

GNG 2101
Design Project User and Product Manual

PowerGrab Mk. I

Submitted by:

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List of Acronyms and Glossary

Table 1. Acronyms

Acronym	Definition
BMS	Battery Management System
FDM	Fused Deposition Modeling
PLA	Polylactic acid

1 Introduction

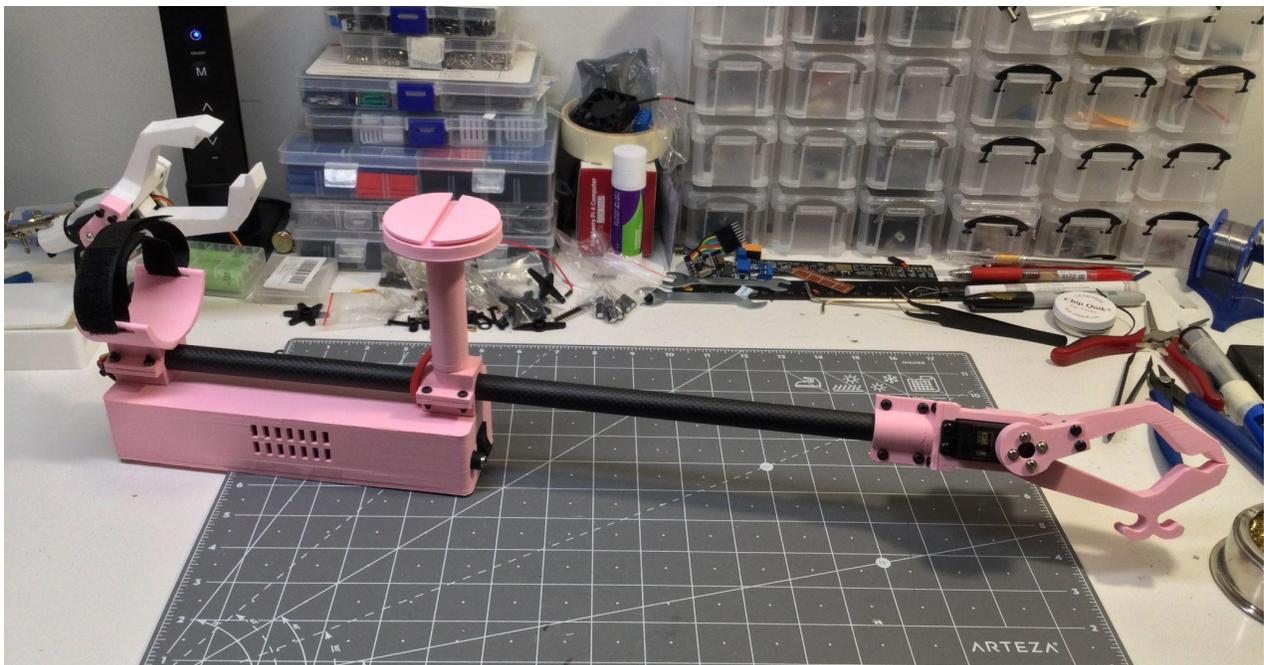
This User and Product Manual (UPM) provides the information necessary for the user to effectively use the PowerGrab Mk1 and for prototype documentation.

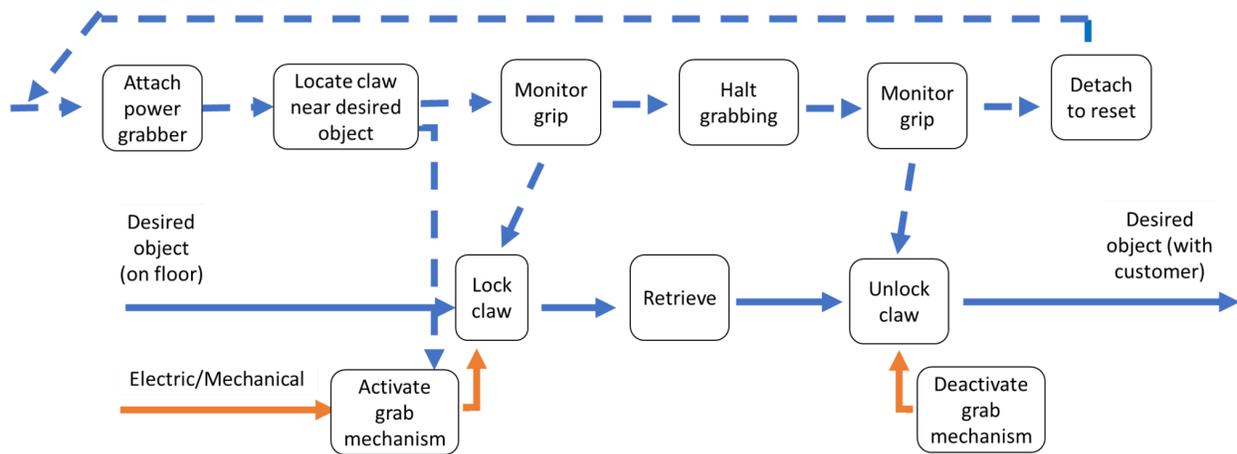
2 Overview

Many people who are handicapped, quadraplegic, and elderly have difficulty picking up everyday items from the ground. It is important that those in need have access to a product that makes this task easier for them in order to improve their quality of life and give them more independence.

Those affected by these conditions are in need of a lightweight portable device allowing them to pick up small items off the floor and to place them where they can then be picked up with ease. This device functions with the use of minimal force or difficult movement, and is easily activated without the use of dexterity.

