GNG 2101

University of Ottawa: Faculty of Engineering

Project Deliverable C: Conceptual Design and Project Plan

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Group Z-22

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Introduction

The goal of this project is to design safe to use automatic power grabber that would help those with physical disabilities that impede them from grabbing objects themselves. In this deliverable the functions and sub functions of the grabber system will be established. Additionally, this deliverable explores various grabber system concepts that would attain the target specification established in the previous deliverable. The designs will be compared and one or a few designs will be selected to be further worked on.

Conceptual Design

This part of the deliverable will break down the systems of the automatic grabber system. The functional decomposition of the automatic power grabber system will aid in the designs of the concepts of the team. Each member of the team will come up with a few designs based on the client's needs developed during the client meeting. Then an evaluation will be performed on each design and a group/final design will be constructed to be further worked on by the team.

Functions

The sub-functiosn

Functional Decomposition

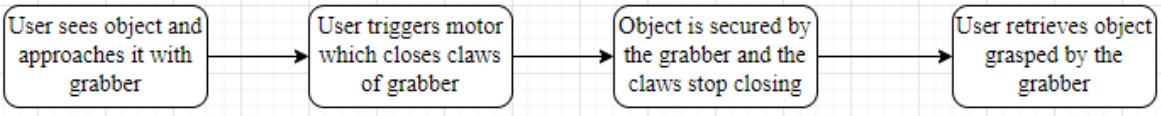


Figure 1: High-Level Decomposition of Power Handle Grabber

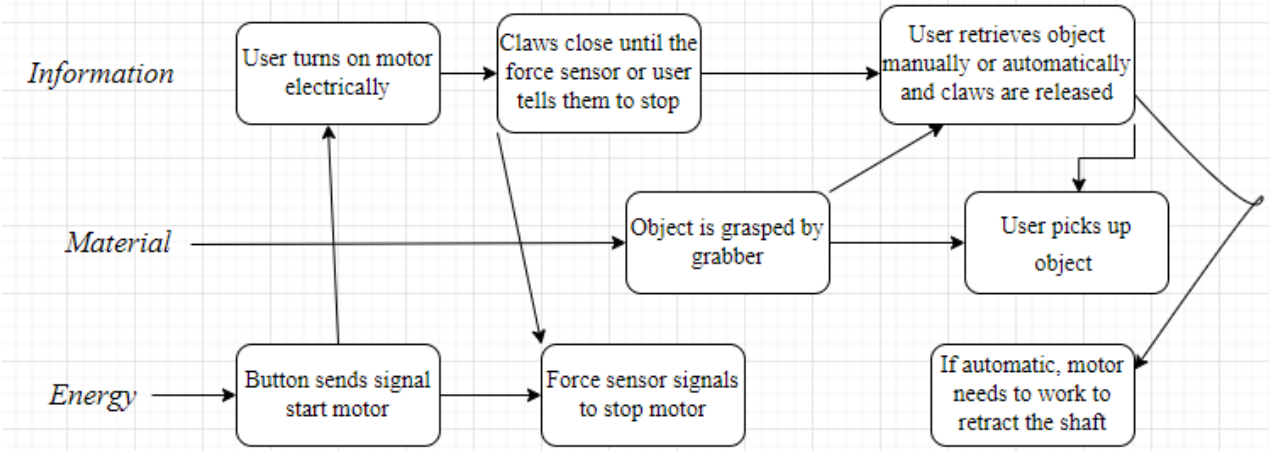
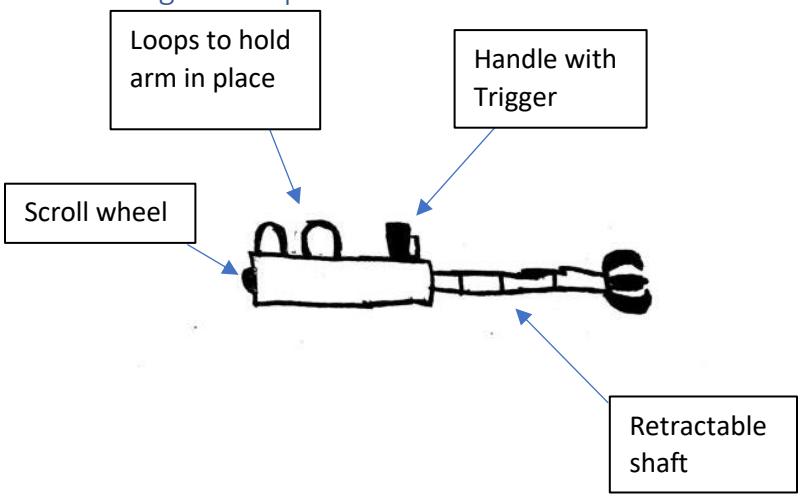


