Assistive Holder for Disabilities
Midpoint Report

Team D4

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EXECUTIVE SUMMARY

This report presents the details related with the designing of the assistive holder for the people with disabilities. The report is divided into seven sections and each of the section conveys different details on the design, development and fabrication of the assistive holder. The initial part of the report is on introduction about the assistive holder and its importance for the people who suffer from movement related disabilities. The proposed design is cost effective and is aimed to help people having financial issues. The introduction part discusses on the project layout is briefly described. The structure, operation and performance of the original system are described under separate headings. Second section includes all the customer needs and other related details. The design includes examining of all the customer needs and generating the plan as per the actual customer needs. Customer needs, the engineering requirements and the house of quality are elaborated in detail under this heading. Third section is informs on the existing designs as available in the market. The existing designs are studied and the details are presented. Three existing designs i.e. collapsible, handgrip and Argos design are explained along with their pictorial views for better understanding. The functional decomposition of the device is also done in this report and a black box is created for identifying certain inputs and their corresponding outputs. Fourth section discusses on ten different proposed models for the work. These designs include Clapper Holder, Paper Cups Holder, Sawed Teeth, Serrated Saw Teeth, Shutter Design, Lock Design, Adjustable, spring, Collapsible and Obontomed Design. The hand-made sketches of all these designs are also included with their respective headings. The reasons of the selection of this design are thoroughly discussed under the heading of the rationale of the selected design. Also, sixth section of this report, our actual design is explained. The CAD model of the assistive holder is shown at the end of the report from different isometric views for better understanding of the selected design. At the end, the seventh section is about the implementation is talking about the manufacturing and changes in our design.

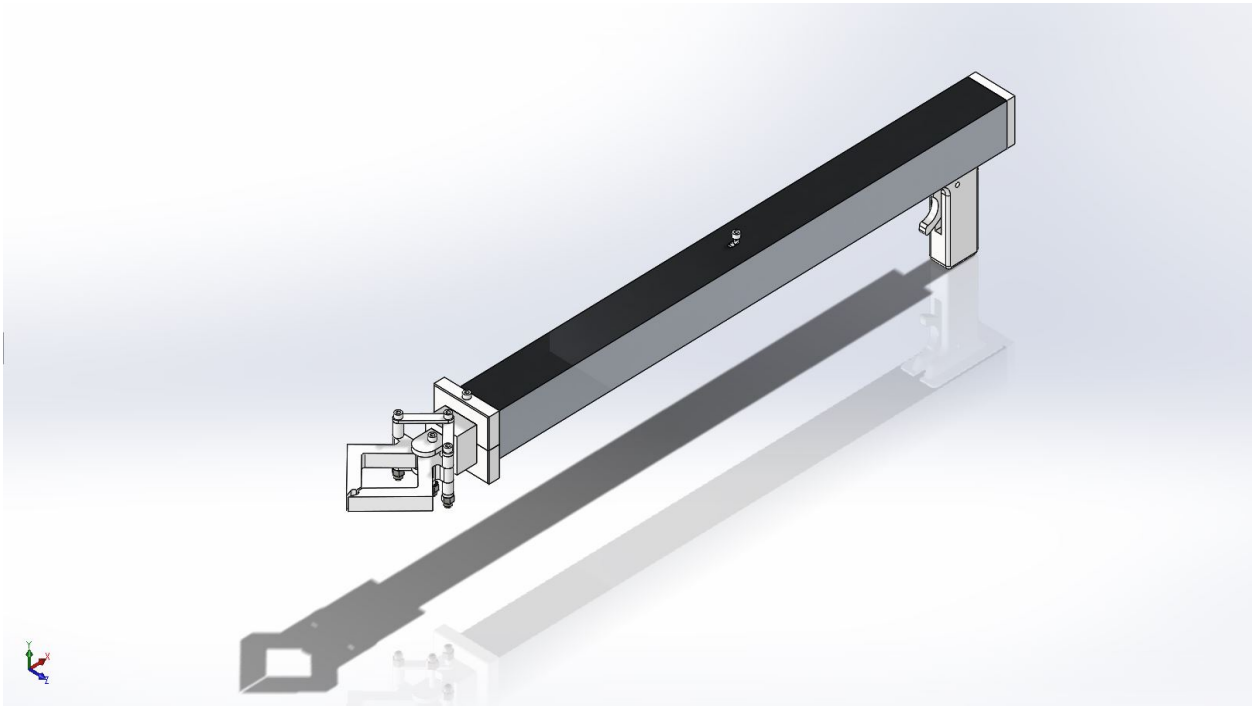

Figure 1: Isometric View

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1 BACKGROUND

1.1 Introduction

The aim of the project is to help people with disabilities to hold things that are beyond their reach because of their disability. People having disabilities are using different kind of assistive devices. Such devices allow people having disabilities to carry out their everyday routine tasks thereby improving their living standard. Use of assistive devices provides opportunities for people having disabilities to play a more productive role in society. This engineering project is to help people with disabilities to play their part for the uplift of society [1]. This project aims to form an innovative and adaptable device, which would be used as assistive device by individuals having disabilities. Although many such devices already exist, this project aims to make an assistive device to help people with disabilities to grasp things easily from a distance. And it also, to develop a cost-effective assistive holder with features same as that of the commercially available one. The designs available in the market are not exactly following the hold mechanisms and lacking either with respect to the user comfort or highly priced. Out effort in this work is to design a assistive holder that has a compromise between the cost and the user comfort. The design is carried out with different perspectives mainly to reduce cost, comfortable usage, load handling capability, minimum load on the user, lightweight and capability to accommodate people of different age. The design is carried out as a team by dividing the work into different sub systems and assigning the responsibilities to each of the team member. The specifications are generated depending upon the customer requirements and a strict adherence to the specifications is maintained throughout the design of the project.

1.2 Project Description

This assistive holder design is for people who have movement related problems, which may be neurological, related, muscle or bone related disorder. Designing an equipment to pick objects for such people will help them in many ways. This device basically consists of an extension bar with two ends. The person having disabilities holds one end in the hand. It contains a handle at the users end for easy gripping. The other end contains a clamp to grasp objects. This device is not solely for art but it is designed by keeping in focus everyday problems faced by people with disabilities. This device assists people with disabilities and makes them independent.

1.3 Original System

Generally, the original system was flexible in such a way that it could be handled in different sizes. The design was lightweight and easy to use. However, it had some weaknesses, which elicited the need for improvements. The issues mainly were with respect to the cost and the performance. Costly systems are motor operated and complex in nature. They served the purpose but were too expensive for a middle class to handle. The simple systems were too difficult to handle.

1.3.1 Original System Structure

Assistive -holders that are commercially available in the market are of different designs and are adjustable in such a way that it can be handled at various lengths. Originally, these assistive devices were built in different sizes such that each size was fixed and was only capable for performing specific tasks. The materials were selected keeping in view their availability. Metallic components were used where strength was required whereas plastics were used wherever possible to optimize weight of the final device. Some of the assistive holder also used lightweight materials such as aluminum and plastic composites. The adjustable length of our design makes it more comfortable and user friendly as it adapts readily according to user requirement.

1.3.2 Original System Operation

This device basically consists of an extension bar with two ends. The user holds one end in the hand. It contains a handle at the users end for easy gripping. A lever actuator is provided near the grip. This actuator, when pressed with finger, closes the jaws of clamp thereby holding the object in between them. A locking lever at rear end of grip is used to keep jaws of clamp closed. Normally, if a user presses the lever to hold an object, he will have to keep the lever pressed to hold that object until he requires. This function puts additional loads on the users. The locking feature is provided which allows the user to lock the jaws of clamp with any object in between them.

1.3.3 Original System Performance

These devices are fulfilling the basic operational requirement, which is expected of them. As, these devices are designed to provide assistance to people having disabilities to enhance their mobility and to extend their movement range. These systems exist from a long time but innovations are always required from time to time to meet the ever-increasing human needs.

1.3.4 Original System Deficiencies

Although the original system performs the intended function but a deep review of original design shows a lot of deficiencies, which need to be addressed. One such deficiency is the limited and fixed length of the extension bar. The design weight needs to be optimized in order to minimize the additional loads on the users. The gripping and grip locking mechanisms also needs special attention to make them function properly and effectively. In every means, the user must get a cost-effective instrument to satisfy his/her needs.

2 REQUIREMENTS

The basic requirements for any device come from its users. As people with disabilities will use this assistive device, it must be easy and safe for use. It should also provide its users with adjustments according to their needs and requirements. It should not pose any threat to its users even in any worst of the conditions. A complete requirement analysis was performed to identify and accommodate the important requirements in the final design. Customers were interviewed about their needs and requirements were prioritized according to their requirements. The details are given in the form of a list as given below.