The PowerGrab Mk1 offers the ease of use necessary for its users combined with the strength and reliability to withstand time. Its lightweight materials and ability to distribute weight make it easy for users to pick up difficult items. This device requires little effort to control due to its E-Z press buttons, and no gripping force is required. Its long lasting battery ensures the reliability that is essential in ensuring the highest quality of time for its users.





2.1 Conventions

When indicating actions described in the “Using the system” section, this action will be written in *Italic*. For example, *Moving the gripper claw* refers to the actions as described in the section called “Moving the gripper claw”.

2.2 Cautions & Warnings

- Do not use and store the device in very cold or very hot temperatures (Suitable temperature: 0 - 40°C).
- Do not charge in poorly ventilated places, e.g. under quilts, blankets, etc.
- Do not use the device in the rain or snow.
- Do not try to pick up anything with the power grabber over 1kg.
- Do not try to pick up anything as big or larger than the claw when fully opened.
- Do not rough handle the device and bang the claw, arm support, handle or power box.
- Do not try to open the power box and alter/fix the system without expert supervision.
- Do not try to lift objects such as fully packed backpacks or grocery bags with one finger of the claw.
- The claw was designed to lift objects up to 1kg using grip derived from the torque of the servo motor. The claw fingers were not designed to lift suspended objects from bags.

2.3 Disclaimer

The producers of this device are not certified electrical engineers, nor have they been properly trained in producing commercial electrical products. This device has not been certified by any regulatory agency or department. The producer of this device shall not be held responsible for any property damage or bodily injuries caused by using this device.

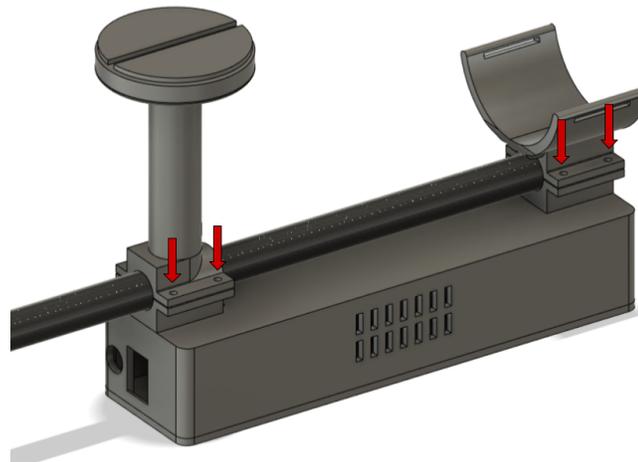
This device is developed for general use in the home environment. It is not developed or intended for use in any inherently dangerous applications, including applications that may create a

risk of personal injury. If you use this device in dangerous applications, then you shall be responsible to take all appropriate failsafe, backup, redundancy, and other measures to ensure its safe use. The producer of this device disclaims any liability for any damages caused by the use of this software or hardware in dangerous applications.

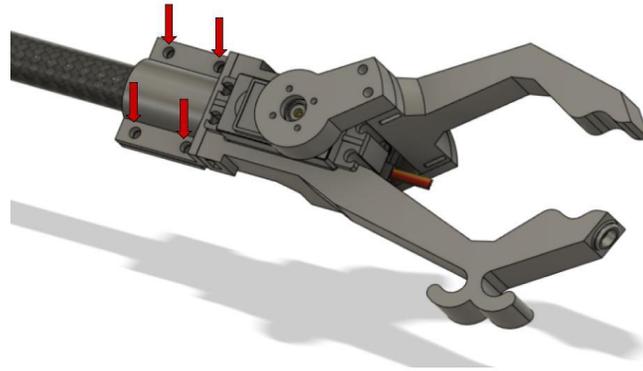
3 Getting started

3.1 Configuration Considerations

The reach of the PowerGrab Mk 1 can be adjusted to the appropriate size. In order to do so, loosen the 8 screws, (4 on the handle and 4 of the armrest) and slide the carbon fiber tube towards the desired position. The 8 screws must then be tightened to secure the device.



The angle of the gripper claw can also be adjusted to any desired angle. To change this angle, loosen the 4 screws on the gripper end and rotate the claw in whichever direction. The 4 screws must then be tightened to secure the claw.



3.2 User Access Considerations

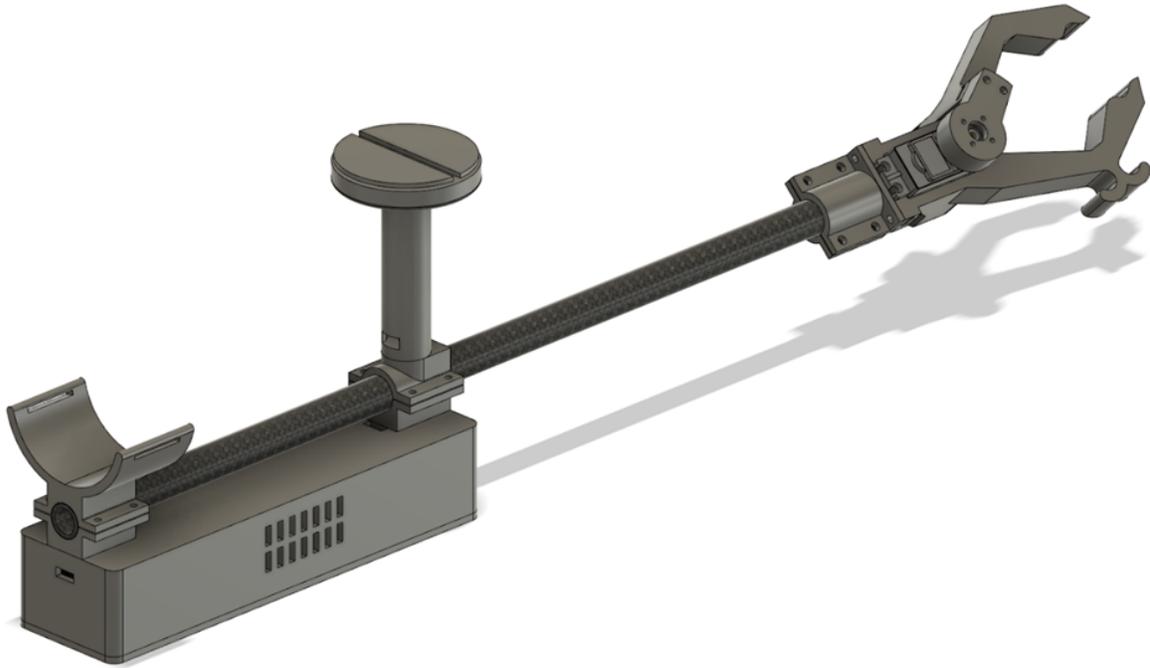
This product is primarily intended for use by handicapped, quadraplegic, and elderly. This product can also extend to anyone with difficulty reaching for or grabbing objects.