Figure 2: Detailed Functional Decomposition of Power Handle Grabber

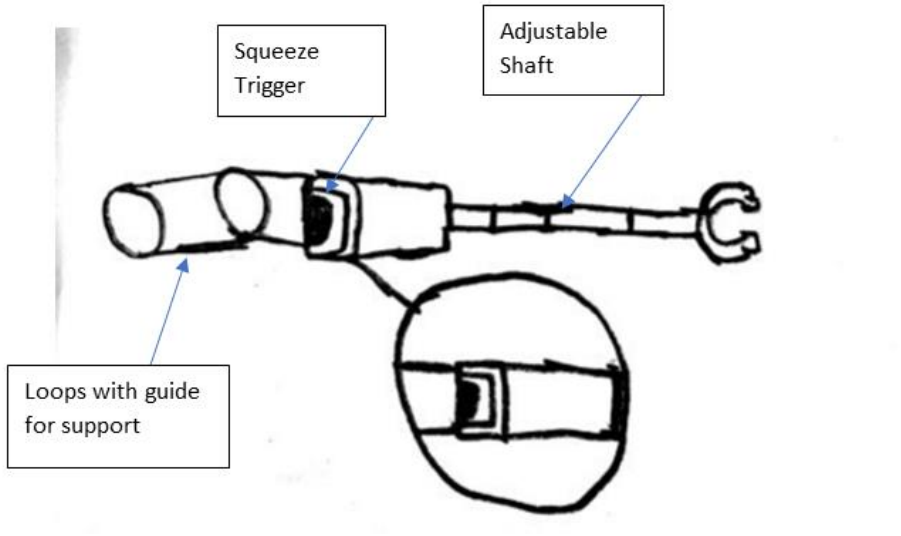
Design Concepts

Sean's design concepts



Concept 1 of the design consists of 3 main components of the power grabber. The body of the grabber houses all the internal motors, circuits, and Arduinos. The main body is where the user will place their forearm, it will go through 2 loops that will hold the arm and keep it attached to the main body of the grabber. On the body of the grabber lies a handle which the user will squeeze to open and close the jaws of the grabber. The shaft is adjustable, changing the length of the grabber to the users desired length. Finally, the jaw of the grabber is a 3-jaw system which will close and open when the handle is squeezed by the user. The force applied by the jaws is adjusted by a scroll wheel on the back of the main body of the grabber, this is to increase or decrease the applied force to pick up either heavy or delicate objects. The grip of the jaws is a greppable rubber.