2.1 Customer Requirements (CRs)

The team to examine the necessary requirements of the customers did a complete analysis on this process. The assistive holder must be lightweight and should not be more than 1.5kg weight. It must have adjustable length for easier accessibility of the object at different times. The adjustable length will be useful to the user to access the objects positioned at different distances. The operations associated with the assistive holder must be minimal and the user must be capable of using it with minimum discomfort. The assistive holder must have sufficient strength and the user must be able to pick considerable large objects. The holding capability of the assistive holder must have a larger range. It must be able to hold a small object as well as a large object with minimal operations. The safety associated with the assistive holder must be large and it should not hurt the user ever in case of incorrect operation. Options for changing the length must be present. The user must be able to adjust the length as and when required. The assistive holder must be able to pick the object positioned at different angles. Table 1 gives the details on the customer requirements.

Table 1 Customer Requirements and Weights Scale

Number	Customer Requirements	Weights (0-5)
1	Light weight	5
2.	Length change	4
3.	Easy to set up	3
4.	Easy to use	3
5.	Safety	4
6.	Angle change	2
7.	Size change	4

An interview was conducted in this research process. The same questions were asked to all the clients about the most vital thing that they are looking for in this design. The given table 2 describes the interviews of three of our customers.

Table 2: Interview Customers

Customers	Customer 1	Customer 2	Customer 3
1	Light weight	Easy to set up	Length change
2	Angle change	Easy to use	Light weight
3	Length change	Light weight	Safety
4	Easy to set up	Safety	Angle change

We work on this design based on our client and customer requirement. The main aim was to design it in accordance with the customers' needs. The interviews with the customers paved way to clearly understand about their needs and design our product accordingly.

2.2 Engineering Requirements (ERs)

The main focus of this project was to create an assistive holder in accordance with the basic customers' needs and safe to handle. The comfort and aesthetics of the assistive holder were also given prime importance while it's designing. The basic requirements of the customers were listed below and a special effort was made to ensure the achievability of these needs. Based on the customer requirements we have created the engineering requirements as the following:

The engineering design requirements were generated after thoroughly analyzing the customer requirements. Focus was given mainly in three areas namely the weight, strength and the adjustability. The weight has to be limited to lesser than 1.5kg. Using materials such as aluminum or plastic can reduce the weight. The assistive holder must have sufficient strength to withstand considerable loads. The length of the assistive holder must be limited to 100cm and the estimated cost must be lesser. Table 3.

Table 3. Engineering Requirements

Serial Number	Customer Requirements	Corresponding Engineering Requirements	Tolerances
1	Round Edges	up to 3mm	$\pm 0.5mm$
2	Weight	< 1.5kg	$\pm 250grams$
3	Max applied pressure	5kpa	$\pm 0.1kpa$
4	The opening angle	Near to 60 degrees	$\pm 5\ degrees$
5	Length	70cm	$\pm 5cm$
6	Adjustable length	Adjustable from 20cm – 30cm	$\pm 5cm$
7	Estimated cost	$500	$\pm \$50$

2.3 Testing Procedures (TPs)

It is required to ensure that generated engineering requirements meet the design criteria. The mechanical characteristics of the design has to be evaluated and the properties mainly modulus of elasticity (E), load carrying capacity (axial and lateral), opening angle measurement and ultimate load carrying capacity. Experimental testing will be performed to estimate each of the properties. In some cases, mechanical analysis software can be used for finding the mechanical properties.

2.3.1 Modulus of Elasticity

The modulus of elasticity (E) of final designed assistive holder has to be carried out by loading it with different masses and estimating the deflection with respect to a reference position. The applied load and the surface area will be used to estimate the stress and the deflection will be used to estimate the strain. Modulus of elasticity (E) = Stress/Strain. The load has to be applied until the assistive holder enters the plasticity region before ultimately failing. By estimating the plasticity region, we can find out the maximum load that the assistive holder can handle. Strain gauges will be pasted at different regions along

the assistive holder to estimate the strains. Data acquisition systems with strain gauge will have to be used.

2.3.2 Load carrying capacity

Lifting loads of different weight and holding it for a specific time can estimate the load carrying capacity. The deflection happened in the assistive holder has to be measured for every load. It has to be found out whether the load being lifted causes any permanent deflection to the assistive holder. This experiment has to be carried out in both the axial and the lateral directions of the assistive holder. While testing in axial direction, the assistive holder will directly lift the object whereas in lateral direction the test weight will be suspended to the assistive holder through a string.

$$load\ Carrying\ capacity = \frac{\pi^2 EI}{L^2}$$

Where E is the Young's modulus, I is the moment of area, L is the length of assistive holder.

2.3.3 Reliability

The reliability of the system has to be estimated by subjecting the assistive holder to 1lakh number of cycles and ensuring that the performance is satisfactory. The cycles can be subjected using an actuator mechanism. The tip of the mechanical actuator can be connected to the handle of the assistive holder. The actuator can be excited with a sinusoidal signal for a particular time. The number of cycles will depend on the actuation frequency.

2.3.4 Adjustability

The modulus of elasticity (E) and load carrying capacity will depend upon the length of the assistive holder. E and load carrying capacity has to be measured for different lengths of the assistive holder. The end jaws have to be kept at different lengths and the test has to be carried out.

2.3.5 Grip

The grip of the assistive holder has can be checked by holding the objects of different weights and lifting them. The weight at which the holder slips is the maximum load that it can handle.

2.3.6 Opening Angle

The opening angle of the assistive holder has to be evaluated through protractor or any other angle-measuring instrument. It has to measure the angle of the assistive holder jaw at fully opened and fully closed conditions. The angle has to be nearly to 60 degrees under fully open condition and close to 5 degrees.

The weight of the assistive holder has to be kept lesser than 1.5kg and weighing scale can be used to measure the weight. Certain materials such as aluminum and plastic (Eartelon) can be used to find out the weight of the system.

The minimum length of the assistive holder has to be kept nearly equal to 70cm. The length of the pick holder can be measured using ruler.

For the testing, we did some testing to set up our device and try to apply the engineering requirement.
Some testing:

1- Safety: we have applied to our design the lock button to lock the device while using it, also made the edges not sharp in order not harm the users by making the edges 3mm.

2- Length change: we applied to our design to shafts (inner shaft, and outer shaft), so the inner shaft is about 30cm and we have lock screw in upper face of the outer shaft. When we open the screw the inner shaft will be free to go out. So we just need the gravity to test the length because the inner shaft go out when we face the device down.

3- Light Wight: some of the team members have visited some stores to look at the light weighted material. So, the found out that the Plastic, and Aluminum are the best two materials that will meet with our customer requirement. Moreover, we need a scaler to record the weight while we test the weight for each materiel.

4- Angel change: we have cut the end both sides of the inter shaft that the grabber teeth attached to it in order to let the grabber teeth's degree 60. So, with this angle the device can hold large objects and small as well. We need some equipment to test the angle. We need to measure the max area when the grabber teeth open. So, we need angle scaler. Also, we can test the angle by trying to hold some different objects that we already measured volume and radius.

2.4 House of Quality (HOQ)

The customer and engineering requirements as described above should be met in the final design in order to fulfill the purpose of this device. Although accommodating all the requirements in our design is difficult job but all possible efforts are made to incorporate as much requirements in the final design as possible. House of Quality (HOQ) analysis makes it easy to identify the incorporation of customer and engineering requirements in final design using a grading system. The requirement list as discussed above must be kept in mind while designing. The relative importance of requirements and their mutual correlation helps us to make design improvements without compromising any requirements. Table 4 below gives the details.

Table 4: House of Quality

Customer Requirement	Customer Weight	Applied pressure 5kpa	The estimate cost between $500	The weight less than 1.5 Kg.	The length is about 70cm	The opening angle near 60 degrees.	Edges round to 3mm	Adusable Length 0-30cm
1. Safety	5	9		9		9	9	3
2. Size Change	4			3	3	9		
3. Light Wieght	4	3	9	9	3	3	3	9
4. Length Change	3	3	9	3	9			
5. Angle Change	4		3		3	9	9	
6. Easy to Set up	5			3			3	9
7. Easy to Use	5	9	9		9	9	3	3
Absolute Technical Importance (ATI)		111	120	117	108	174	123	111
Relative Technical Importance (RTI)		7	4	5	9	1	2	8
Tolerances		± 0.5Kpa	±$50	±250 grams	±5cm	± 5 degree	± 0.5mm	± 5cm
Testing Procedure (TP#)		2.3.2	2.3.1	2.3.1	2.3.4	2.3.6	2.3.5	2.3.1

3 EXISTING DESIGNS

3.1 Design Research

Prime motive of many researches, in the past years, has been to somehow allow people with disabilities to carry out their everyday task independently. Vast amount of literature containing theories, working and development of many assistive devices are present in the Internet and social media agencies. These devices are intended to either help the user to move or to help them pick up things with minor or no movements of lower limb. The main objective of this project is to make an assistive device to help people with disabilities to do their work and other normal works with ease. It will basically comfort such people. It has been observed that people with limited movement usually refrain to socialize with other people thereby disturbing their mental and creative development.

A thorough research with a focus to study existing assistive devices for people with disabilities was carried out and presented in this section. Advantages and design gaps of these devices along with the expectations of the users from these devices are carefully understood and presented. All this useful information is then implemented to bridge the gap between user requirements and existing designs by introducing a modified design of a holder assistive.