3.3 Accessing/setting-up the System

The system must be powered to beyond a certain threshold to operate. The system mechanism cannot be used while charging, the system disables upon charging, therefore the buttons will not activate anything. Recommended charging time is 1 hour for a full day's use. The system can be charged on or off, but regardless in both cases the system will not operate. Once the system has adequate power and is not charging the user may flip the power switch to enable the system functionality. The user can tighten the velcro straps around their forearm and place their thenar webspace, or area between the thumb and index finger, around the grip handle. The system is now fully equipped and functional for use.

3.4 System Organization & Navigation

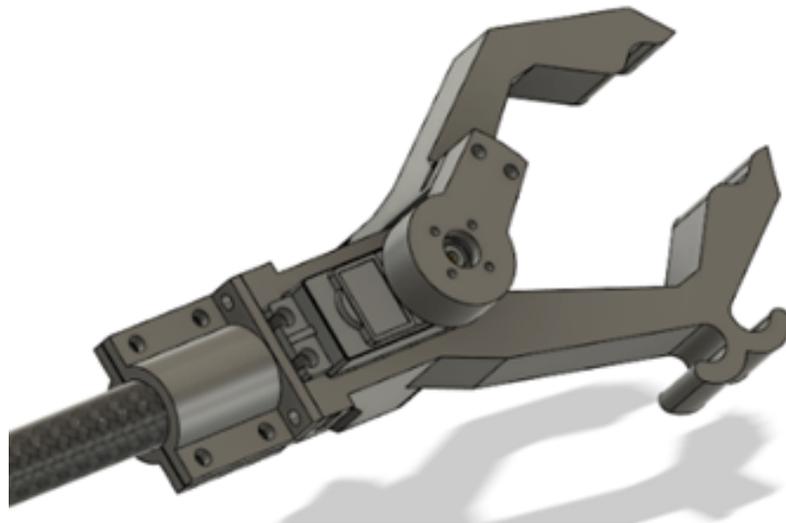
The power grabber consists of 4 main subsystems; the claw, the handle, the arm rest, the arm and the electronics box.



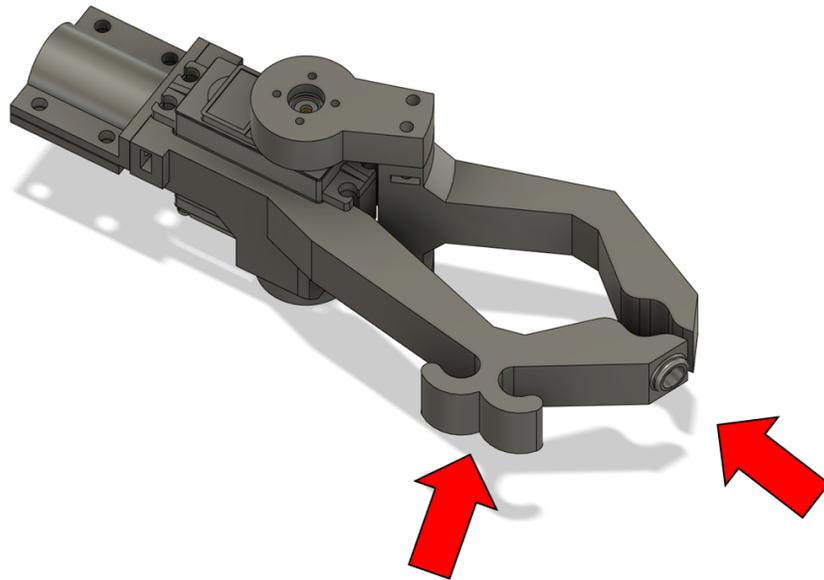
Power grabber full system

3.4.1 Claw

The claw sits at the end of the arm and is connected with 4 bolts using friction grip. The servo is located slightly above the connection and actuates one of the claw fingers. The other finger is fixed in place and has a magnet at the tip. The fixed finger also has 2 hooks to allow the user to drag or lift up smaller objects.