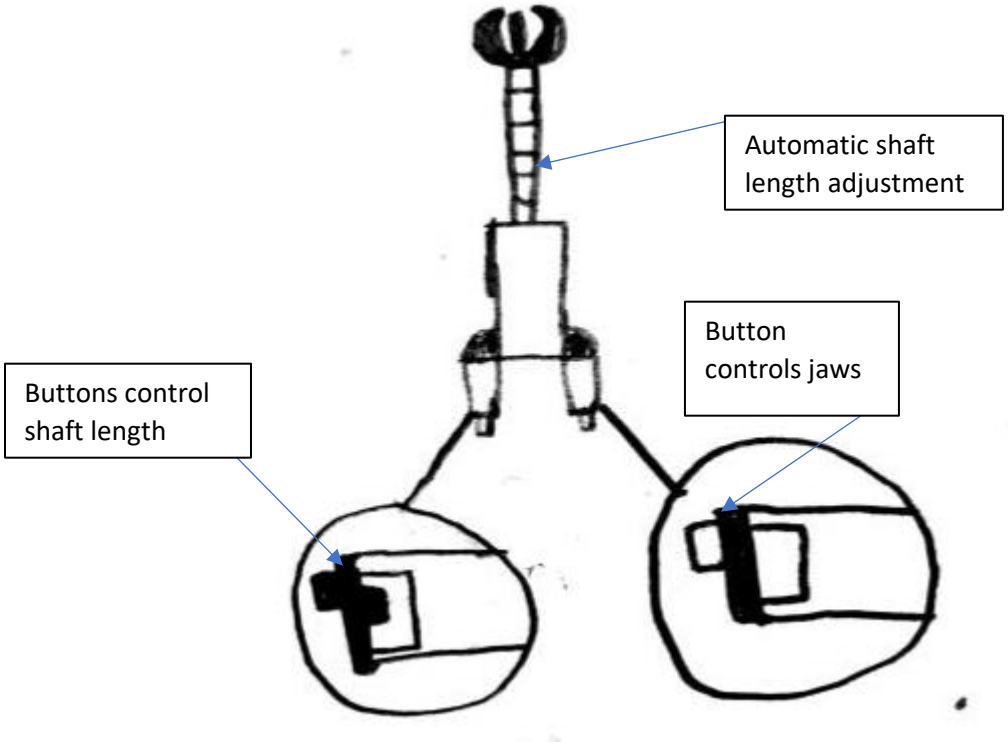
Pros	• Can pick up smaller objects with the 3-jaw system. • Loops to support arm help with comfort when using the grabber. • Scroll helps pick up delicate objects or heavy objects.
Cons	• May be difficult to put on if user has difficulty putting arm through then loops. • 3-jaw system may make it difficult to pick up certain objects with obscure shape



Concept 2 has an extension that comes outwards towards the user that they put their arm into to help support the grabber, it consists of two loops that are attached to the back of the main body of the grabber. The user will then place their hand on the handle at the back of the main body where they will squeeze the handle to open and close the jaw. The tips of the jaw will be magnetic to gram small metal objects such as keys. There will also be a force sensor in the jaws to ensure delicate objects are not broken. The shaft of the grabber will be adjustable so the user can adjust the length of the grabber. The material of the jaws is rubber with a magnetic tip so it can pick up smaller objects. It can attach a small hook to the jaw tips as well for smaller loose objects.

Pro	• Guide with loops help the suer with comfort and stability. • 2-Jaw system will help with more basic shapes and is cost effective and cheap.

	• The squeeze trigger makes it easy for the user.
Con	• User may have issues with getting arm in guide. • Grabber jaws can only grab simple objects with its 2-jaw system. • Extra material is required to build arm guide.

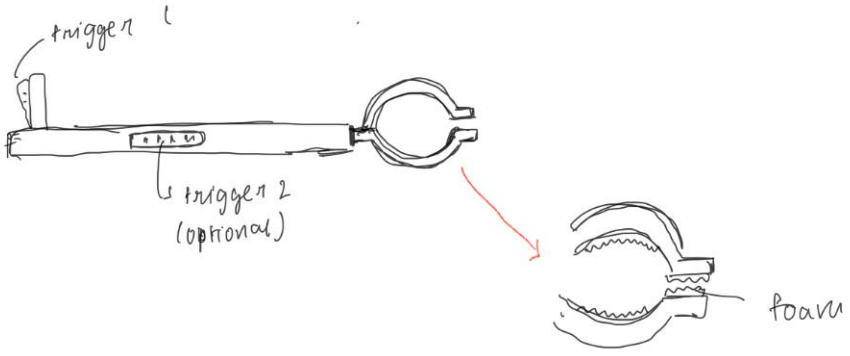


Concept 3 has two handles for the user, the left will adjust the shaft of the grabber to either extend or retract, while the right closes and opens the jaws of the grabber. The right handle will be controlled by a button to open and close, whereas the left handle will have two buttons to control the extension and retraction. The handles will be attached to the main body of the grabber. The jaws of the grabbers consist of three jaws that would grab an object. The jaw of the grabber is rubber so it can grip objects easier.

Pro	• 2 handle system makes it easy for the user to do all thing with just the device. • Automatic retractable jaws make it easy for the user to adjust the length.
Con	• 4-Jaw system makes it hard to grip some obscure shaped objects. • Grabber will weigh significantly more. • Grabber will require more extra parts and cost more.