3.2 System Level

There are a lot of existing designs for assistive devices similar to assistive holder, which fulfills the basic requirement of holding objects. These devices are characterized depending upon their degree of motion and the extent of accessibility they provide to their users.

3.2.1 Existing Design #1: Collapsible Design

The figure 2 given below shows a collapsible type design of holder assistive. The clamp jaws are such designed so as to make this device easy to grab objects from a reasonable distance [3].

Figure 2: Collapsible Design [3]

3.2.2 Existing Design #2: Handgrip Design

The figure 3 indicates a Handgrip design [2]. This design is used to help people with mobility problem on and off the toilets or all through a shower, giving support in the shower or helping them to do their activities.

Figure 3: Handgrip Design [2]

3.2.3 Existing Design #3: Argos Grabbing

The figure 4 indicates an Argos grabbing assistive. Argos grabbing assistive has got rails which are utilized to help with adjust and bolster, as a guide to help with movement or in regions where a slip or fall is viewed as a high hazard [5].

Figure 4: Argos Design [5]

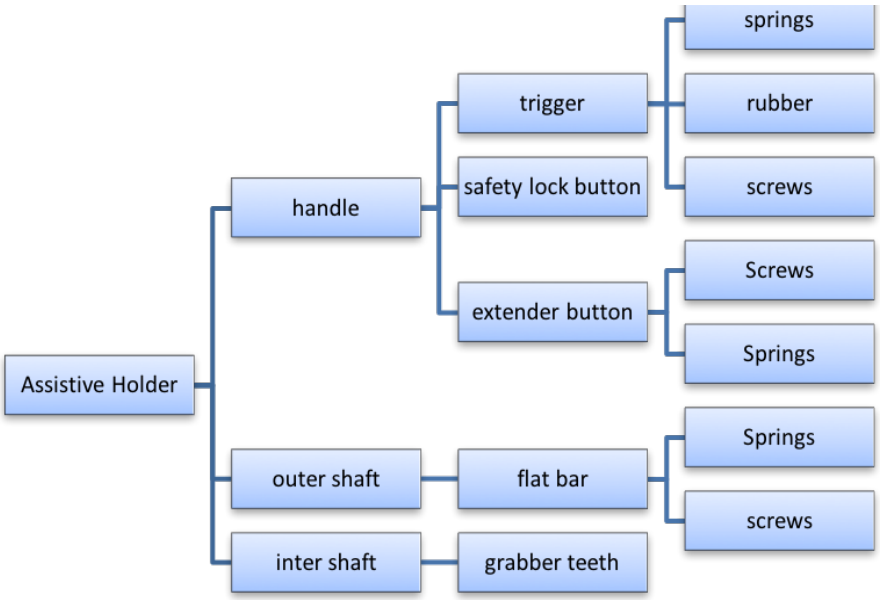
3.3 Black Box Model and Functional Decomposition

The black box model is explained for the assistive holder. It explains the basis of the assistive holder and helps the reader to understand the overview without really understanding on what is happening inside. It also explains the material, signal and energy for the device. What kind of energy needs to work and from any materiel the device should be made. The black box model is taken as the reference for the test and further analysis is carried out.

Figure 1: Black Box Model

The functional decomposition process was utilized for breaking down of the device into smaller components to make the selection of our design easier. The material needed in the device is also explained in this chart. The main components of the device are also shown in the given chart. As you see in the figure 5 that the device with the parts.

Table 5: Functional Decomposition



3.4 Subsystem Level

3.4.1 Subsystem #1: Jaw Design

The jaw design will be an important part for the assistive holder. The jaw portion has to hold the object and it is expected to have sufficient strength and at the same time should not damage the object through excessive force. Some option can be provided to the user to exert smaller and larger force on the object that is being handled.

3.4.1.1 Existing Design #1: 1X GardenersDream

This design has a rubber coating along the inner metallic structure [2]. The rubber coating will provide a small load on the object. These teeth will have more grips and will hold the part in an easier manner. However the sawed teeth can also damage soft and weak objects.

3.4.1.2 Existing Design #2: Homecraft AA8058W Handi-Reacher

The assistive holder will have nearly 180 degrees jaw angle to lift bigger sized object [1]. The wider angle will ensure picking of the large sized object.

3.4.1.3 Existing Design #3: Litter Picker

The jaw can have a rubber clamp to prevent slipping of the object under hold. During the lifting operation, the rubber clamp will first hold the object and increase the grip [7]. The user will then operate the lever mechanism to further hold the object in a tight manner.

3.4.2 Subsystem #1: Hand Grip

The Hand grip construction of the assistive holder must be in such a way that will give maximum comfort to the user. This is one of the main design criteria and is associated with almost all the assistive holders.

3.4.2.1 Existing Design #1: 1X GardenersDream

The arm of this assistive holder is tubular and the handle is covered with a rubber. The rubber cover has small projections that are soft in nature. They provide sufficient grip to the user thereby avoids slipping of the object [4]. This assistive holder uses high quality aluminum as the base material that gives sufficient strength and support to the object.

3.4.2.2 Existing Design #2: KEPLIN STRONG ALUMINIUM PICK UP

This assistive holder uses specially made plasto-rubber like material to provide proper grip. The arm resting portion and the object holding portions are made of high quality plastic materials [8]. The weight is kept as lower as possible so that the user gets sufficient grip and is comfortable at operating the assistive holder.

3.4.2.3 Existing Design #3: Reacher Grabber by BeGrit Healthcare

The handle is metallic (aluminum) and is knurled at the ends to provide sufficient grip. The metallic projections sometimes cause damage to the user's palm. It is normally covered with a rubber jacket that prevents the direct contact of the metallic portion with the human palm. It is made of aluminum alloy and the design is such a way to minimize the weight and maximize the strength [5].

3.4.3 Subsystem #1: Extendibility

The assistive holder has to be extendable to larger distances so as to allow the user to pick objects that are placed at nearby locations.

3.4.3.1 Existing Design #1: Reacher Grabber by BeGrit Healthcare

This design will allow 32 inches adjustability. The user can elongate the assistive holder up to 32 inches to pick and hold objects that are at nearby locations [4]. However, the increase in length will cause a reduction in the weight lifting capability.

3.4.3.2 Existing Design #2: KEPLIN STRONG ALUMINIUM PICK UP

This assistive holder has a grip lock trigger that will lock the jaw before lifting the object. This will ensure safety to the user as well as the object that is being lifted [3]. It has hole-lock mechanism to lock the holder at different lengths so that different users can comfortably use them.

3.4.3.3 Existing Design #3: Reacher Grabber by BeGrit Healthcare

This assistive holder has an extender that works on two concentric tubes [5]. The outer tube gives strength to the assistive holder and the inner tube extends as per the users' requirement. The jaw is present in the inner tube and it operates to hold the object [5]. The user must have sufficient strength to hold the device.

4 DESIGNS CONSIDERED

Designs described below are considered to form an effective design solution for the specified user and engineering requirements.

4.1 Design #1: Clapper Holder Design

The first design that was considered is called clapper holder. This design will be lightweight, which is one of our CRs and it is very useful for people with disabilities. Also this design can come with all ERs we want to apply it to our Project. This design has some advantages like Lightweight and universal usage (usage by all age group). People with disabilities can use it with a single hand. The major disadvantage for this design is its susceptibility to damage while lifting heavier objects. The system is made of light strength material and may damage itself upon lifting heavier objects.

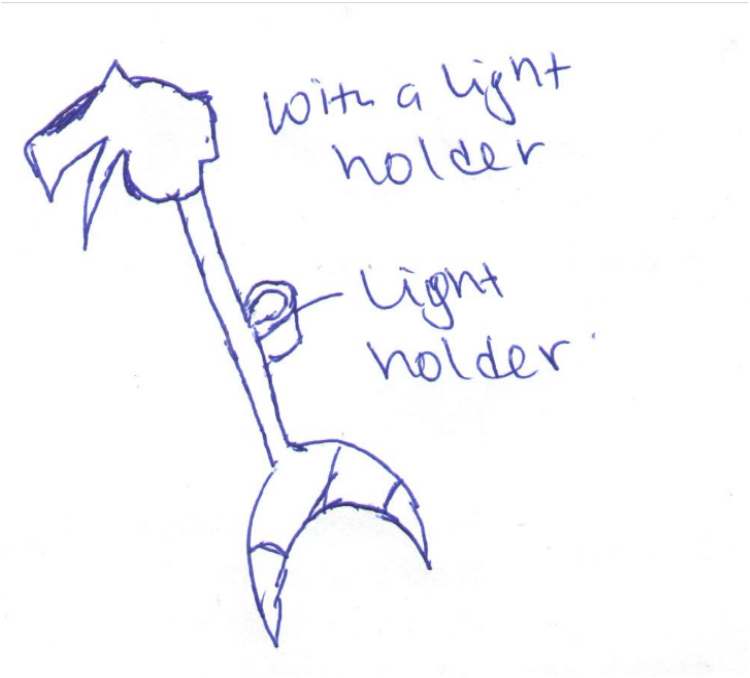


Figure 6: Clapper Holder Design

4.2 Design #2: Paper Cups Holder Design

The second design that was considered is called paper cups holder. A person in a relatively higher level to pick and place any object to a lower level can use this design. This design will be very good to use when the user is stationary at a location and trying to move an object. The design is very simple and the user can use it without any discomfort. The number of parts for this system is very less and it is easier to assemble. This design can be useful to pick up cups and other small parts. This assistive holder is not useful when the user is trying to lift an object positioned at the chest level of the user. It is a best performer when the object has to be picked from the ground.

