Assistive Feeder Manual

Ammar Khawaja, Yehoshua Halle

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Printed Parts

1. Post
2. Servo cover 1
3. Linkage 1
4. Servo cover 2
5. Linkage 2
6. Base
7. Rotating plate bottom
8. Cover
9. Leg knob x 4
10. Foot x 4
11. Rotating plate top
12. Battery panel

*See CAD Folder**

Tools Needed

1. Assistive Feeder printed parts
2. Soldering Kit
3. Wire strippers
4. Wire strippers
5. Super glue
6. Double-sided tape

Parts Needed

1. CD
2. Solid core wire
3. Stranded wire
4. Mono jack
5. Potentiometer with cap
6. Joystick module
7. Arduino Motor Shield Rev3
8. Arduino Uno
9. Power switch
10. Servos (x2)
11. DC motor with gearbox
12. Buck converter
13. Red led
14. 7.4V Li-ion Battery 3000mAh
15. 1/4"-20 3.5" Hex Head Screw (x4)
16. 1/4"-20 Steel Locknut with External-Tooth Lock Washer (x4)
17. M3x0.5 8mm Phillips Flat Head Screw (x12)
18. M3x0.5 Brass Screw-to-Expand Inserts for Plastic (x10)
19. 0.9" Wide, 3" Long Nylon Plastic Cable Tie (x12)
20. Reusable Fastening Cable Ties (x4)
21. USB-B to USB-A cable
22. Heat shrink
23. 330 Ohm resistor
24. 100 kOhm resistor (x2)
25. Velcro straps (x2)

3D Printing Settings

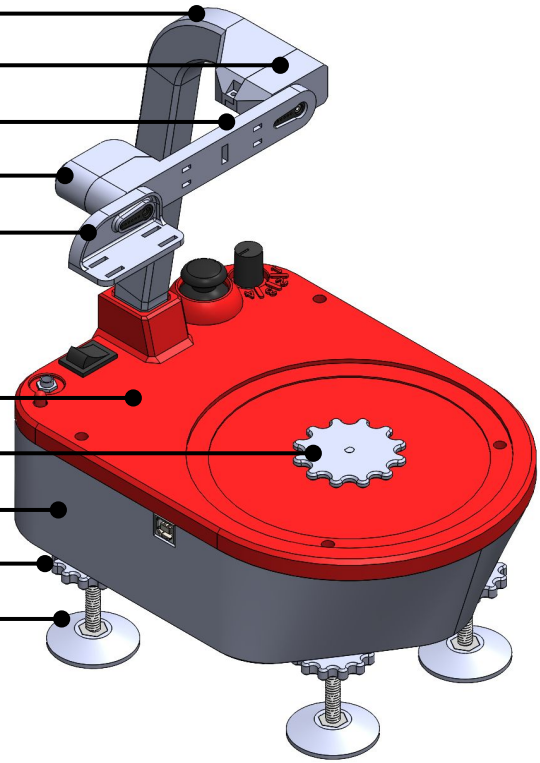
Suggested general print settings:

- Layer height: 0.2mm
- Infill: 10%
- Supports: on specific faces, see individual parts
    - Blue shaded areas have supports

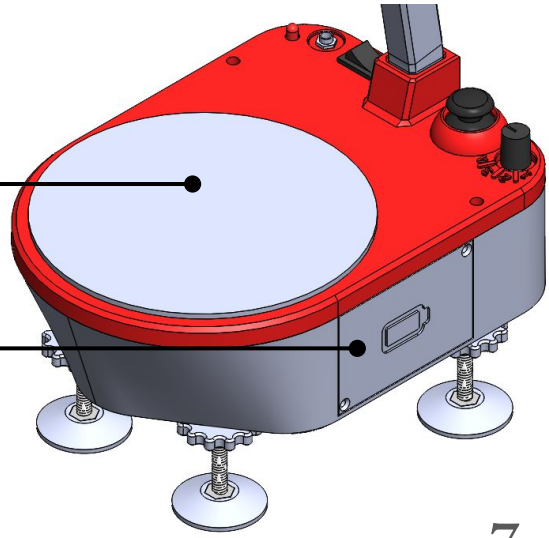
Images show best print orientation and support locations.

3D Printed Parts

1. Post
2. Servo cover 1
3. Linkage 1
4. Servo cover 2
5. Linkage 2
6. Base
7. Rotating plate bottom
8. Cover
9. Leg knob x 4
10. Foot x 4