Claw of the Power grabber



Subsystem Concepts of the Claw



Connection between claw and the arm

3.4.2 Handle

The handle is connected roughly at the center point of the arm with 4 bolts using friction grip. This is also connected to the front end of the power box. The front end of the power box, the side closer to the claw, is where the charging port and on/off switch are located. At the top of the handle is a large cap which serves 2 functions, the first is the interface to which the user controls

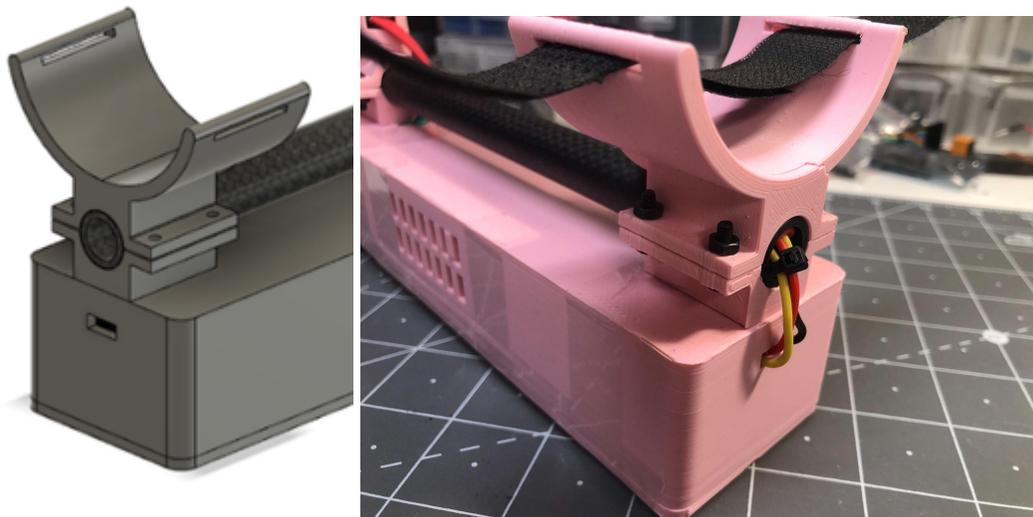
the claw with, and the second is to act as additional leverage for lifting. There are 2 buttons located at the top of the cap, one which closes the actuating finger of the claw and one that opens the actuating finger of the claw.



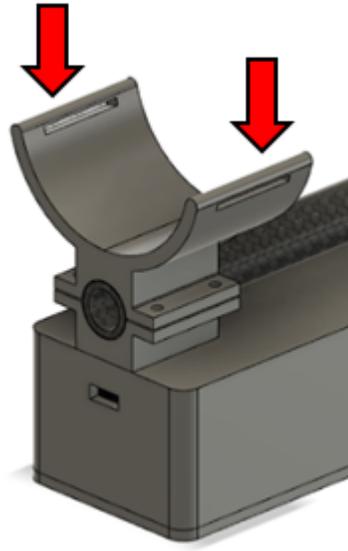
Handle of the Power Grabber [left], Connection of Arm with Handle [center], Buttons on the Handle [right]

3.4.3 Arm Rest

The user arm support is located at the back end of the arm and power box. The arm support has an arm brass to situate the users forearm and velcro straps to be tightened around the forearm. This redistributes the weight of the load and makes lifting up objects easier.



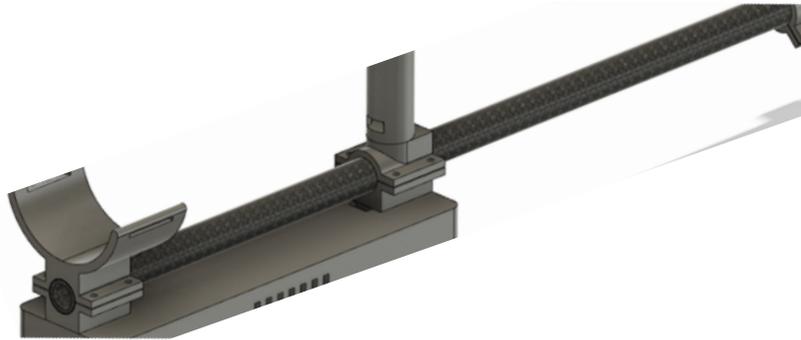
Arm Rest of the Power Grabber [left] and Connection of Arm with Arm Rest [right]



Strap Location of the Arm Rest

3.4.4 Arm

The arm is connected to every other system and essentially holds the power grabber together. At the front end of the arm is the claw. At the back end is the arm support. At the center is the handle. Underneath the lower half of the arm is the power box. Every connection is made using bolts and friction grip.

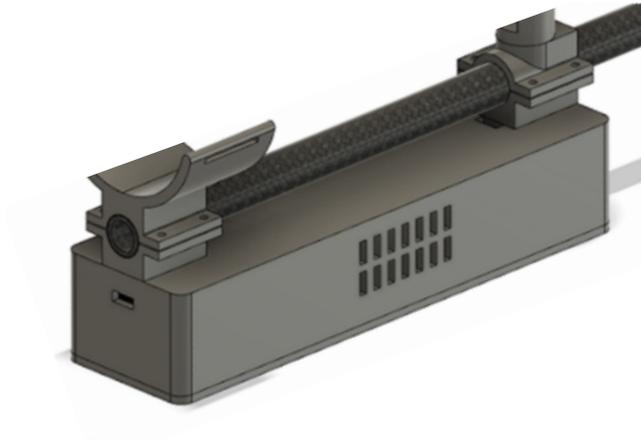


Arm of the Power Grabber

3.4.5 Electronics Box

The power box is located underneath the lower half of the arm and is connected to the arm in 2 places. The first connection to the arm is at the front end of the power box, the side closer to

the claw. This is located roughly in the center of the arm and is underneath the handle. The second connection to the arm is at the back end of the power box. This is located at the tail end of the arm and is also underneath the arm support. There are air vents on the side of the box to allow for cooling. The power box holds all the electrical equipment, the front end has the charging port and on/off switch.



Electronics Box of the Power Grabber

3.5 Exiting the System

To turn off the device, flip the power switch located on the electronics box to the off () position. To unequip the device, detach the velcro strap and remove the arm from the device.