Figure 7: Paper Cup Design

4.3 Design #3: Sawed Teeth

The third design that was considered is called sawed teeth. It is adjustable and moveable. It allows the person to lift different types of objects. It has sawed teeth, so it can hold any solid part. The person with disability can use it for different purpose. For example, turn light on and off, to turn water from sink on and close it. The main disadvantage of this design is that the teeth might get damaged while the user tries to pick or drop an object.

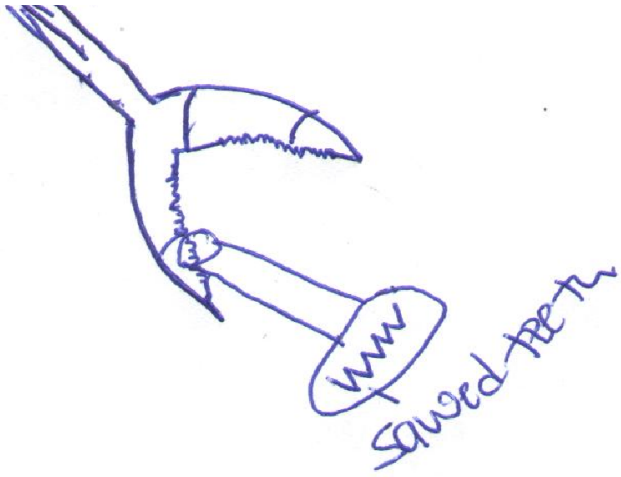


Figure 8: Sawed teeth Design

4.4 Design #4: Serrated Wide Saw

The fourth design that was considered is called serrated wide saw. This design is following the CRs. Because its angle can be open up to 180 degree. So the people with disabilities can change the angle while they are using it. Moreover, there is an extra spring will be useful to support the device in case the person drop it by mistake. This spring will close and hold the part automatically. This is one of the big advantages for this device. It can handle glass and dishes with more care. The load is taken by the spring the device cannot work very well if the extra spring is broken.

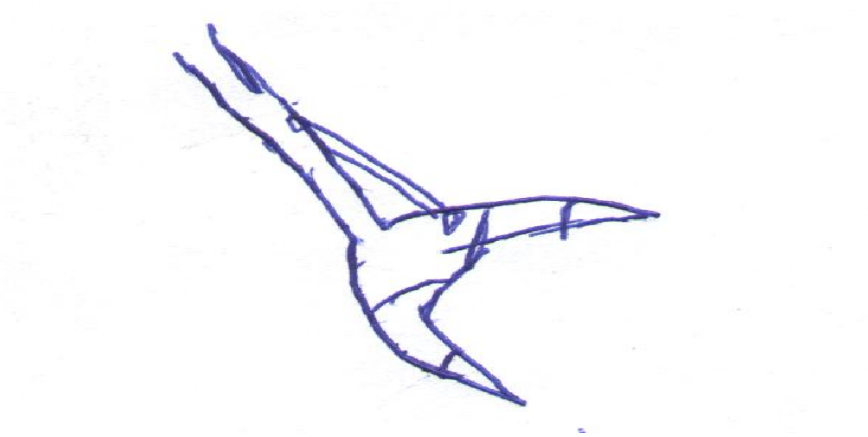


Figure 9: Serrated wide saw Design

4.5 Design #5: Shutter Design

The fifth design that was considered is called shutter design. In the market, there are currently different models of canes, each of which presents a different type of grip. Their design is one or the other depending on the service they are intended to provide, mainly on the degree of disability of the user. Also can use it with hold and pick up cups that have holder. This design is very easy to use and is designed as per the user needs. But it might be not work for some person because the parts this design can hold it is limited.

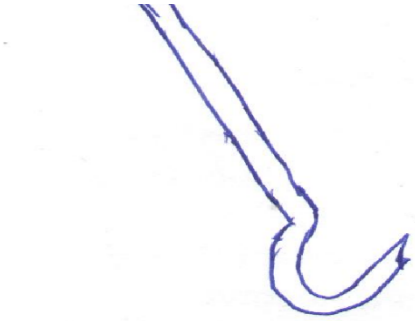


Figure 10: Shutter Design

4.6 Design #6: Lock Design

The sixth design that was considered is called lock design. This tactile tool is made with synthetic fibers. The people with disabilities can use this device without any problem. It locks immediately when the user touches the subject that he/she want to reach. So advantage of this design is making the people with disabilities feel easy to use. The disadvantage is that this design might damage some parts such as glasses or cans. It cannot be used with soft materials.

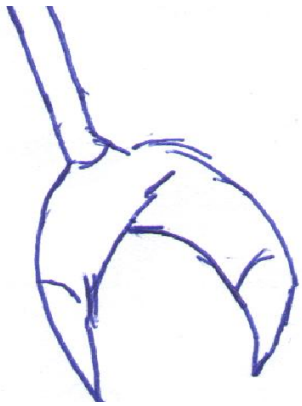


Figure 11: Lock Design

4.7 Design #7: Adjustable

The seventh design that was considered is called adjustable. The height and length can be adjusted as appropriate for different sizes of hammock type vestibules. This design applied to the people with disabilities as in the CNs (length change). The advantage of this design is that the users can change the length to reach the high solid material. The disadvantage is that when the users make the device taller the device will be weak and its load bearing capacity will decrease.

Figure 12: Adjustable Design

4.8 Design #8: Spring Design

The eighth design that was considered is called spring design. The spring would be a supported for the opening. When people with disabilities use this design, the spring would be helpful for holding the solid material and will not put high pressure on the glasses or paper. Adjusting the spring stiffness can control the load applied on the object. The disadvantage is that, with time the spring stiffness may change, and the design requires the spring to be replaced at periodic intervals.

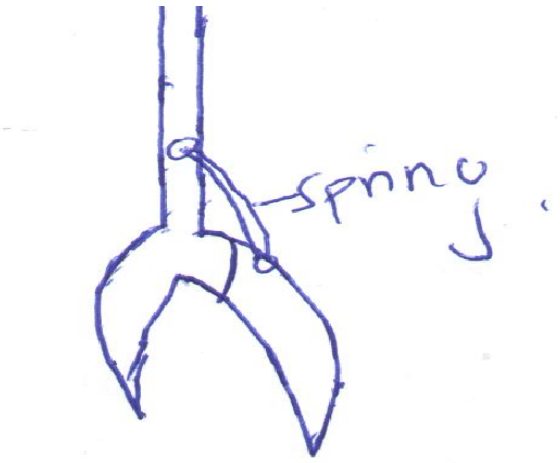


Figure 13: Spring Design

4.9 Design #9: Collapsible

Design number nine that was considered is called Collapsible design. This three-point shelf holder is powder-coated steel with a flexible fit. This design is what the people with disabilities are looking for because it can help them to hold anything that is on the ground by pointing on it and pull the trigger to grab it so they can hang it and change its place. But the solid material that hanged by collapsible might fall down, which will cause damages.

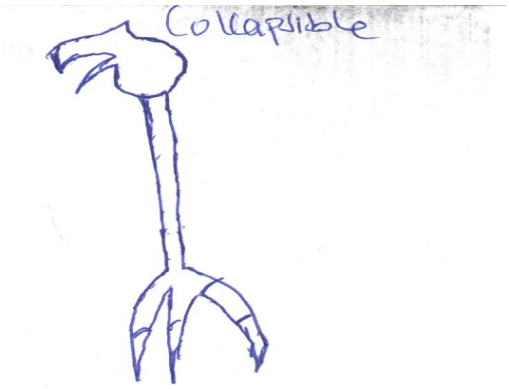


Figure 14: Collapsible design

4.10 Design #10: Odontomed

Finally design number ten that was considered was Odontomed design. It is a design that the people with disabilities could use it to pull the solid material up from the ground. It can pull up everything from the ground, but it depends upon the user's strength, this device is difficult to be used by people who are weak by themselves or too aged.