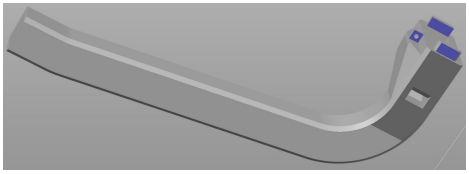


11. Rotating plate top
12. Battery panel

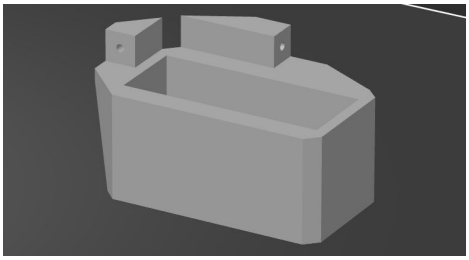


3D Printed Parts

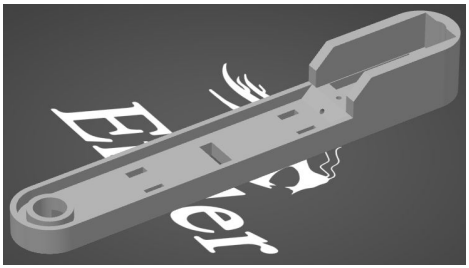
1. Post



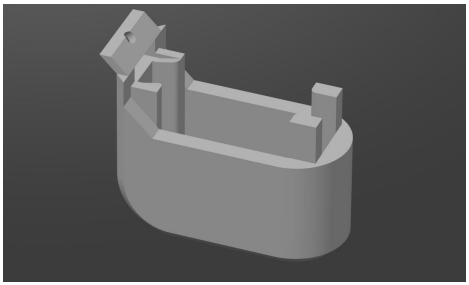
2. Servo cover 1



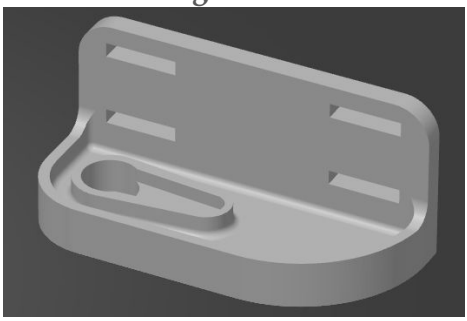
3. Linkage 1



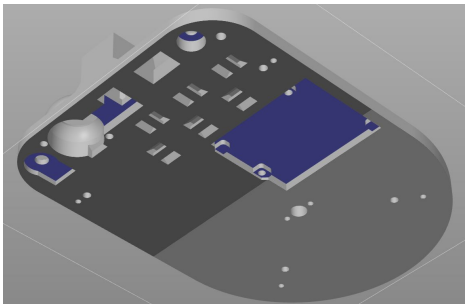
4. Servo cover 2



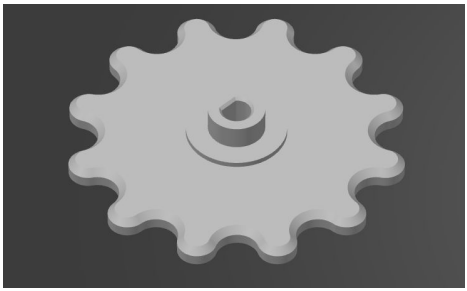
5. Linkage 2



6. Base

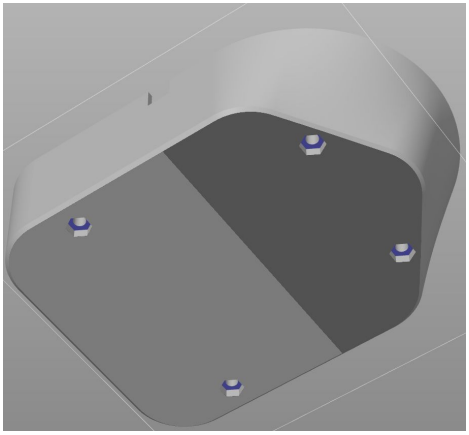


7. Rotating plate bottom

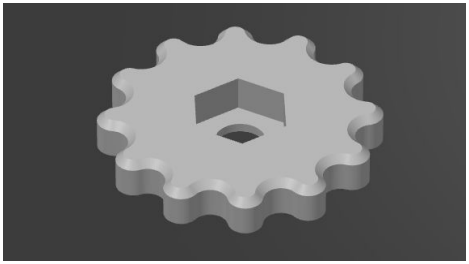


3D Printed Parts

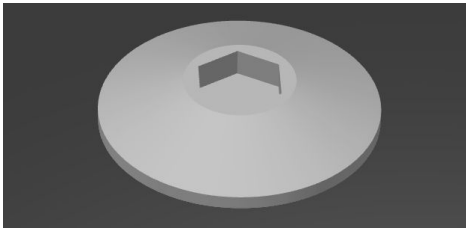
8. Cover



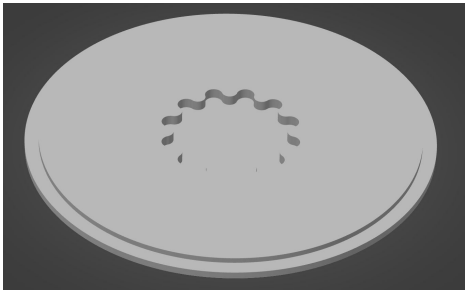
9. Leg knob x 4



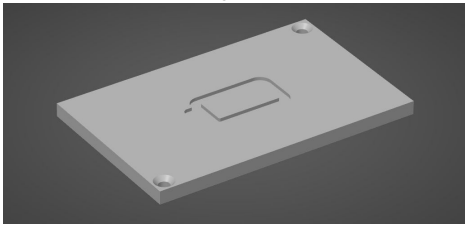
10. Foot x 4



11. Rotating plate top



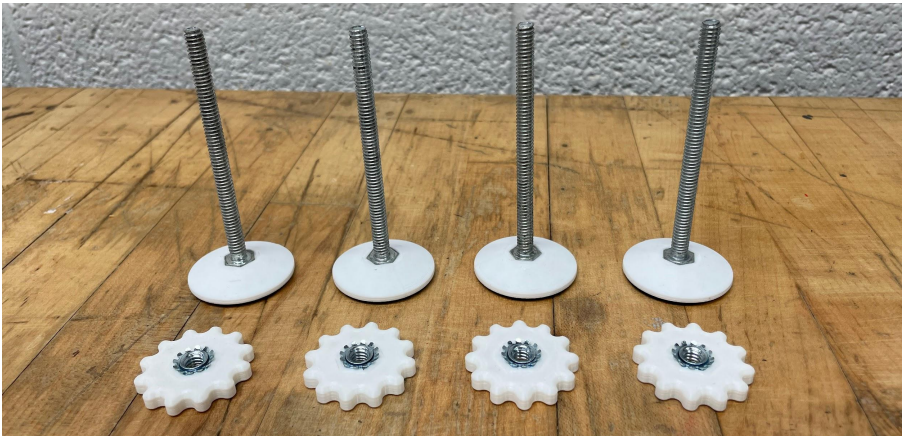
12. Battery panel



Assembly Instructions

Note: Suggested wire lengths account for the length of wire inserted into terminals. Just cut the wire at that length, then strip the ends. Stripping the ends of wires is an implied step.

Gluing Leg Bolts and Nuts



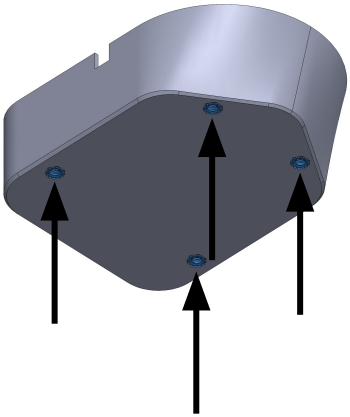
1. Glue the 3.5” 1/4-20 bolts into the feet.

2. Glue keps nuts into each jam knob.

3. Glue 4 keps nuts into the bottom of the cover.

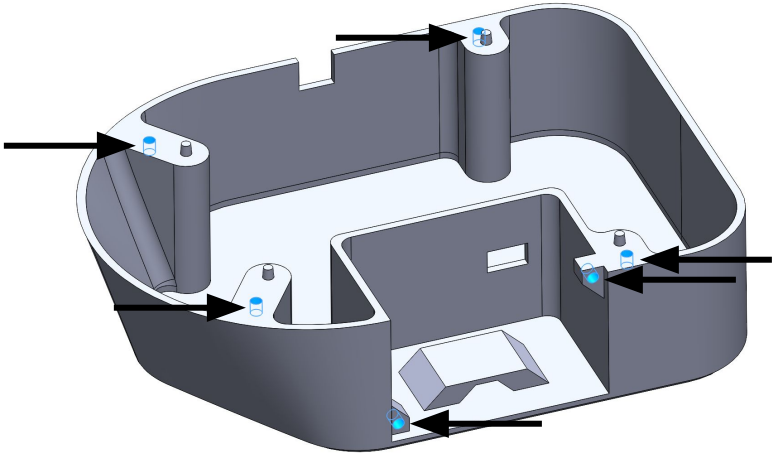
4. Screw nuts into the jam knob and the base.