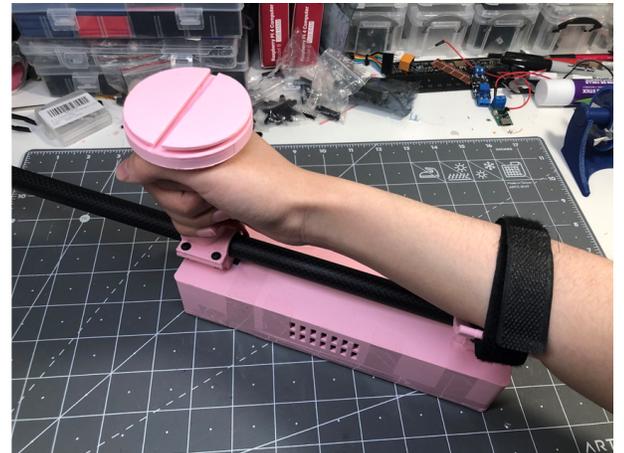
4 Using the System

1



Use dominant hand to grab the handle

2



Tighten the strap around the forearm.

3



To turn on the device, flip the power switch located on the electronics box to the on (|) position.

4



Move the power grabber around to test comfort

5



If the claw is closed like in the image above.

6



move the gripper claw (press the button to open)

7



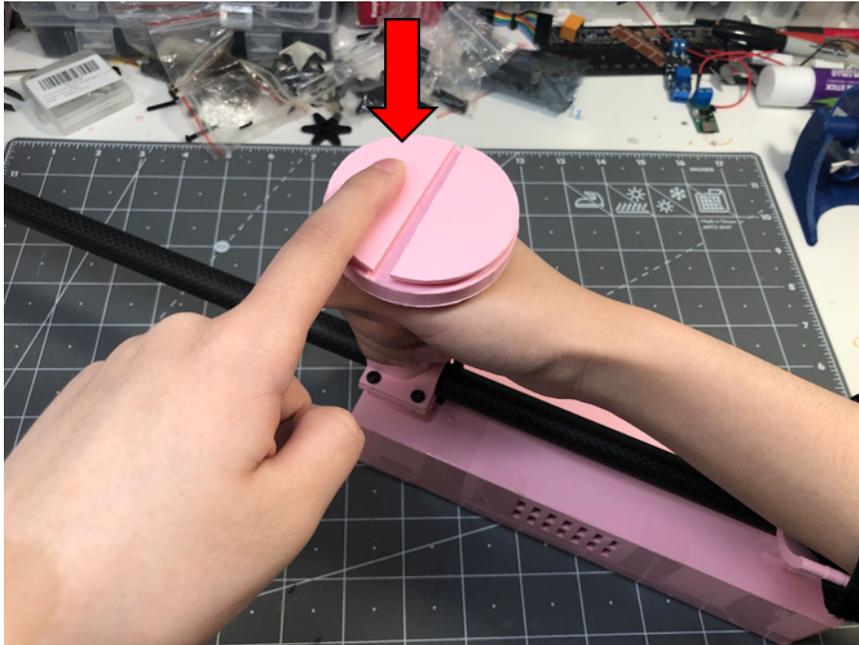
The claw is now opened

8

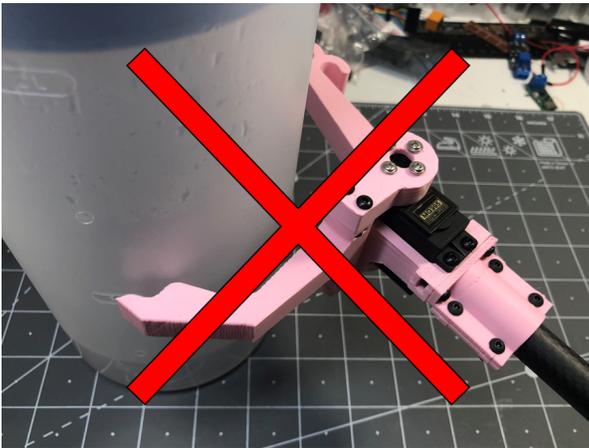


Position the gripper end of the device near a desired item

9



move the gripper claw (press the button to close)



Do not grab objects that are too big

10



Relocate the item to the desired spot and *move the gripper claw* to let the item rest on the desired surface.

11



Once finished untighten the velcro

12



Let go of the power grabber

13



Leave the power grabber somewhere safe and accessible

14



To turn off the device, flip the power switch located on the electronics box to the off (○) position.

15



Charge the device when not in use or when the battery is depleted.

The following subsections provide detailed, step-by-step instructions on how to use the various functions or features of the PowerGrab Mk 1.

4.1 Moving the gripper claw

To move the gripper claw, press on one of the two buttons on the top of the device. Press the button closest to the user to open the claw. Press the button closest to the gripper end to close the claw. Press on this button repeatedly until the claw is gripping the item with enough force.

4.2 Charging

To charge the device, insert the charger in the port located on the electronics box. If the power switch is turned on, the device's other functions will automatically disable. The PowerGrab Mk 1 cannot be operated while it is charging.

5 Troubleshooting & Support

- In the event where the device does not respond, always verify that the power switch is at its on (|) position and that no charger is plugged into the device before proceeding to contact the product supplier for technical support support.

5.1 Error Messages or Behaviors

- If the device gradually applies less gripping force over time or loses effectiveness, this could be a sign that the battery is depleting. Correct this issue by charging the device which must not be used during this process.
- If the device instantly loses all or partial functionality, this could be the indication of an internal electrical issue. In this case please see providers for proper technical assistance.

5.2 Maintenance

Ensure that the device is charged daily depending on frequency of use.