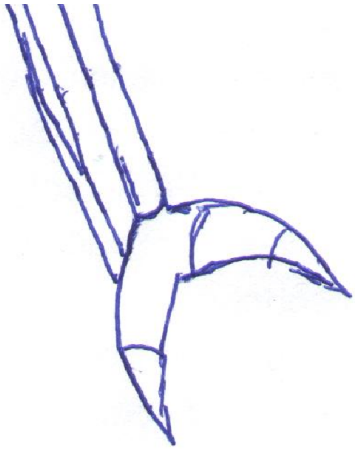


Figure 15: Odontomed design

5 DESIGN SELECTED

All the 10 considered design were studied. Each of the designs was analyzed with respect to the customer requirements as well as the engineering requirements. These designs should be follow the customer needs and applied to all the engineering requirements. The 10 considered designs are different and each needs to be following the customer requirements and the engineering requirements. Each one has different idea and different way to use. So we need to figure out which one is better and can follow our customer needs. The best design we might to follow from design considered is design 1, design 3 and design 4. Because this is the best designs and we want to work with it. They satisfy the customer requirements and the engineering requirements to a greater extent.

5.1 Rationale for Design Selection

The Table 5 below provides a detailed Pugh chart that will compare each of the proposed designs with respect to the customer requirements and will help in selecting the best three designs.

Table 6: Pugh Chart for Selecting of the best designs

Criteria / Design #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Light weight	+	+	+	+	+	+	-	-	-	-
Length change	-	-	+	+	-	+	+	-	-	+
Easy to set up	+	-	-	+	-	+	-	-	-	-
Easy to use	+	+	+	+	-	-	+	+	+	+
Safety	-	-	+	-	+	-	+	-	-	+
Angle change	+	+	+	+	+	-	-	-	+	-
Size change	+	+	+	+	-	-	+	+	-	+
∑ +	**5**	**4**	**6**	**6**	**3**	**3**	**4**	**2**	**2**	**4**
∑ -	**2**	**3**	**1**	**1**	**4**	**4**	**3**	**5**	**5**	**3**

The Pugh chart shows that the design #1, #3 and #4 are more suitable for the existing project and it fits well with the customer and the engineering requirements. Design #3 and #4 are most suitable for the required design. The selected designs were further confirmed through the decision matrix as shown in Table 5.

The selected design is light weight making it easier to handle and use by exerting less effect on the user's hand. Also, a handle built in the design makes it easier and comfortable to use. The flexibility to vary length of the arm brings the objects closer to person so getting the work done with minimum possible movement of the person having disabilities.

Table 7: Decision Matrix

Number	Customer Requirements	Weightings (%)	Design #1	Design #3	Design #4
1.	Light weight	15	4	5	5
2.	Length change	20	3	7	5
3.	Easy to set up	5	3	4	4
4.	Easy to use	10	6	6	4
5.	Safety	20	4	2	4
6.	Angle change	10	2	4	8
7.	Size change	10	4	4	6
8.	Adjustable Length	10	2	4	6
Total		100	28	37	42

The decision matrix shows a good comparison of the individual selected design against the customer requirements. A weight was given to each of the customer requirements and was compared against the design capability of the selected design. The comparison was carried out in a strict manner and minimum possible weights were given for each comparison. The result shows that design #4 fits the requirements better than the other proposed methods.

5.2 Design Description

People having disability have special needs to do their daily chores. Such chores which are very simple and easy for a normal person sometimes become very difficult even impossible to perform for the person with certain disabilities. The disability of lower limb makes the motion of upper body very difficult. If a person with such disability has to grab something from the floor he needs special equipment like assistive Holder to pick it up. Such people usually are on wheel chairs and it even becomes more cumbersome to pick something while sitting on the wheel chair.

As shown on the CAD (Figure 19 & figure 20) our design aims to help people with disability. So, our design comprises of four important parts namely, handle, Trigger, Lock button, outer shaft and Extender button. These three components are essential for the assistive holder design. The strength of these individual components will be confirmed through analysis software as well as through experimental tests.

5.2.1 Handle

The handle of the assistive holder is the important part and is the portion that is dealt by the user. The handle is supposed to be soft and must not harm the user. It should be sufficiently rough so that it does not slip from the user hand. A high quality plastic with rubber lining is a preferred choice. The plastic handle can be glued together to a rubber sheet to improve the handling.

5.2.2 Trigger Lock

The trigger lock is the portion of the handle as operated by the user to lock the assistive holder for avoiding the slippage of the object that is holding. Once the object is held in between the assistive holder jaw, the user will have to operate the lock. The trigger lock can be made through a sliding mechanism. It can be a simple sliding latch like arrangement.

5.2.3 Outer Shaft

The shaft of the assistive holder has to be a Flat bar with sufficient strength. Aluminum or its alloy can be used for the fabrication of the outer shaft. Components such as inter shaft and grabber teeth has to be appropriately adjusted to get the required strength.

5.2.4 Extender Button

It is essential to have an arrangement so as to extend the assistive holder. A telescopic arrangement with lock provisions can be made to design the extender in the assistive holder. Two concentric tubes can be made to lay one inside another. The inner tube will project out as set by the user and provisions for locking the inner tube at certain predefined intervals can be set.

The design is about 100 cm length and the size are divided in two parts:

1- From the handle to the end of the outer shaft 70 cm.

2- From the begging of the inter shaft to the end of grabber teeth 30 cm.

These parts are connected to each other when the user pull the trigger, the grabber teeth would grip the object, after that the user could click the lock button to make the grabber teeth still holding the object. Also, the users could change the length because in inner shaft are three holes that for the length changes. The users could push the extender button that on the handle the flat bar that on the outer shat goes up, so that makes the inner shaft release and slid down or up. When the users choose which size they want they remove their fingers from the extender button.