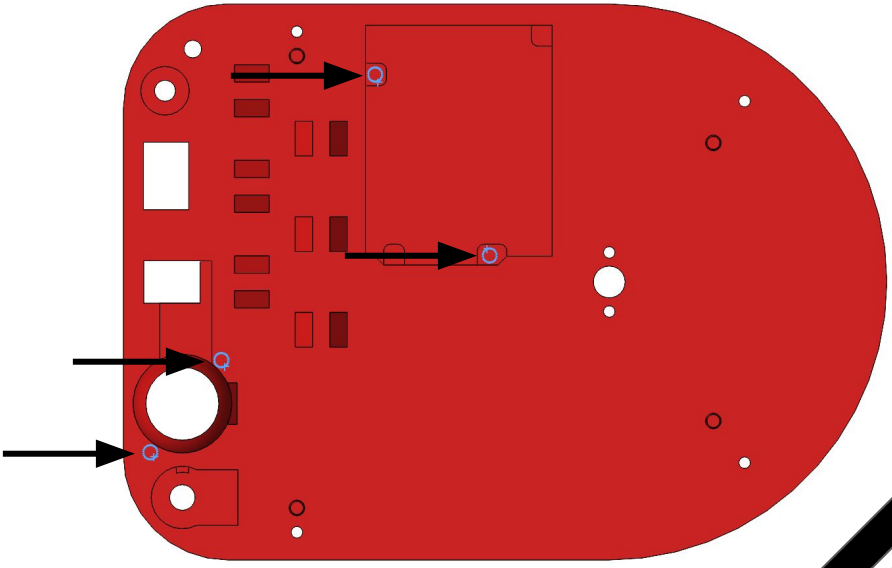
5. Let the glue cure during the rest of the assembly.



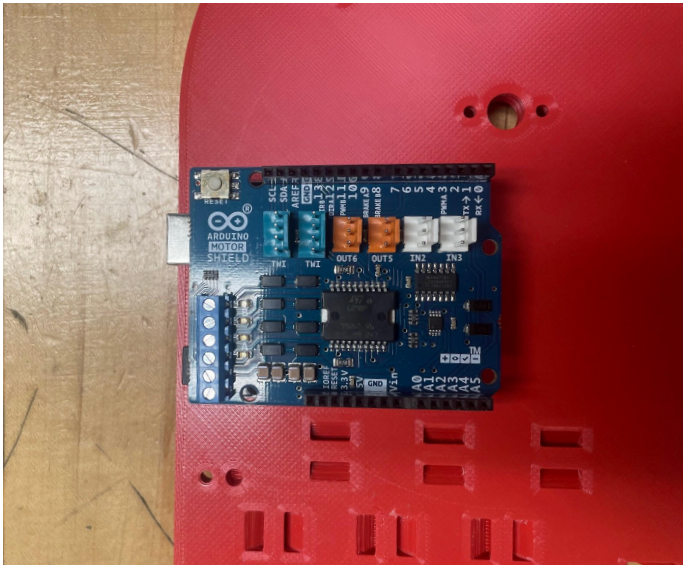
Threaded Inserts

Press 10 threaded inserts into the following holes in the base and cover. The tip of a phillips head screwdriver can be used to apply force to the insert.