5.3 End-of-life Disposal

When the device has reached its end of life, open the battery box and take out the two 18650, and hand them to a certified recycler for recycling.

Recycle the circuit board separately as they may contain material that may cause environmental pollution.

The body of the device is made out of PLA, which can be degraded in a composter under correct conditions.

5.4 Support

In order to obtain customer support involving the PowerGrab Mk 1, send all questions or concerns to the Centre for Entrepreneurship and Engineering Design (CEED) of the University of Ottawa:

613-562-5800 ext. 1559
makerspace@uOttawa.ca

6 Product Documentation

This product was built as the combination of an electronic system and a physical system.

6.1 Electronics

6.1.1 Table 3, BOM (Bill of Materials), Electronics

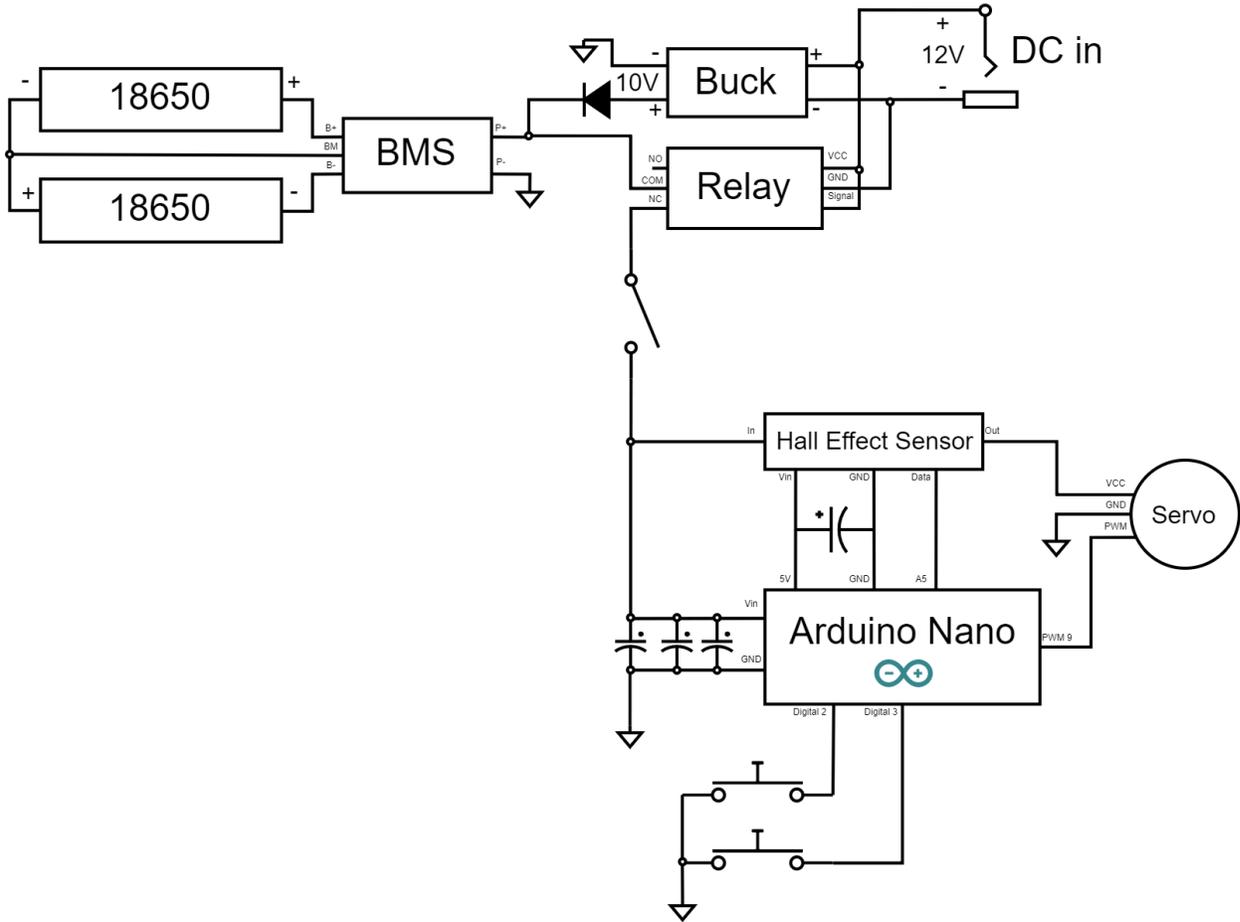
Item #	Name	Description	Qty	Cost	Total cost	Source
1	Servo motor	Actuator of the claw	4 (only using 1)	\$36+tax	\$10.17	Amazon
2	4x 18650 Li-ion batteries	Lithium batteries	4 (only using 2)	\$30+tax	\$16.95	Amazon
3	battery charging board	charging board for 18650 batteries	10 (only using 1)	\$16.95 +tax	\$1.92	Amazon
4	DC-DC Boost Converter	Boards to boost voltage	5 (only using 1)	\$12.99 +tax	\$2.94	Amazon
5	Arduino Nano	Control system	3 (only using 1)	\$30+tax	\$11.30	Amazon
6	Power switch	Power switch	15 (only using 1)	\$10	\$0.75	Amazon
7	DC power Supply	Power supply	1	\$15	16.95	Amazon
8	Relay Module	Relay Module	1	\$10	11.30	Amazon
Total electronics cost:					\$72.28	

6.1.2 Equipment list

- Servo motor
- 18650 batteries
- Charging board
- Boost converter

- Arduino nano
- Soldering iron
- Solder
- Electrical wiring
- Power switch

6.1.3 Instructions



The circuit diagram of the electronics system

Components are connected as the graph shown. When servicing, be sure to first remove the battery to avoid potential fire or explosion.