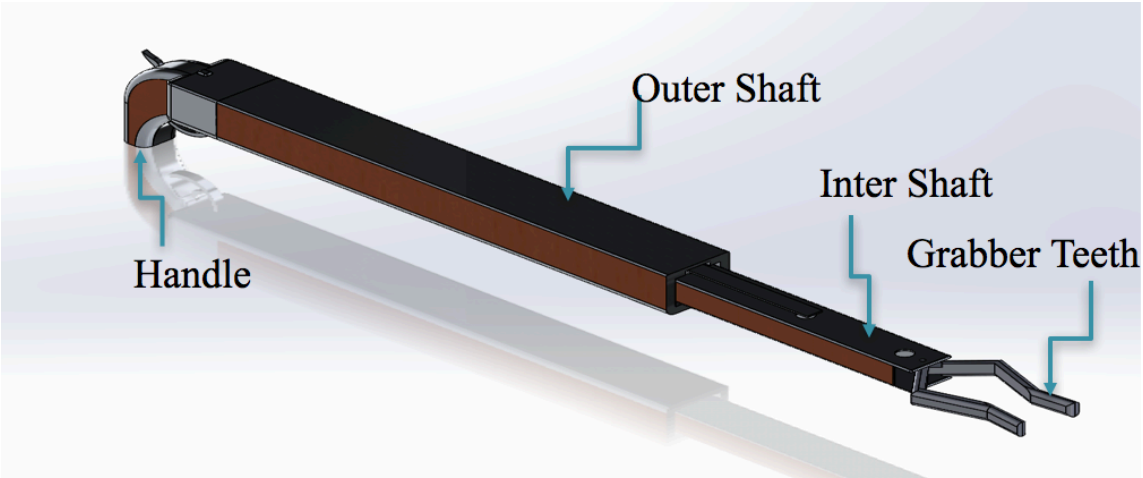


Figure 16: Model Isometric View

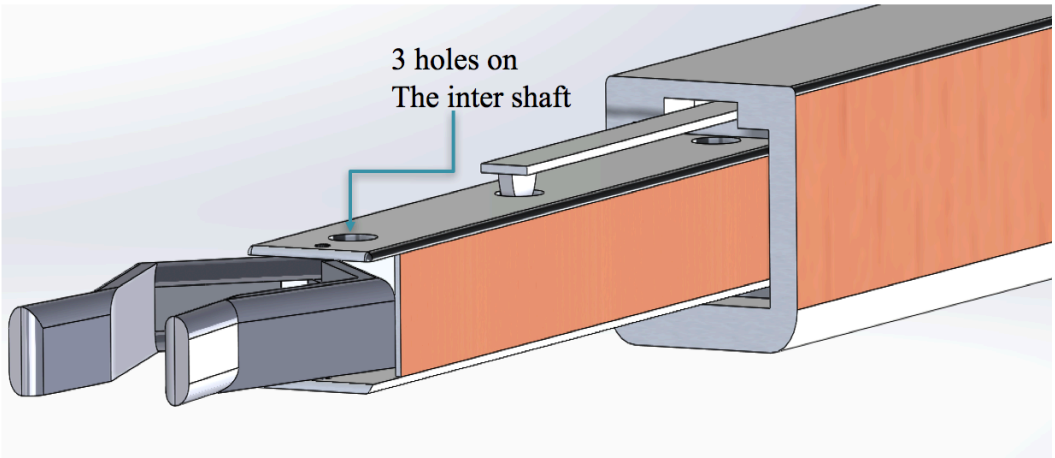


Figure 17: Close up View of Clamp Jaws

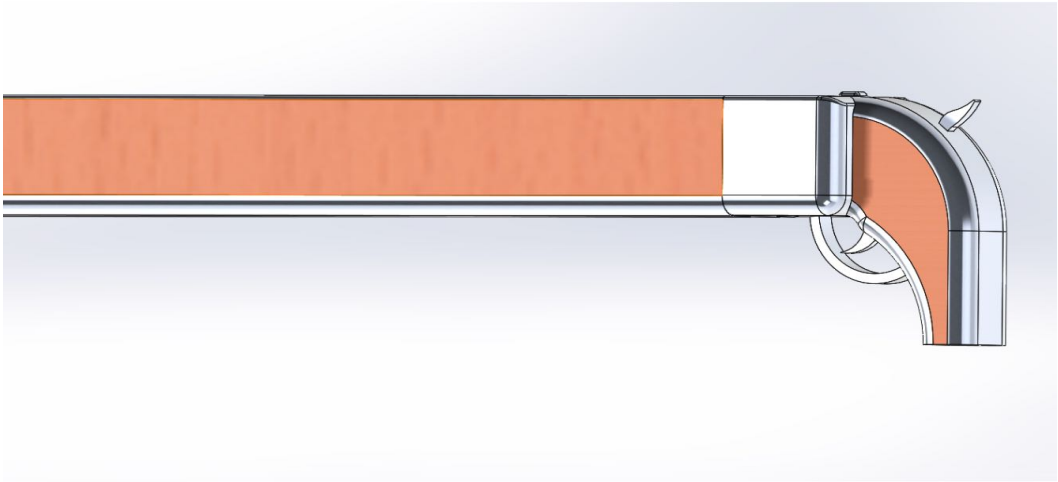


Figure 18: Close up View of Handle and Actuating and locking lever

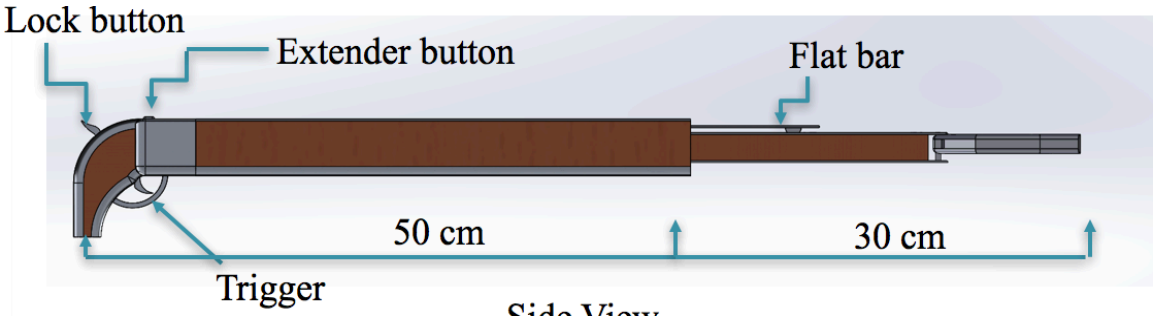


Figure 19: Model Front View

6 Proposed Design

6.1 Intended Design Construction

As a team, first we have to do a prototype for our design that would look like our final design. Our prototype would be made of cardboard because it is easy to make and curve. When we finished the prototype, we looked at the mistakes that the design had. After that, we fixed it. Then we have done our CAD by following the correct dimensions; next we have to print our CAD on 3D printer so that we can go to show our client how the final design would look like.

The CAD can show all dimensions and size for each part for the device that will help us when we do the final product. We need to make another prototype using different part from some stores like HOME DEPOT and some online sources like AMAZON. So, we can make our final design by using simple materiel for example plastic pipes and extended rubber. That will help us to know how this product will work and we can explain for our Client and customer how the device will be.

Most of the design construction will be internal fabrication and we will be using certain tools to do them. The tools used will be mainly cutters, pliers, wrenches, riveters and spanners. These tools will be used to fabricate the handle and the trigger lock portion.

6.2 Materials

The selection materials for construction of different assistive holder parts are the important consideration for the design. The material must be lightweight with sufficient required strength.

The assistive holder has three main parts the frame, the holder and the handle. Aluminum and plastic will be good choosing for make the device lightweight.

6.2.1 Frame-Aluminum

The frame has to be lightweight and aluminum is the best of the available options. This metal has low density and sufficient strength. The weight is lesser and has excellent corrosion resistance. The properties of this metal makes is suitable for its use in assistive holder.

6.2.2 Metallic Holder with rubber bush

The holder of the assistive holder will be made of specialized rubber that is hardened to have sufficient strength. It must hold the object without slipping. Silicon based rubbers can be the excellent choice for fabrication of the holder. The saw tooth arrangement will be provided to hold the material of larger weights.

6.2.3 PVC based handle

The function of the handle in assistive holder is to hold to the user and also to provide functions so as to hold the object. High quality plastic has to be used for the PVC handle and the strength has to be sufficiently large. The PVC is the best choice as it can give maximum comfort to the user. The PVC part can be made rough to improve the friction and the grip.

6.2.4 Bill of Materials

We need to collect some of materials that we need for our project. Our budget for this project is $2000. We can buy some part and test it to see if this part works very well before we use it in the final product. That will help us in the second semester when we start build the final device. We will collect this part from some different sources to start build the new prototype and test it. We need to buy some springs, aluminum shaft, trigger, flat bar and rubber. Also, there are some parts that we need to manufacture. For the handle, we did not find in any source. So, we need to make our handle with our dimensions. Maybe we need access to machine shop (98C). We will try to make some parts during the holiday. First, we will start build the shafts, the inner and outer shaft. Because these parts are the most important parts for the device. The other parts for the device will be build based on these two shafts. Because all parts connecting to these parts. We need some tools to build our device such as drive screes, bolt cutter and meter ruler to measure our device's length. For building our device we will need both power and hand tools. We need power tools to cut and manufacture some small parts. And for the hand tools we can set up our project and assemble all the part together. We will start build the handle because it's need sometimes. Making the handle need between 2 and 3 weeks in the machine shop. When we have all parts ready, we can make it ready in one week. Our team will start collecting parts and manufacture part we need. In the begging of the second semester most of parts that we will make it will be ready, so we can buy to rest and start building. The device will be ready in the mid of the second semester.

Here is our bill of materials:

Table 8: Bill of materials

Part	Source	Quantity	Cost	Tax	Total
1- handle with trigger	Bed Bath and Beyond	1	$19.99	5.6%	$ 21.11
2-Flat bar	Home Depot	2	$4.28	5.6%	$ 9.04
3- Aluminum square tube	Home Depot	1	$19.54	5.6%	$ 20.63
4- Aluminum square tube	Home Depot	1	$15.31	5.6%	$ 16.17
5-Screws	Home Depot	10	$3.54	5.6%	$ 37.38
6-Springs	Home Depot	2	$3.98	5.6%	$ 8.41
7- Rubber	Home Depot	2	$1.95	5.6%	$ 4.12
8-Safety lock	Home Depot	1	$2.29	5.6%	$ 2.42
9- Rubber thread	Amazon	1	$10.99	5.6%	$ 11.61
10- Shipments		1	$150	5.6%	$ 158.40
					Total: $ 289.29

So, our budget that we have is $2000 total, so we have estimate the cost for all the parts that we need for now and it is $289.29 including Tax. Also, the remaining Budget is $1710.71. All of this are just estimation because we still have to do the prototype, Print the design on 3D printer, and we might need some other parts that support the design.

6.3 Cost and Budget

The budget allocated for this work is around $2000. This cost includes the design and fabrication of the proto model as well as the final design. The cost required for the proto model is as presented in table 8

Table 9: Cost Breakup for assistive Holder prototype

Material	**Cost ($)**
Materials	289.29
Manufacturing	200
Assembly	100
Total	**589.29**

6.4 Schedule

We have created our Next semester schedule. So, we will focus on the Hardware review which is finished 50% of our actual design, so we will work on it from Jan/15/2018 to the due date and we need to meet our client to discuss about our project if there is any change should be in the project. After the meeting with our client and likes the project we will complete the rest of the project. So, we would like to finish our project by the beginning of March. The next semester schedule shown below in figure 21:

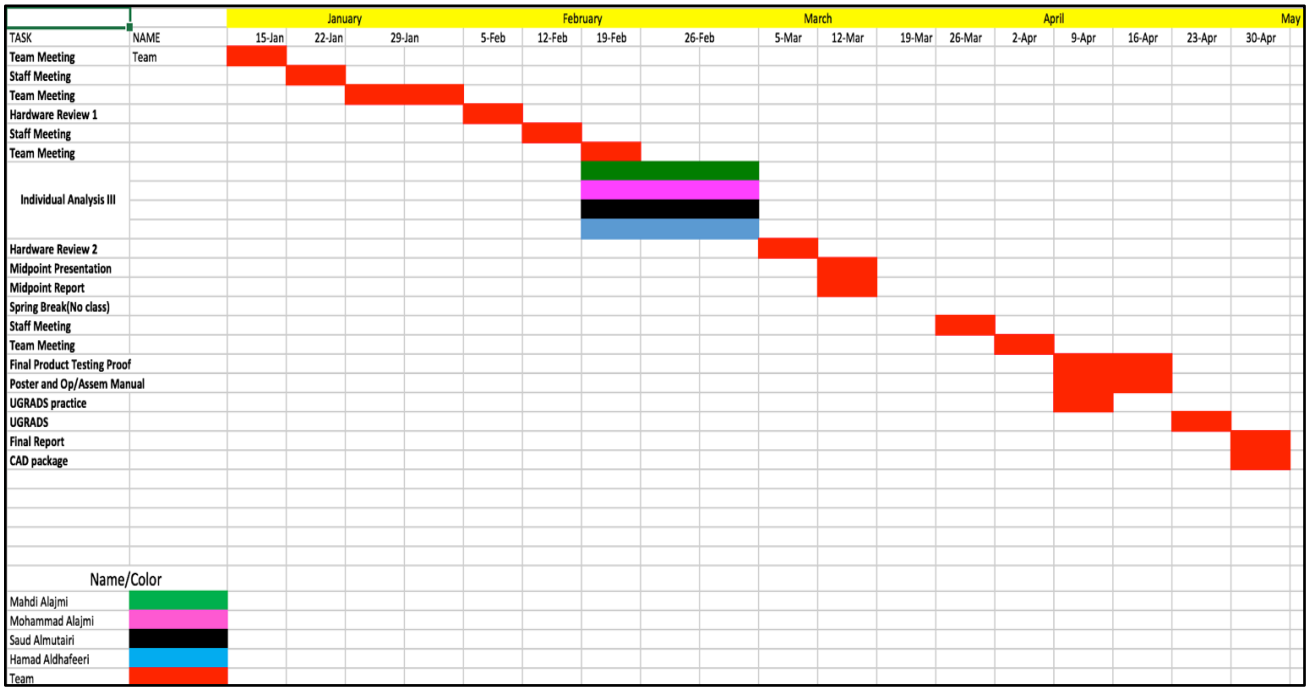


Figure 20: Gantt chart for Schedule

7 Implementation (second semester)

The design#4 is finalized after detailed analysis and the same has to be practically implemented. All the customer requirements have to be kept in mind for implementation. In certain cases the implementation phase involves practical difficulties, which would not have been considered in the design phase. In the presented work a detailed analysis was carried out and the chances of any deviation while practical implementation may be negligible. The main issue that needs to be addressed is the cost effectiveness, lightweight and reliability. Aluminum was decided to be the fabrication element. Aluminum is lightweight and has sufficient strength to take care of sufficiently large loads. The jaw portion of the assistive holder cannot be metallic; the reason behind is the load that it applies on the object. The metallic jaw may damage sensitive objects such as glass and dishes. For protecting the objects from the jaw loads the jaws were designed using plastic material. A low stiffness spring was used to lift the objects. Figure 21 presents the plastic jaw that was used for the implementation.

7.1 Manufacturing

The manufacturing process of the assistive holder was carried out at Kuwait during the break. The design was developed in solid work. This computer aided design software has many features and can generate drawing, which can be directly used by the fabrication departments. Out design was fabricated in a machine shop. The jaw portion of the assistive holder was made using a toughened plastic. It has four small components namely the base plate, the jaw holder, support shaft and the jaw. All these four components were independently fabricated and assembled to form a component as shown in figure 23. The shaft portion of the assistive holder is fabricated using a metallic material and does not have much machinery involved. When we finished the CAD package we showed to our client before we start manufacture to make sure this design meets the client requirements. After we got approve from our client we started build and manufacture the parts. We started build the inner parts to test the mechanism and make sure it is working correctly. We explained each part that we built to the client to make sure they understand every part and how this part work.

We have manufactured parts that are connecting together that each one is helping the other parts to go to the next level of transitions let's start with the handle and trigger and how the system would work. First of all, when the user is holding the device from the handle in the figure 22 and the trigger in figure 21 is attached to the handle. Moreover, the trigger has extra peace that is connected to the shafts that on the device as is shown on the figure 23. So, when the user pulls the trigger the extra peace going to move the shaft forward and that's going to cause opening the jaws as it shows on the figure 23. Moreover, on the jaws on figure 24 there are four links, which called jaws supporters and jaws holder they are both helping the jaw to be stronger and never vibrates when it is working.

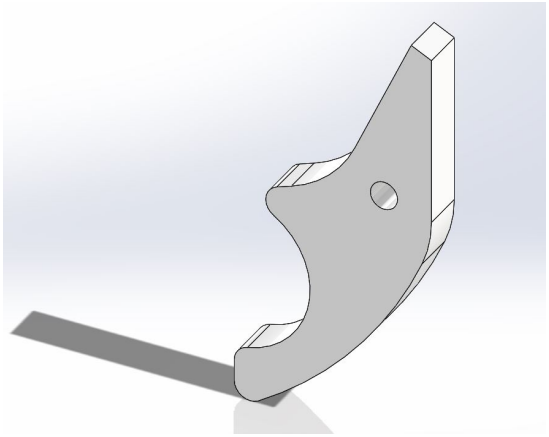


Figure 21: trigger

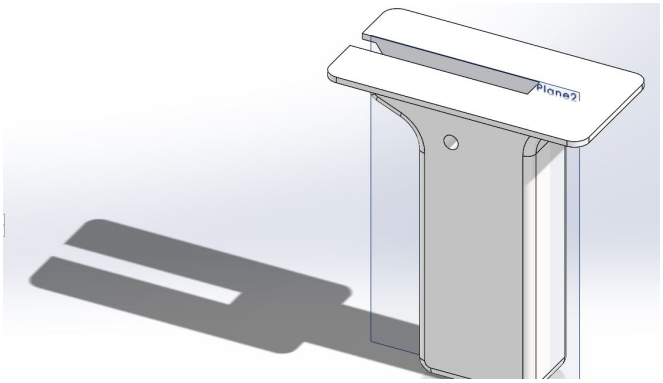


Figure 22: handle

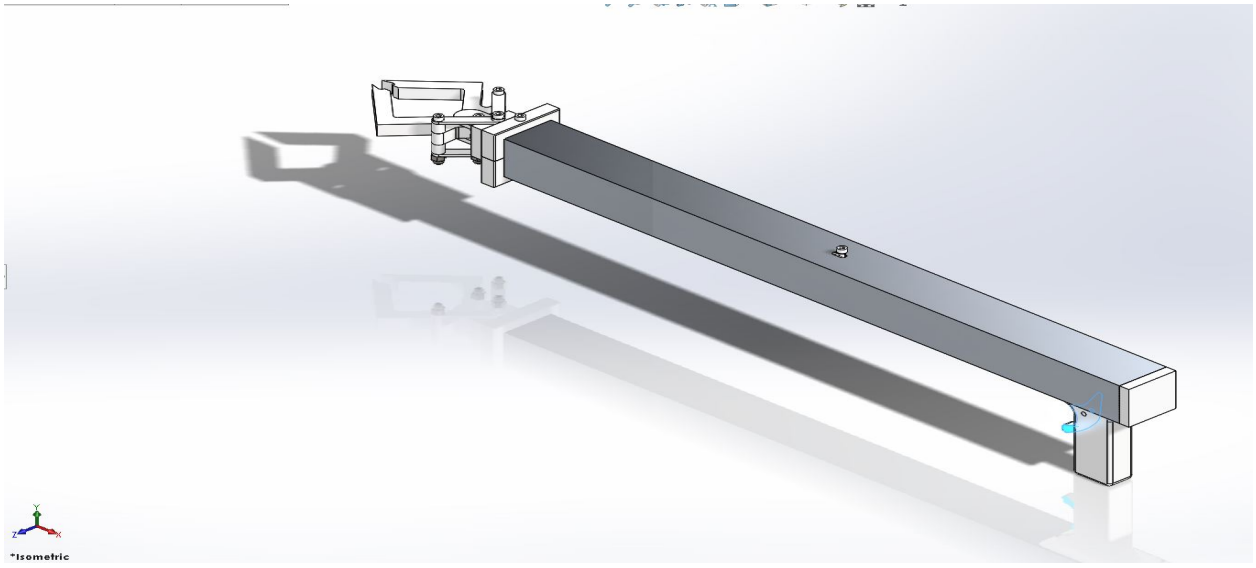


Figure 23: final design

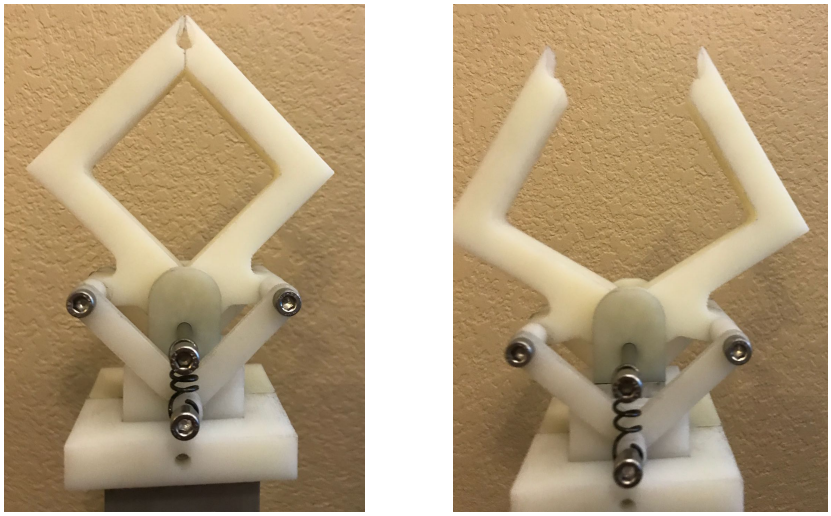


Figure 24: Jaws

Also, in the device the user can change the length freely from 70cm to 100cm that means that the user has 30cm to change. And that system works based on the sliders that inside the device that is made from artylon plastic which help the pipes inside the device to slide smoothly and never get damaged. As you see in the figure 25 is the artylon that has been manufactured and it works as sliders for the pipes that is showing on figure 26