Arduino

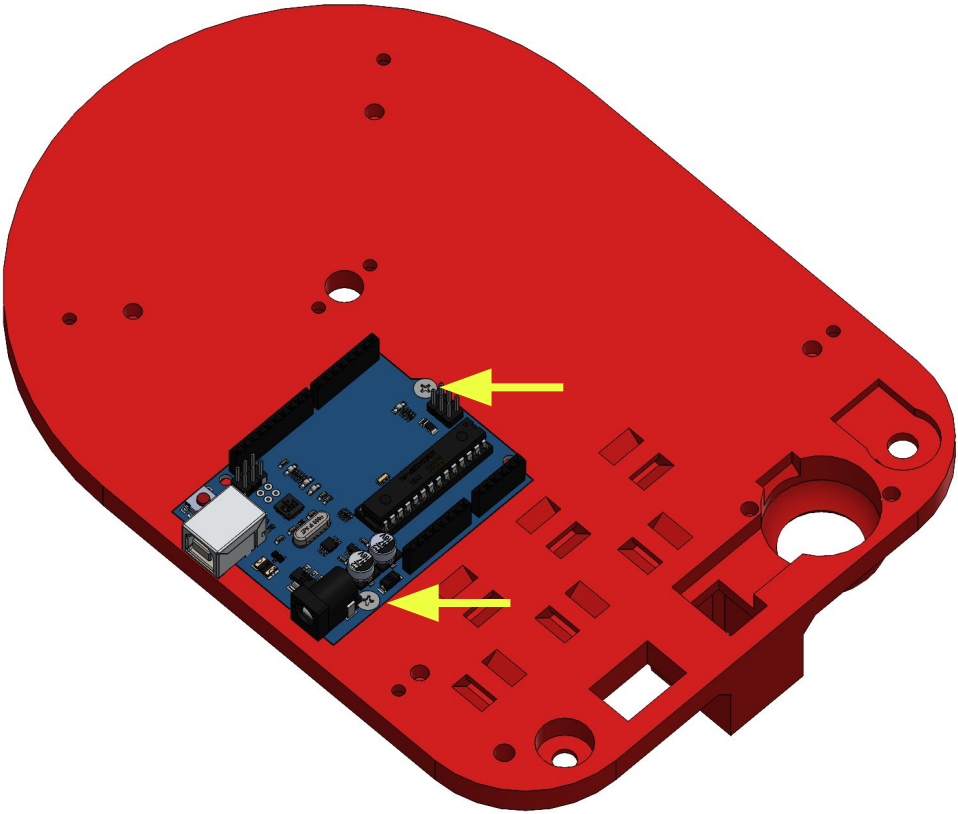


1. Upload the “AutoFeeder” Arduino sketch to the Arduino. The sketch can be found at:

   https://github.com/shua5115/AutoFeeder

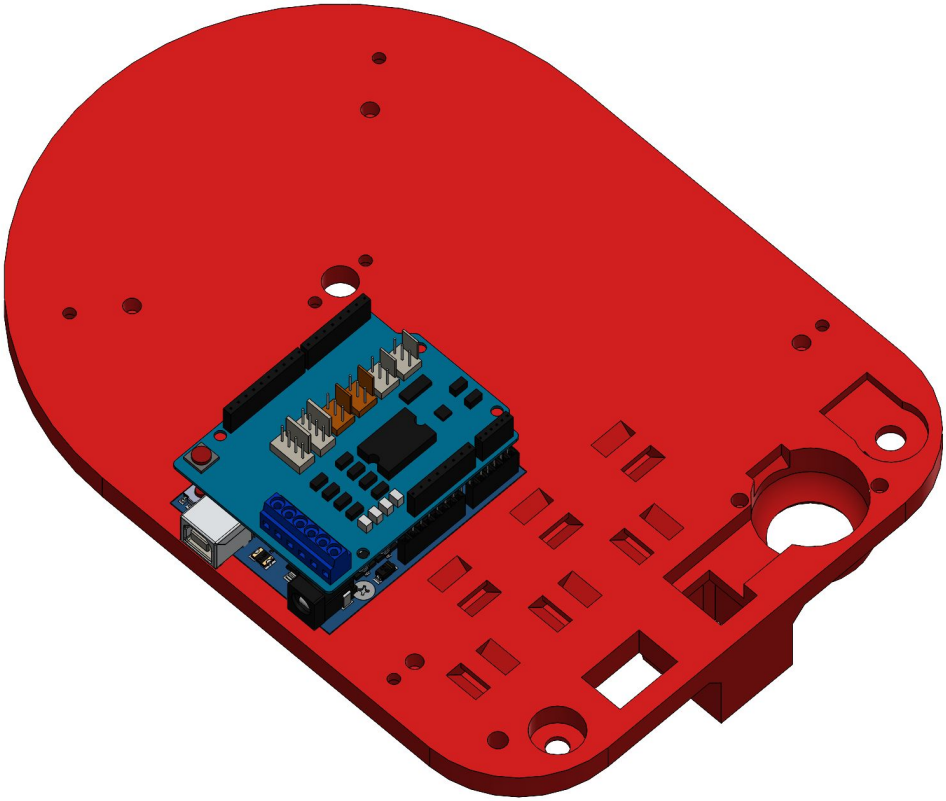
2. Set Arduino UNO into the base

Arduino



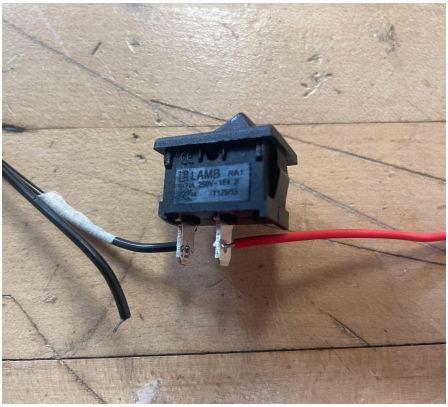
3. Screw the M3 screws into the threaded inserts

Motor Shield

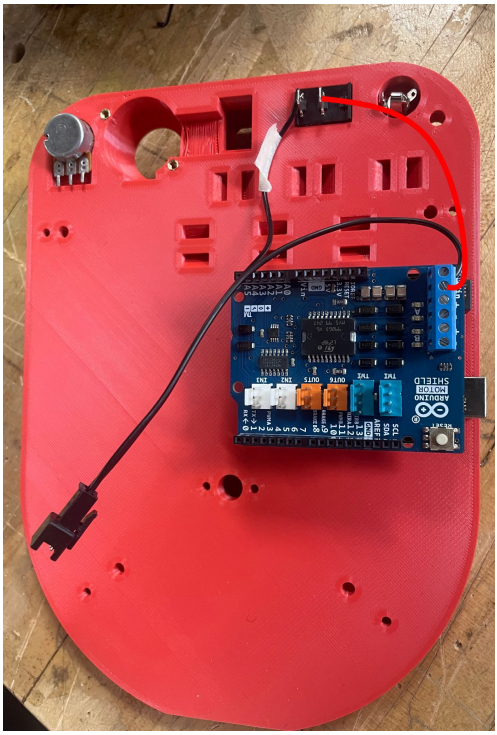


1. Press the Motor Shield into the top of the Arduino. Make sure that the pins are aligned and not bent.

Power Switch Wiring

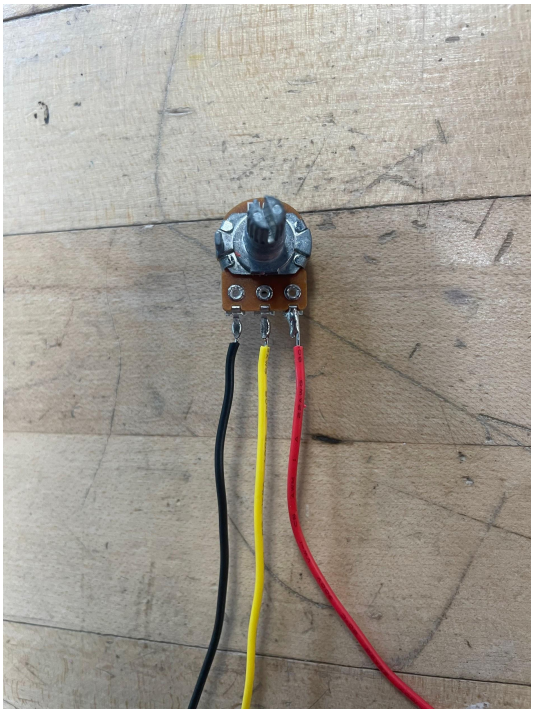


1. Cut red (power) wire to 6 cm length.
2. Solder power wire to the power switch.
3. Using the battery, check which wire on the JST SM cable is power. **This can depend on the battery.**
4. Solder the power wire of the JST SM cable to the power switch.



5. Insert the red power wire from the power switch into the Vin screw terminal on the motor shield.
6. Insert the JST SM ground wire into the ground screw terminal on the motor shield.