6.2 Physical system

6.2.1 Table 4, BOM (Bill of Materials), Physical system

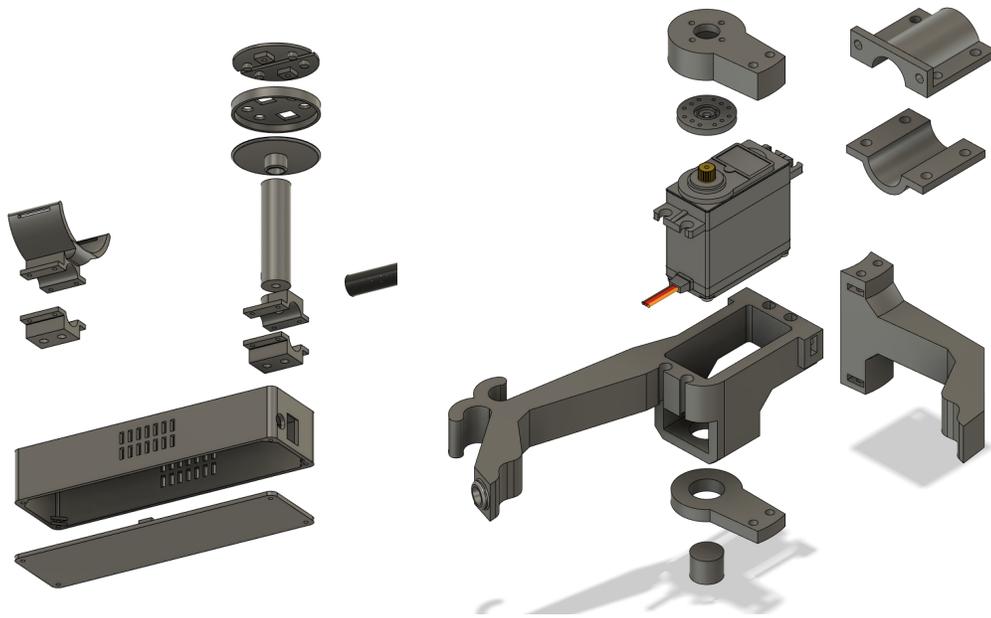
Item #	Name	Description	Qty	Cost	Total cost	Source
1	Clamps	Plastic 3D modeled clamps	2	negligible	negligible	3D print
2	Carbon Fiber Tubing	18", 15mm carbon fiber tubes x2	1	\$49/2 USD	\$31.51 CAD	SmallRig
3	Handle	Plastic 3D modeled	1	negligible	negligible	3D print
4	Armrest	Plastic 3D modeled	1	negligible	negligible	3D print
5	Electronics box	Plastic 3D modeled	1	negligible	negligible	3D print
Total physical system cost:					\$31.51	
Total project cost					\$103.79	

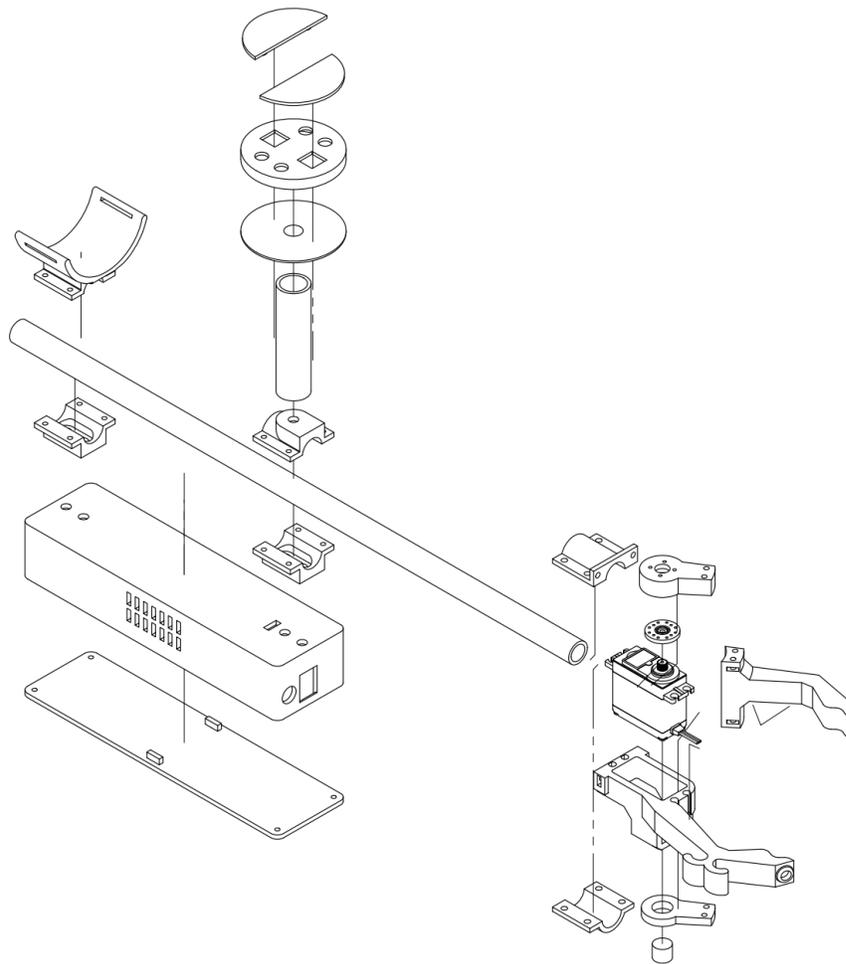
6.2.2 Equipment list

- 3D printer
- Pink PLA filament
- 15mm carbon fiber tube
- 12 small bolts and nuts
- Solidworks and Fusion 360 software