Selection Criteria	Weight	Design Concept #1	Design Concept #2	Design Concept #3
Cost	0.1	4	3	1
Handle Ergonomics	0.2	3	3	2
Weight	0.1	3	2	1
Grip of Grabber	0.2	3	3	4
Ease of Operation	0.25	2	3	3
Force Detection System	0.05	2	3	3
Magnets	0.025	0	5	0
Hook	0.0125	0	5	0
Portability	0.0125	3	2	1
Ease of Retrieval	0.05	3	3	5
Total	n/a	2.69	2.96	2.56

Kesi's design concepts



Concept 1 includes two triggers. The first is to be held by the primary hand, while the second by the secondary hand. The second is to help the clients gain a better grip on whatever object they want to grab; this is optional. The grabber can be extended using a linear actuator so the body can extend and retract. The grabber will be shaped as shown in the illustration above. This shape

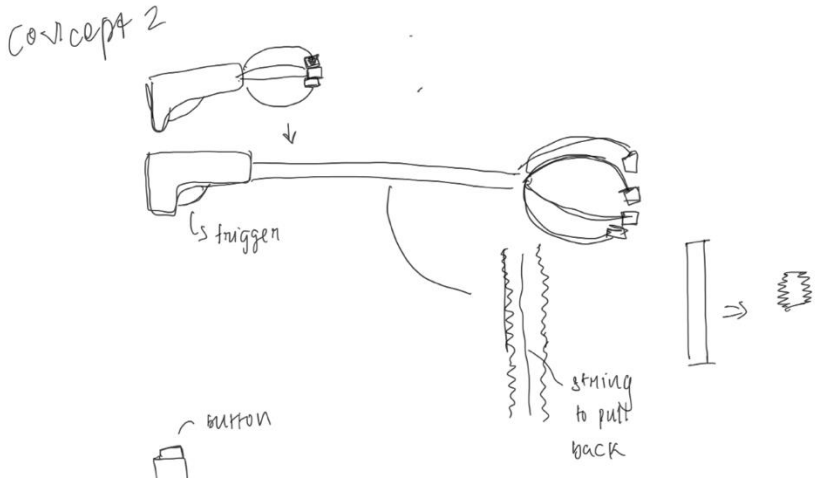
can accommodate objects as large and cylindrical as a water bottle or as small and cubic as a Lego piece. The grabber would also be coated with foam.

Pros:

- Versatile to grab many object
- Has two hands for extra support to not strain the client's grip

Cons:

- Might be uncomfortable to hold.
- Is not automatic (require two triggers to extend and retract)



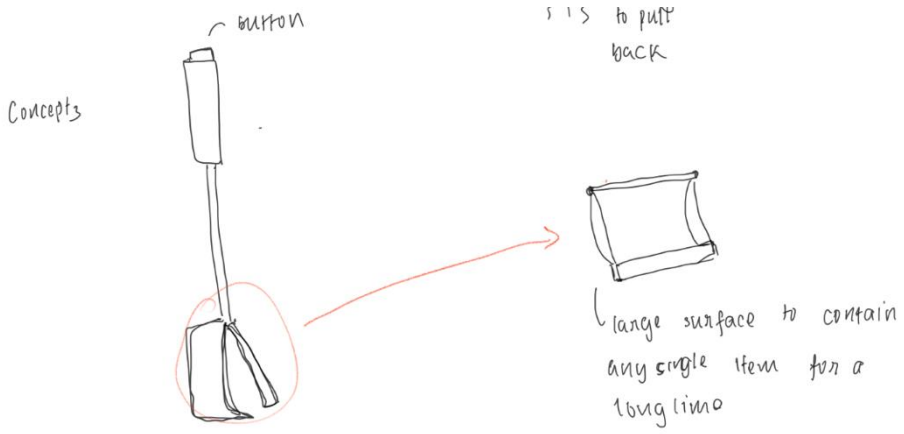
The grabber is "shot" out using a spring projectile motion mechanism in Concept 2. To shoot the grabber, there is only one trigger. The body of the power grabber is made of an elastic material that allows it to squeeze in its initial position while remaining fully straight when released. The grabber is a claw with sensors at the tips. When one detects an object, the others begin to close in until all detect, and the grabber retracts to its original position.

Pros:

- Easy to use
- Very light to carry

Cons:

- Limited to objects to carry



Concept 3 includes a button to control the linear actuator, which is located at the body to extend or retract. The grabber has a large surface to ensure it carries the object as fragile as a crystal ornament for an extended period of time (or until it is returned to the client's position).