Potentiometer

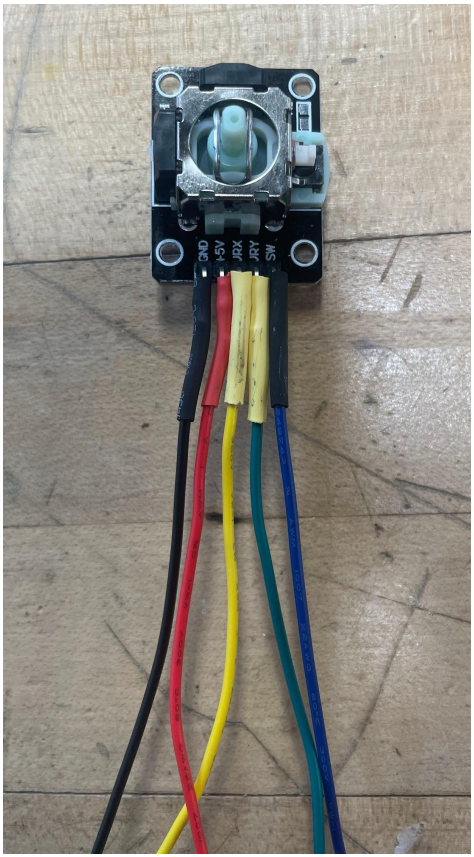


1. Cut power and ground wires to 6 cm and data wire to 12 cm.

2. Solder ground, data, and power wires, left to right, into the potentiometer.

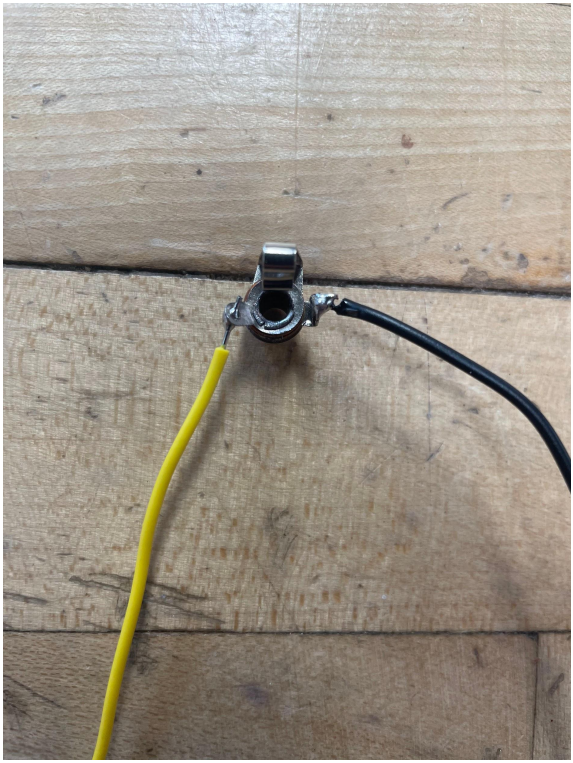
Joystick

1. Cut 15 cm lengths of power, ground, and blue (button) wires.
2. Cut 10 cm lengths of and yellow (x axis) and green (y axis) wires.
3. Solder the power, ground, yellow, green, and blue wires to the joystick pins, per the image.
4. Apply heat shrink to the exposed solder joints.



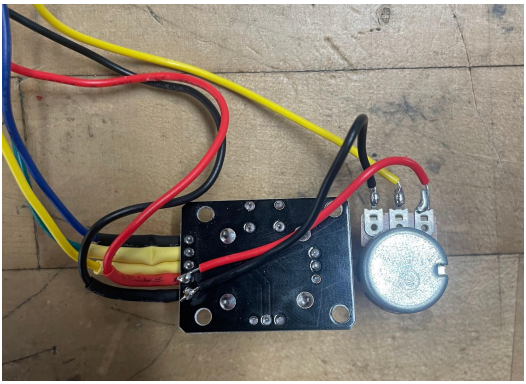
Mono Jack

1. Cut a data wire to 15 cm and ground wire to 10 cm.
2. Solder data and ground wires to mono jack. The specific terminal does not matter.

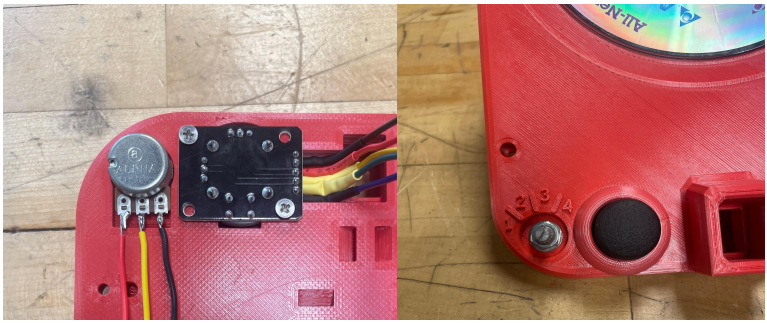


Potentiometer + Joystick

1. Solder ground and power wires from potentiometer to ground and power in joystick module.



2. Place and secure the potentiometer and joystick in their respective slots on the assistive feeder board, as shown.



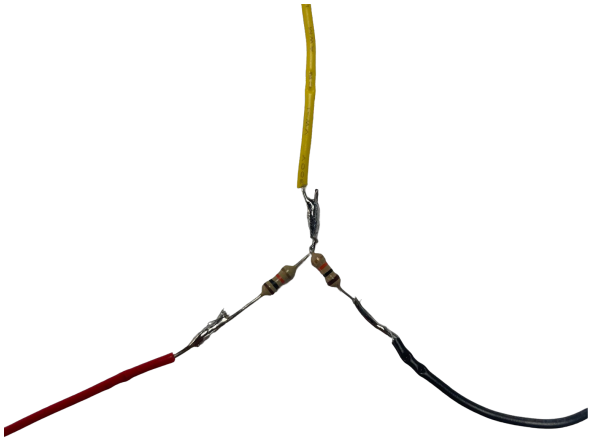
Voltage Divider

1. Get two equal resistors and ensure both have 1 cm of wire on each side.

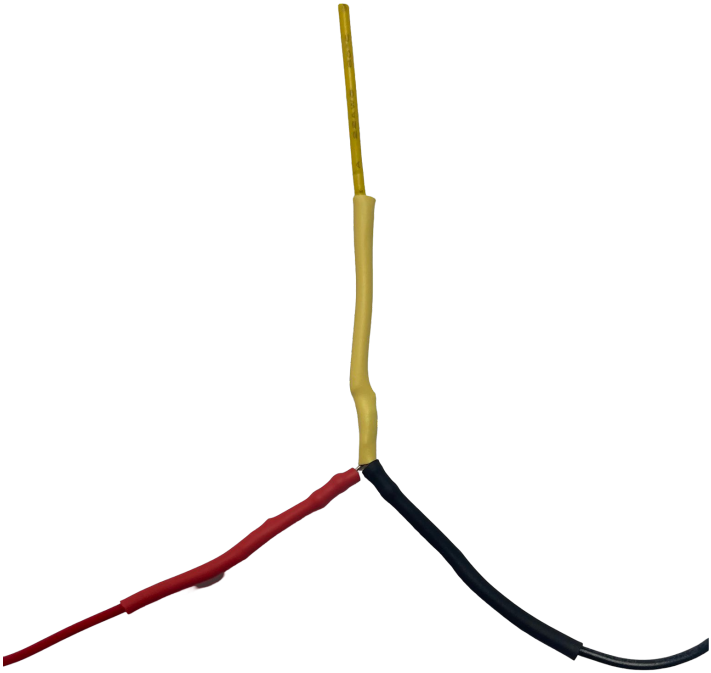
2. Twist one side of the resistors together and solder them.

3. Cut and solder power and ground wires of length 8 cm to the other side of resistors.

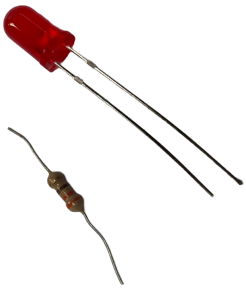
4. Cut and solder data wire of length 8 cm to the twisted wires.



