed for the design, but still overall the design doesn't have any shortcoming. This is just an option to improve which can improve in future work.

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11 APPENDICES

11.1 APPNEDIX A: Bill of Materials

Item #	Part Name	Quantity	Decryption	Function	Material	Manufacturing Process	Dimension
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
2	Hand Grip	2	Hold the item	Hold by the hand or underarm to support	Foam	Foaming	6 x 10 in
3	Lower stick	2	Stick for support	Support the legs and hold the cuffs as well	Aluminum	Aluminum Molding Process	23 in
4	Underarm Holder	1	Provide support	Provide the support through the underarms	Aluminum	Aluminum Molding Process	21.78 in