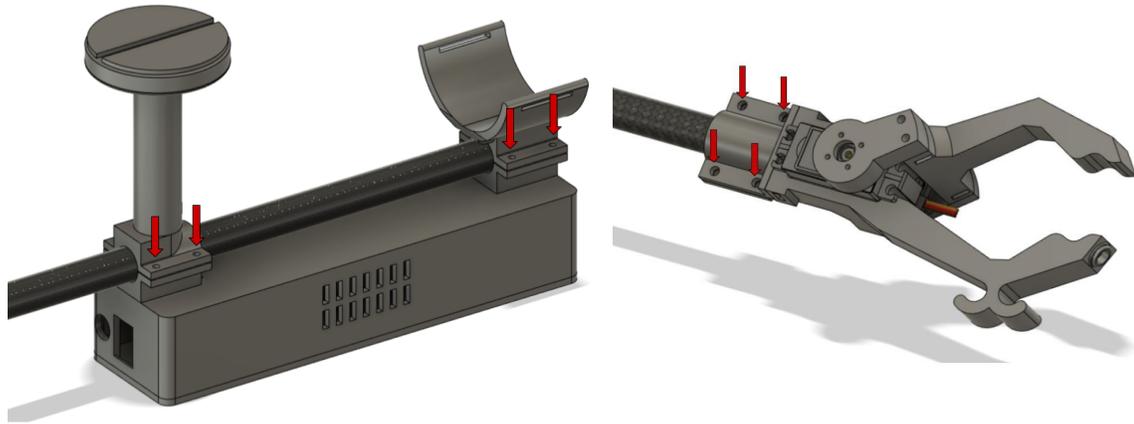
6.2.3 Instructions

In order to create the physical (non-electrical) parts of this product, we first made our detailed CAD designs for each part as shown below.





We then used these CADs to print real 3D versions of these designs out of PLA. This material was chosen as it is sturdy and reliable, and is very low in cost. These parts were then assembled with glue as well as bolts and nuts. The screws indicated in the images below were left slightly loose for mounting on the carbon fiber tube. Once both subsystems are complete (gripper claw and handle), we mount both onto either side of a 15mm carbon fiber tube and any electrical wiring is fed through this tube, connecting both subsystems of the device. Carbon fiber was chosen over plastic or metal as it offers the best strength and durability with the lightest weight. The screws shown below are then tightened to secure the whole. All electronics are inserted into the electronics box by removing the screws on the box cover, inserting said electronics, then fixing the cover back on with said screws.



Velcro is then fed through the openings in the arm rest for securing the device on the user's arm. Magnetic straps could have been another option for this function, however the added weight was deemed unnecessary.

6.3 Testing & Validation

We tested lifting 8 small objects; a stuffed animal, a hair brush, a tooth brush, a pair of shoes, a water bottle, a piece of clothing, a cutlery (fork), and a children's book. We practiced using the grabber and picking up each of these items. We found that it was easy to pick up everything except maybe the book, getting underneath the book was slightly difficult. See video for testing.

7 Conclusions and Recommendations for Future Work

If we had more resources, we would have implemented the USB-C charging port since its growing household use and ease of use are very consumer friendly. We would make a custom PCB to further shrink the size of the power box. Rather than 3D printing we would use injection molding to create our product, which will make it cheaper and lighter.

We considered making a different handle design to accommodate certain people, namely a vertical palm self-handle utensil. Taking this into consideration we might also want to make the parts interchangeable, to allow for further customization; the arm length, the handle, the claw, etc. One possible extra part we could have designed was a secondary arm support that would attach to the carbon fiber rod.

If possible, we would consider re-designing the power grabber to be weatherproof.

We also considered making a separate remote control that could attach to any part of the power grabber, this way if the user wanted to, they could operate the power grabber from a different position.

8 Bibliography

APPENDICES

9 APPENDIX I: Design Files

Link to makerepo

<https://makerepo.com/ZitaiPeng/1140.gng2101c3p2power-grabbereh>

Table 5. Referenced Documents

Document Name	Document Location and/or URL	Issuance Date
HandleAssembly v14.avi	https://makerepo.com/ZitaiPeng/1140.gng2101c3p2power-grabbereh	2022-04-10
Grabberv17.avi	https://makerepo.com/ZitaiPeng/1140.gng2101c3p2power-grabbereh	2022-04-10
IMG_5321.MOV	https://makerepo.com/ZitaiPeng/1140.gng2101c3p2power-grabbereh	2022-04-10
IMG_5320.MOV	https://makerepo.com/ZitaiPeng/1140.gng2101c3p2power-grabbereh	2022-04-10
IMG_5319.mp4	https://makerepo.com/ZitaiPeng/1140.gng2101c3p2power-grabbereh	2022-04-10

10 APPENDIX II: Other Appendices

Document Name	Document Location and/or URL	Issuance Date
Deliverable G_ Business model	https://makerepo.com/ZitaiPeng/1140.gng 2101c3p2power-grabbereh	2022-04-10
Deliverable C_ Conceptual Design and Project Plan	https://makerepo.com/ZitaiPeng/1140.gng 2101c3p2power-grabbereh	2022-04-10
Final Presentation	https://makerepo.com/ZitaiPeng/1140.gng 2101c3p2power-grabbereh	2022-04-10
Deliverable F_ Prototype 2	https://makerepo.com/ZitaiPeng/1140.gng 2101c3p2power-grabbereh	2022-04-10
Deliverable D_ Detailed design	https://makerepo.com/ZitaiPeng/1140.gng 2101c3p2power-grabbereh	2022-04-10