5. Apply heat shrink to cover exposed wires.



LED



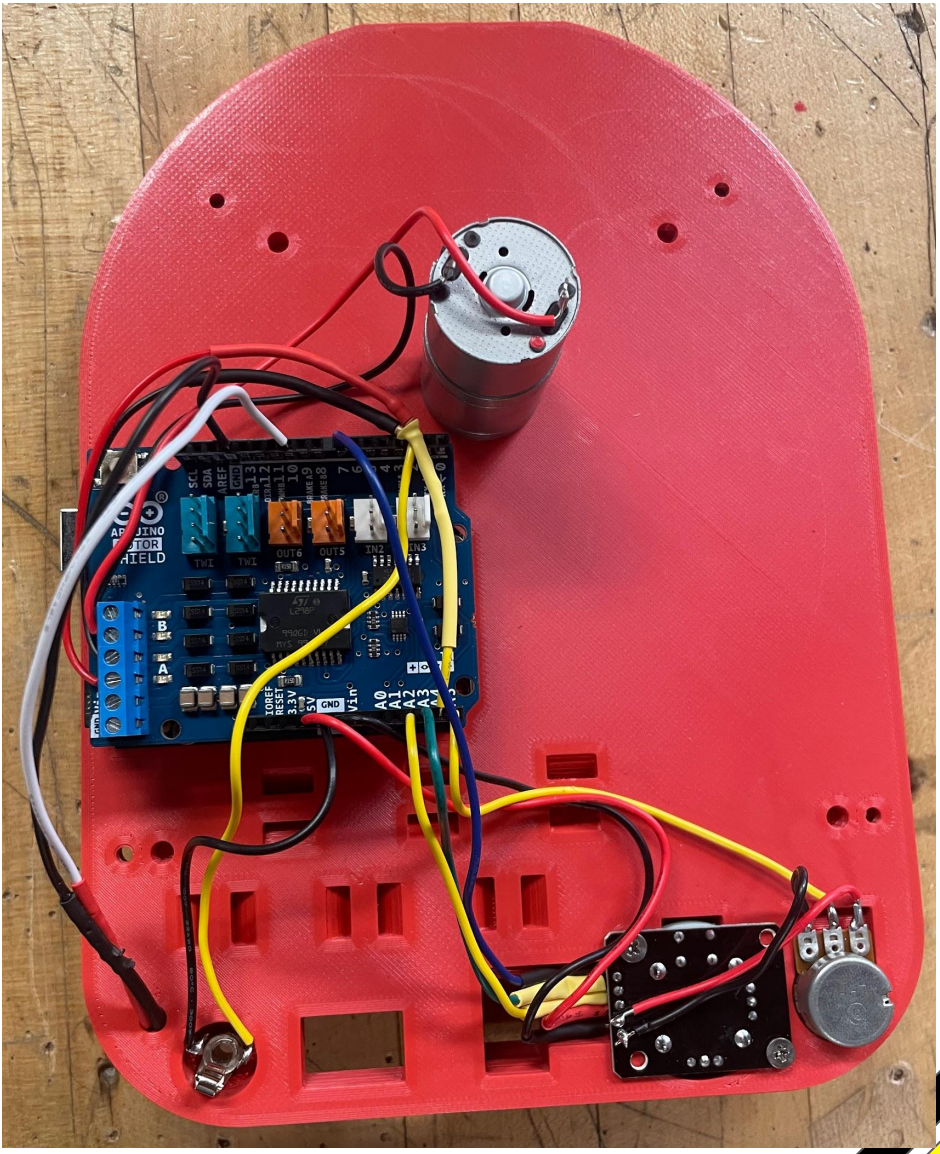
1. Trim the 330 Ohm resistor to have 1 cm of wire on either end.

2. Solder resistor to negative terminal (shorter side) of LED.

3. Cut ground and power wires of length 15 cm. Solder ground to resistor and power to other.

4. Put heat shrink around exposed wire.

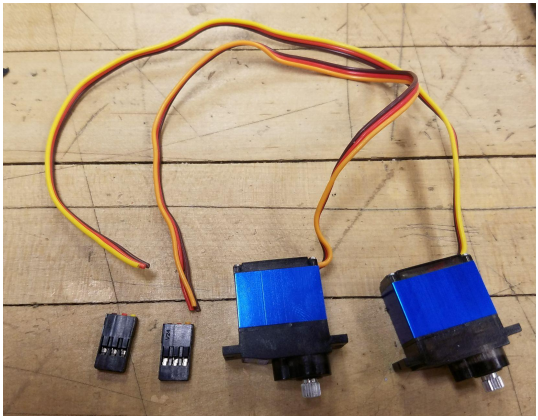
Wiring I/O Hardware



Wiring I/O Hardware

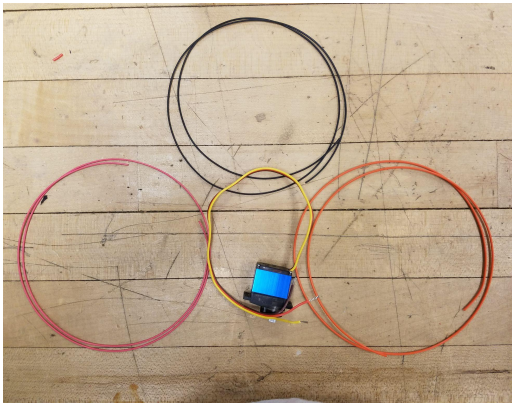
1. Joystick power and ground to the 5V and GND pins.
2. Joystick X axis (yellow) to A2
3. Joystick Y axis (green) to A3
4. Joystick button (blue) to digital 7
5. Potentiometer data (yellow) to A5
6. Mono jack ground to GND
7. Mono jack data (yellow) to digital 2
8. LED power to digital 10
9. LED ground to top GND pin
10. Voltage divider power to A+
11. Voltage divider ground to A-
12. Voltage divider data (yellow) to A4

Servo Motors



1. Cut the ends of the servo motors to expose the wires and strip the ends to expose the metal.

2. Cut a pair of power and ground wire to 25 cm, and another pair to 60 cm.



3. Cut a yellow data wire to 25 cm and a green data wire to 60 cm.

Servo Motors

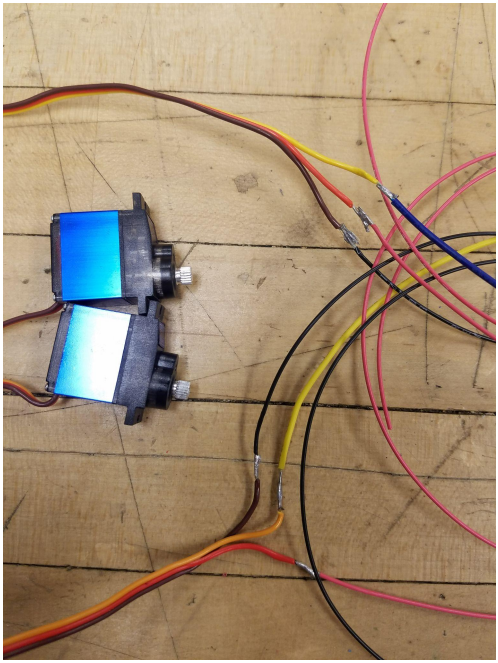
4. Solder the 25 cm wires to one servo, and the 60 cm wires to the other.