Pros:

- Easy to use
- Can hold large fragile item

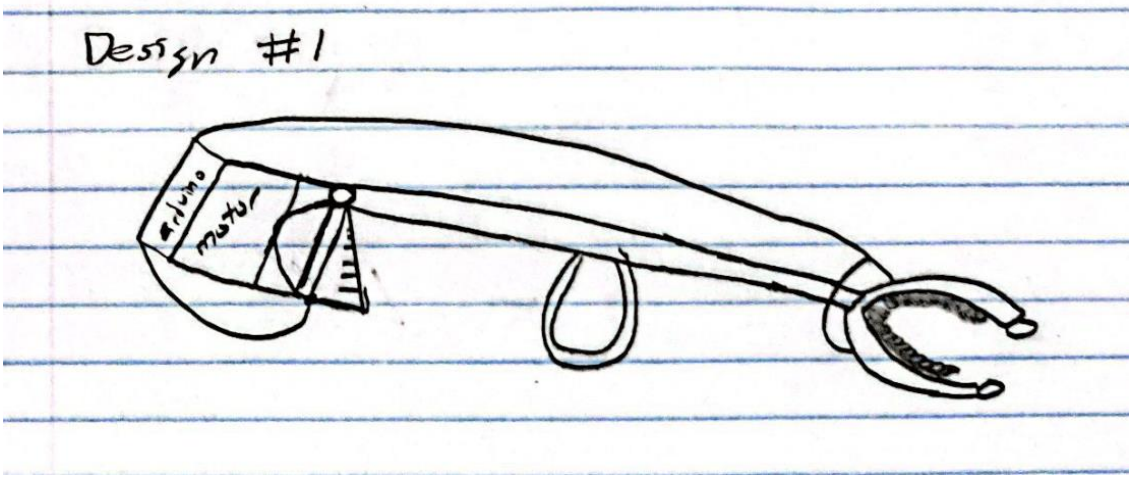
Cons:

- It is not arthrogryposis friendly.

Table 4: Weighted Decision Matrix of Kesi's Concepts (scale 0-5)

Selection Criteria	**Weight**	**Design Concept #1**		**Design Concept #2**		**Design Concept #3**	
Cost	0.1	3	0.3	3	0.3	4	0.4
Handle Ergonomics	0.2	4	0.8	2	0.4	1	0.2
Weight	0.1	2	0.2	4	0.4	4	0.4
Grip of Grabber	0.2	4	0.8	2	0.4	0	0
Ease of Operation	0.25	2	0.5	3	0.75	3	0.75
Force Detection System	0.05	2	0.1	4	0.2	0	0
Magnets	0.025	3	0.075	0	0	0	0
Hook	0.01	4	0.04	3	0.03	0	0
Portability	0.0125	4	0.05	4	0.05	4	0.05
Ease of retrieval	0.05	3	0.15	4	0.2	0	0
Total	1	3.015		2.73		1.8	

Daniel's Design Concepts



Description:

This design is quite simple in the sense that it is very similar to an original handle grabber. The key difference is that this one is motorized of course. The handle is designed such that the trigger does not need to be pulled back far for the motor to start and the grabber to grasp. The loop in the middle of the bar is designed such that the user can put their wrist in the hole and lift up the power handle grabber to retrieve the object they picked up. The grabber is equipped with foam so that more fragile objects will not be broken so easily. There are also magnets at the ends of the grabber so magnetic objects can be retrieved easily. The grabber has a force sensor which if it detects too much force being put into the object, the trigger will lock so that no more force can be used. The Arduino and motor are intentionally placed behind the handle to balance the weight of the power handle grabber, making it easier for the user to maneuver. The lines running outside are the wires, which in the actual design will of course be much closer to the bar.

Table 1: Pros and Cons for Daniel's first Design Concept

Pros	• A straightforward design which does not require too much more material than an original power grabber. • Facilitates use with a force sensor. • The shaft is balanced out.
Cons	• Handle may not be very comfortable for user and may occasionally slip causing the power handle to drop the object. • The method used for picking up the object may not be ideal as it requires the user to lift up the bar and reach to pick up the object (or the user can also

	set it on a table, but this is not always possible). • The foam may reduce the grip of the grabber.