Figure 25: parts

Figure 26: aluminum pipes

We have finished our design 99%, and there are no manufactured parts left. The only thing that is left is the accessory such as rubbers on the jaws. As it shown on the figure 24 above that the end of the jaws having a space and it is going to be supported by rubber in order to hold the small object such as the pencils and drawing tools. Also adding magnets on the jaws in order to magnetize the iron objects that on places that the device can't reach. Moreover, put rubbers on the edges for the user safety and to ensure that the device never gets damaged.

Table 10: New Budget

Material	**Cost ($)**
Materials used	200
Manufacturing	518
Shipment	150
Total	**868+Tax**

Our budget is $2000 to do our device. We spent $200 in the material that we want our device to be made of. Also, for the manufacturing parts, we spent $518. And we spent about $150 to ship the parts that we manufactured. Our budget has been changed from the previous semester, because the first semester was estimate budget. Also, we have $200 from our budget for any emergency situation. For example, if we get any damage in any parts. We have this amount of money to rebuild this part again.

		March			April				May		
TASK	NAME	12-Mar	19-Mar	26-Mar	2-Apr	9-Apr	16-Apr	23-Apr	30-Apr	7-May	14-May
Presentation:	Team										
Making Slides	Mohammad										
edtting slides	Madhi										
	Saud										
Mid Point Report	Team										
edit Last semester report	Hamad										
Follow comments for last semester report	Mohammad										
Hardware Review 2& summary											
Register for UGRAD	Mohammad										
Testing	Team										
Final Testting prof	Team										
Ugrad practice	Team										
UGRADS	Team										
Final Report											
work on Report	Mohammad										
	Saud										
edit and review report	Mahdi										
	Hamad										
Final CAD	Team										
Legend											
Completed											
In Progress											
Needs to be started											

Figure 27: Gantt chart

In figure 27 is showing our current Gantt chart for the second semester. We are currently on time with the tasks that we are required to accomplish. Everyone on the team has his own mission for completing the tasks that he is assigning to do. The green bar is the ones that we have accomplished it, the yellow bar the work that in progress, and the red need to be started. So, as you see Hardware reviw2 summary needs to be started first because we do not want to be behind the schedule, so when we finish the HR2 summary, the all team are going to the testing prove,

and we are going to complete our device 100% and it is going to be ready to give it to our client. After that the team are going to do the UGRAD practice in order to stay on time.

7.2 Design Changes

We have made changes in our design because that the previous design would not meet the client requirements such as the length change, grabber teeth and the weight of the device. These changes have been made because we need better materials for the weight, better idea for the grabber teeth and better idea for length change.

1- Previous design

In the previous, we did the device on the solid work and we did not think about the weight of the design, grabber teeth, and length change.

**Lightweight:*

In this design we have made the design in the solid work and we used the materials from aluminum and wood, which was really heavy than what our client and us wanted. All the parts that were applied on the device were heavy. As it shown in figure 28

**Grabber teeth:*

Our design for the grabber teeth was not meeting the requirement of our client, it was from Aluminum and not professional to hold the small objects as our client required us to do. In this design the grabber would not work very well to hold the small object and the users are going to have difficulties by using it. As it shown in figure 28

**Length change:*

In this design, we made three holes that in the inner shaft, which would let the user to change the length three times, which means limited changing of length. So our client said that the users likely did not feel happy with the limited changing of length. As it shown on figure 28.

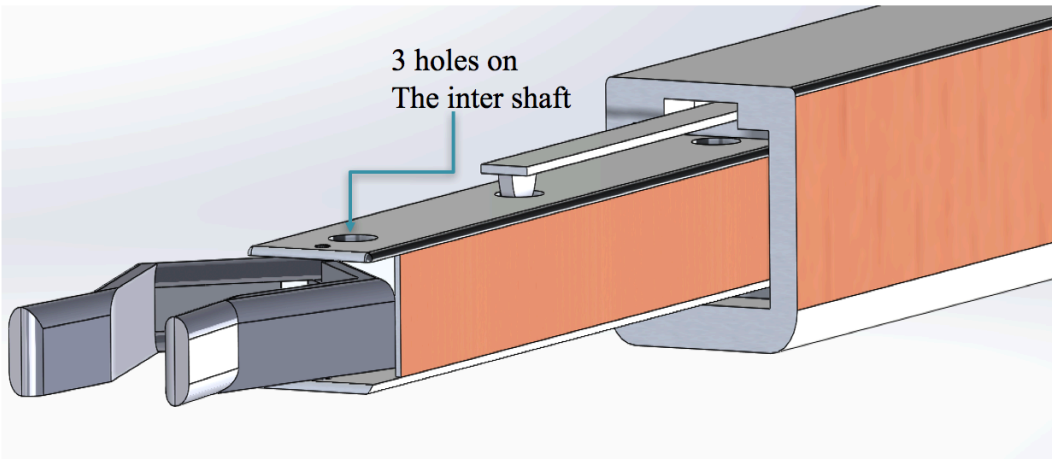


Figure 28: previous design

2- Current design

First of all, that as team we looked at the customer requirements, so we have applied them on the solidworks in order to meet the requirements that we got from the client. Moreover the client said that they want the device lightweight, grabber teeth could hold the small objects, and the length change. These three requirements are the important requirements that we need to do.

**Lightweight:*

The way that we could do this is look out materials that has lightweight, and we found out that the best materials that is going to meet this requirement such as the 1060 Aluminum, and artylon plastic. After picking these two materials, we have to see which part should be made from to manage the weight. So the pipes are made from the aluminum and the other parts such as the grabber teeth, the handle, trigger, and inside sliders are made from artylon, which let us get the lightweight device as it shown in figure 29.

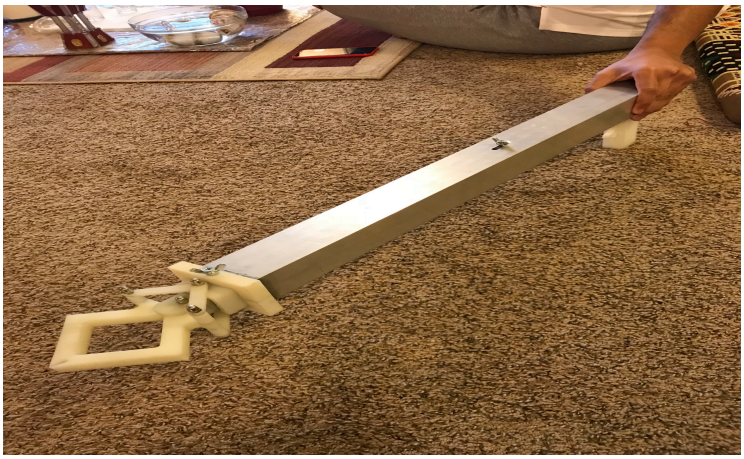


Figure 29: current design

**Grabber teeth:*

While we were designing our project we made sure that our device could hold the small object that one of the client needs. So we have made the end of the grabber teeth has space while it closing and manage it in order to hold the small object such as the pencil and drawing tools. Also, it could hold the other objects as it shown in figure 30 and 31.

Figure 30: small objects

Figure 31: other objects

**Length change:*

In our current we have made some changes from the previous design with changing the length. So we have removed the three holes that in the inner shaft and make free length changing. When our client saw this idea and the users, they like it because they would feel free when they want to change the length. So the actual devise is 100 cm, which is divided in two shafts length, so the inner shaft is 30cm and outer shaft is 70cm. so the users are going to change the length in the inner shaft. The length changing starts from 70cm to 100cm. as it shown on figure 32 and 33.

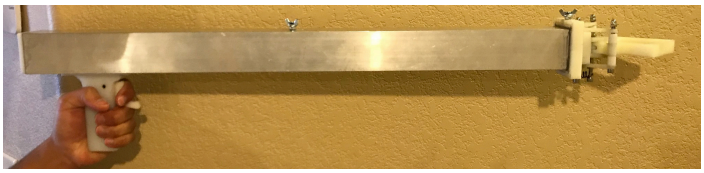


Figure32: Device with 70cm length

Figure33: Device with 100cm length

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