Servo colors:

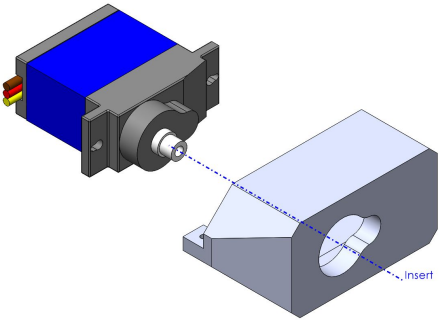
- Brown = ground
- Orange = power
- Yellow = data

The 25 cm wire connects to the servo for **Linkage 1**

The 60 cm wire connects to the servo for **Linkage 2**

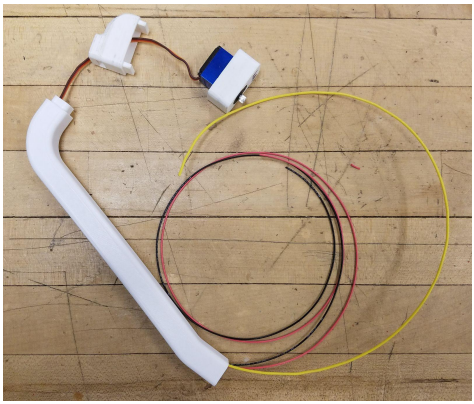


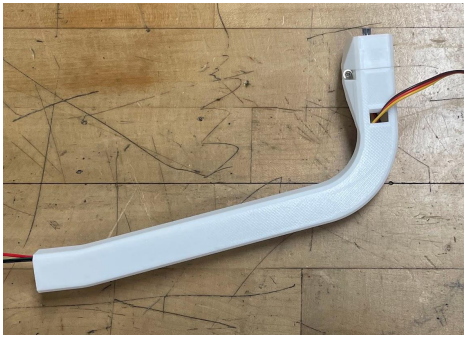
Servo Motors



5. Take the linkage 1 servo and insert it into the "Servo Cover 1" part using the thinner screws that came with the servo.

6. Slide the wires through the Post Elbow and the Post.

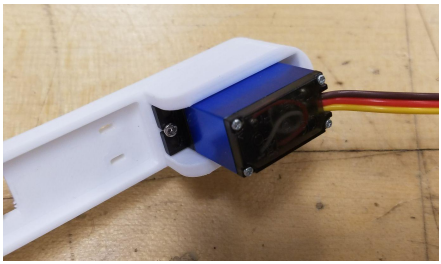




7. Using the screws that came with the servo, screw the Servo Cover to the Post.

Servo Motors

8. Take the linkage 2 motor and insert it into the end of the Linkage 1 part.



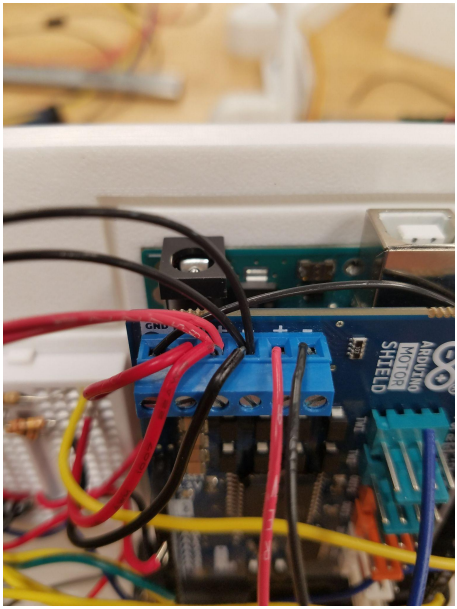
9. Screw the servo into the part

10. Pass the wires through the Servo Cover 2 and Post, as shown below:

Note: the wire should pass through the center slot in Linkage 1 before the Post, but this was not captured in the image.

Servo Motors

11. Pass all of the servo wires through the center hole in the base.

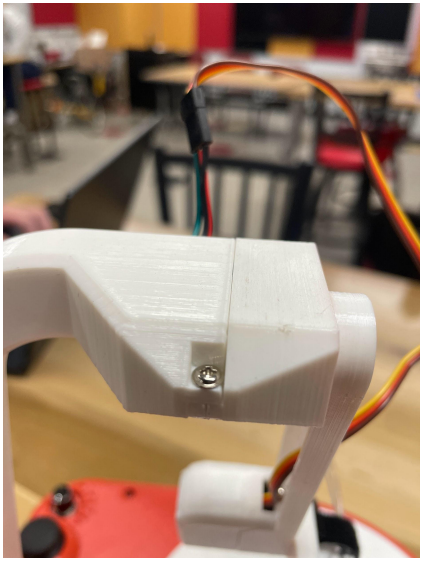


12. Connect the power wires to terminal A+ on the Motor Shield, and connect the ground wires to terminal A-. Tighten the clamping screws.

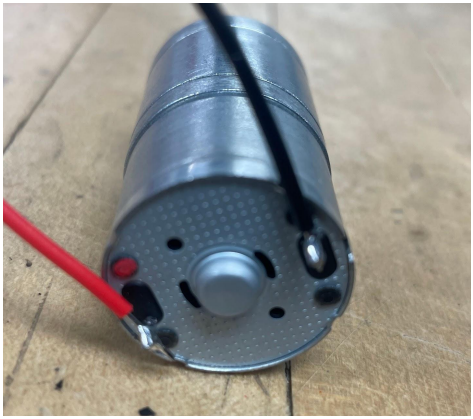
13. On the Arduino, connect the yellow linkage 1 signal wire to digital port 5 and the green linkage 2 signal wire to digital port 6.

Servo Motors

14. Screw the two servo motors casings shut.

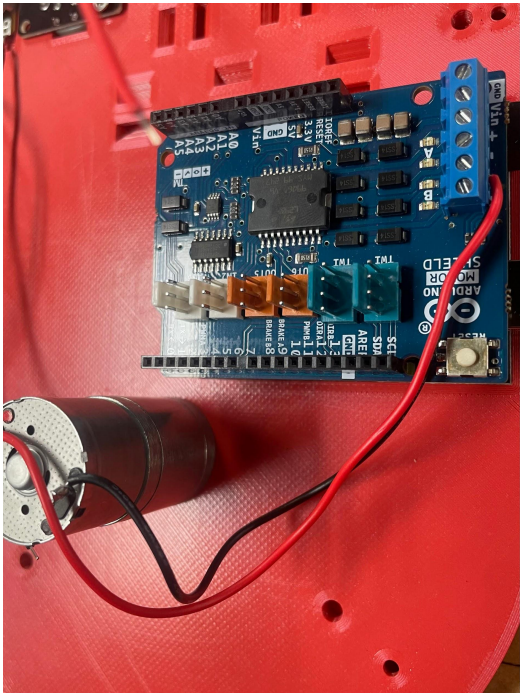


DC Motor



1. Get the DC motor. Cut power and ground wires to 15 cm and solder to the motor.

2. Screw the motor into the base using screws. Insert the ground motor wire into ground and the power motor wire into power.