Description:

This design introduces several new features to the power handle grabber. Like the first design, the grabber has foam for fragile objects and magnets at the ends. There is still a force sensor as well. However, this design involves the use of two buttons. The first button at the top is used to move the claws of the grabber inwards and grasp the object. The user holds the button and the claws slowly move inwards. The force sensor would act similarly to the first design where when enough force is detected, the user would not be able to close the claws anymore. The second button makes use of the retractable arm which is also new to the design. The arm would bring in the grabber so that the user does need to reach far to grab the object. When the user releases the second button, the grabber will open its claws to release the object and the bar will begin to extend again. The lines running outside are the wires, which in the actual design will of course be much closer to the bar.

Table 2: Pros and Cons for Daniel's second Design Concept

Pros	• The shaft's weight is balanced out. • The use of buttons should theoretically reduce the possibility of slipping, as the user only needs to press in one spot. • The retractable shaft will greatly ease the retrieval of the object.
Cons	• The foam may reduce the grip of the grabber. • The use of two small buttons does not eliminate the possibility of a finger slipping (although it is preferable to the whole hand slipping). • If the user's finger slips while holding the second button, the object will fall. • The two-button system may be annoying, as the user will need to avoid pressing buttons when they do not want to (may be hard with limited grip).

Description:

This design recycles many main ideas from previous designs. It continues with the use of magnets, a retractable arm, and a force sensor. However, it uses one large button on top of the

handle. This is designed to be simpler for the user to operate. Pressing the large button will cause the claws to close. However, the force sensor will continue the process automatically from this point forward. It will detect once enough force has been put on the object, stop the closing of the claws, and commence the retraction of the bar. If the user presses the button again, the automated process will stop, and the grabber will reset. Thus, the button is to be pressed again when the user is ready to pick up the object or as an emergency stop. This design should make the process as simple for the user as possible. There is also rubber instead of foam inside the claws of the grabber. This will make fragile objects slightly more vulnerable than with foam, however, will vastly increase the grip of the grabber. The lines running outside are the wires, which in the actual design will of course be much closer to the bar.

Table 3: Pros and Cons for Daniel's third Design Concept

Pros	• Rubber will increase grip of the grabber while also slightly decreasing the vulnerability of fragile objects. • Nearly fully automated system facilitates operation for the user. • The retractable shaft will greatly ease the retrieval of the object. • The large button will allow for easier maneuverability for the user.
Cons	• The fully automated system depends heavily on technology and will be difficult to integrate. • If the user presses the button by accident, the item can fall and break.

Table 4: Weighted Decision Matrix of Daniel's Concepts on a Scale of 0-5

Selection Criteria	**Weight**	**Design Concept #1**	**Design Concept #2**	**Design Concept #3**
Cost	0.1	4	2	1
Handle Ergonomics	0.2	2	4	5
Weight	0.1	3	3	3
Grip of Grabber	0.2	3	3	4
Ease of Operation	0.25	2	3	4
Force Detection System	0.05	4	4	4
Magnets	0.025	5	5	5
Hook	0.0125	0	0	0
Portability	0.0125	2	2	2

Ease of Retrieval	0.05	1	4	5
Total	n/a	2.24	3.2	3.7

Final Concept

The final concept includes the best of our designs. After evaluating our designs using a weighted decision matrix and conversing amongst ourselves about the best features of our designs, we have decided upon a final design which is not only feasible but should exceed user needs. The final design includes a special claw design, which is circular but near the ends it is small and straight. This allows for circular objects such as water bottles to be picked up, but also small objects such as pencils or erasers. The shaft is extendable and retractable both manually and automatically. This will allow for the user to retrieve the desired object easily. The handle provides plenty of support, including two rings where the user places their arm. This allows the user to not expend as much effort on their wrist but use their arm to support the weight of the shaft. The handle consists of a simple trigger which will only need to be pressed twice throughout the whole process. Once to close the jaws of the grabber, and the second time to open the jaws of the grabber and retrieve the object. Refer to the drawing below to see how the final design will look.

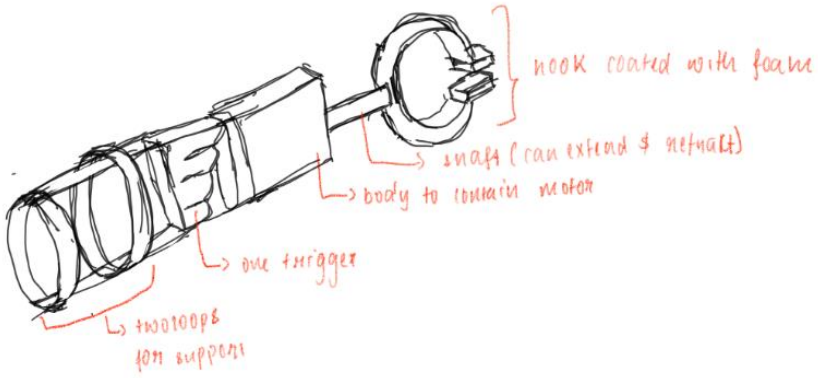


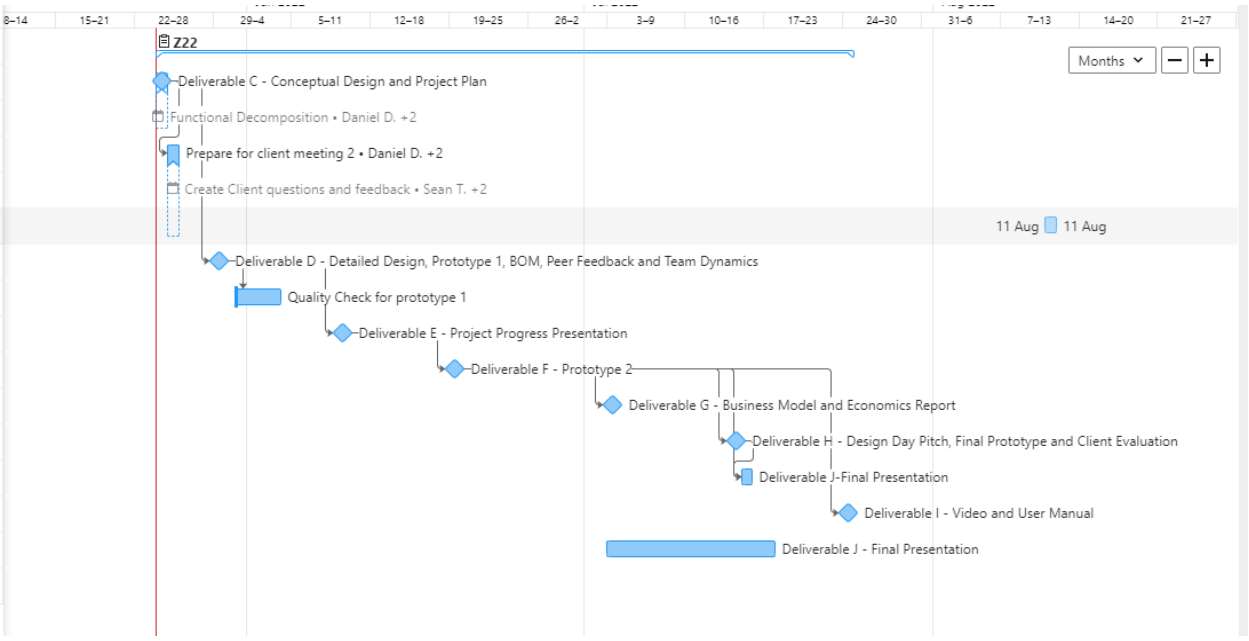
Figure 1. the final design concept sketch.

Comparing Concept to Target Specifications

Metric #	Need #	Metric	Unit	Marginal	Target	Final Concept

1	6	Weight of the Grabber	Pounds	1.7	1	Yes
2	8	Length of the Grabber	Inches	16	20	Yes
3	2	Force applied to object	Pounds	1	3	Yes (but may be difficult to keep within boundaries)
4	10	Object Weight	Pounds	1	3	Yes
5	14	Battery Life	Hours	5	8	Yes
6	5	Motor Speed	RPM	N/a	N/a	N/a (we can buy a suitable motor)

Gantt Chart



Conclusion

In short, our group evaluated nine separate design concepts using a weighted decision matrix. The best design of each group member was analyzed and discussed, and the best features of each of these designs were agglomerated into the group's final design. This design, along with the final three which were discussed, will be presented to the client in our next client meeting on

May 27, 2022. This meeting will provide much-needed feedback on the design and how to execute it to the best of our abilities. This will allow the team to start to produce the first prototype.