DC Motor

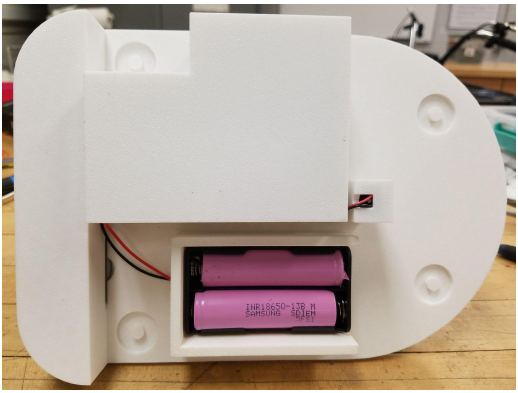
3. Place the CD into the circular divot in the base. Make sure the CD is face up.

4. Carefully press the "Rotating Plate Bottom" part to the shaft of the DC motor.

Servo Calibration

1. Press the Post into the Base

2. Connect the battery to the Arduino



3. Then, while the power switch is off, insert two charged 18650 battery cells into the battery holder.

Servo Calibration

4. While the linkage arms are disconnected, turn the power switch on. The servos should start moving.

5. Once the servos stop moving, the robot should be in the position depicted to the left. This is the “fully extended” position.

6. So use the servo horns and screws included with the servos to connect the linkage arms to each servo to match the fully extended position.

Servo Calibration

7. Press the joystick button once and the servo arms should move to this position, shown in the image. This is the "home" position.

8. If anything went wrong during this step, consult the troubleshooting section.

To recap the servo calibration process:

1. Turn the robot on and wait until the servos stop moving.
2. Attach the linkage arms to make the "fully extended" position.
3. Press the joystick button and verify that the robot matches the "home" position.

Profile Reset

Now that the servos are calibrated, the scooping paths the spoon will follow, called “profiles”, should be reset on the Arduino.

When the robot is in the home position, press and hold the joystick for at least 10 seconds, until the LED light blinks 4 times. If the robot starts to move, then the joystick wasn’t held fully. In that case, turn the robot off and back on, return it to home, and try again.

Testing

By completing the servo calibration and profile reset, the functionality of the Arduino, Motor Shield, batteries, power switch, LED light, joystick button, servo current and voltage sensing, and servo motors has been confirmed.

But, there are a few remaining electrical functions that should be tested before the robot is glued shut, in case something isn't working:

- Mono jack input
- DC Motor
- Profile Potentiometer

Mono Jack & DC Motor Testing

Turn the robot on, plug in a compatible switch to the mono jack, and activate the switch. This should cause the robot to go from the fully extended position to the home position.

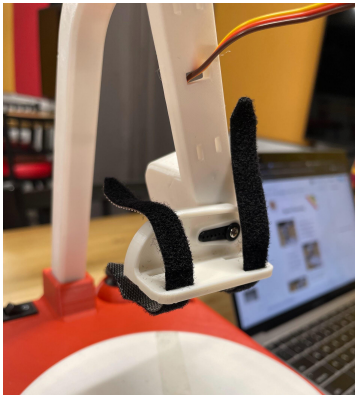
When in the home position, activate the switch again. This should cause the DC motor to spin for as long as the switch is active. Press the switch again to return to home. Finally hold the switch to rotate the plate.

Potentiometer Testing

To test the profile potentiometer, the LED should blink for a short time whenever the device detects that the profile selection has changed.

Twisting the potentiometer back and forth should result in the LED blinking frequently. The blinks should roughly align with the lines between the numbers on the Base.

Spoon Fastening



1. Take the velcro straps and slide them through the holes in Linkage 2 as shown in the image.

2. Wrap them around a spoon and slide through the other hole.

3. Finally, slide the velcro strap onto itself to fully secure the spoon. Make sure it is as tight as possible.

Rotating Plate Adhesive

Apply one layer of double sided tape in a "+" shape to the Rotating Plate Top.

Final Product

Congratulations! You made an assistive feeder! It will be a major help to its user. Pat yourself on the back!

Troubleshooting

Device won't turn on even though the power switch is on?

- Turn it off if there is smoke, fire, or smell of melting plastic!
- Check battery charge
- Check wiring & soldered connections for shorts
  - Make sure power and ground are not touching *anywhere*. Shorting power and ground in the best case will cause the Arduino to turn off. In the worst case, this will short the Li-ion batteries and melt your plastic parts and/or fry the Arduino.
- Check if it is the Arduino or servos.
  - Arduino has a yellow light that turns on when running
  - Check the servo wiring for shorts, incomplete/incorrect connections

Device turns on and is fully extended, but won't go to the home position after sending an input.

- Does the input work with the mono jack input or the joystick? Check both to narrow down the input issue.
- If joystick isn't working: Is the button (SEL) wire connected to digital port 7?
  - If not, plug it in. If so, check the solder connection.
- If mono jack isn't working: check the solder connections and the wire to digital port 2.
  - Also make sure that the device is fully plugged in.

Troubleshooting

Device turns on and doesn't move, but the red LED is blinking. (This means you are running on low power)

- Is the device running on battery power?
- Are the batteries charged?
- Did you turn on the device while connected to USB?
    - If so, remove the USB connection and turn it on connected to battery power only, then re-insert the USB.
- Is there a problem with the circuit connected to analog pin A4?
    - Refer to the image for correct wiring.

Device doesn't scoop food well after initial setup.

- You should re-calibrate a profile if it isn't working well. The default profiles after a reset are not applicable to many plates/bowls.

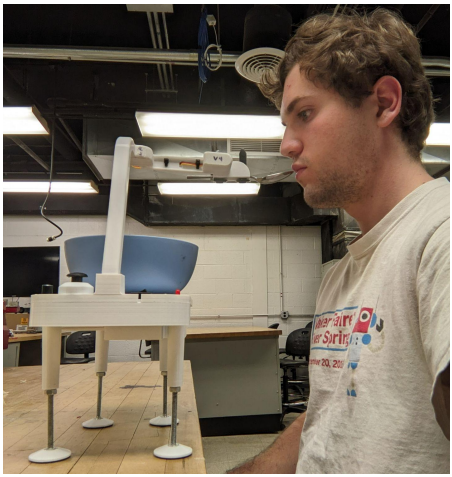
Usage Guide

- Physical setup
- Profile Calibration
- General Usage
- Behavior Graph

Physical Setup

1. Turn the device on and let it reach the fully extended position.

2. Adjust the legs such that the spoon is very close to the user's mouth.



3. Plug the user's input device into the mono jack. Verify that the input works by having their input return the arm to the home position.

4. Finally, align the bowl/plate to the rotating plate's center.

Profile Calibration

1. Set the profile selector knob to the profile you want to calibrate.

2. When the device is turned on and in its home position, hold the joystick button down for at least 1 second, until the LED light turns on.

3. When your release the joystick button, the rotating plate will begin to spin. Use the spinning to make sure the bowl/plate is centered when you calibrate.

Profile Calibration

4. Once the bowl/plate is centered, face the device as shown, and use the joystick to move the spoon around in space.

5. Move the spoon to 5 key points on the bowl/plate and click the joystick button to set each point:

- Top back edge
- Bottom back corner
- Center bottom
- Bottom front corner
- Top front edge

6. After the final point is set, the arm will return to the home position.

7. You can cancel the calibration by holding the joystick button for 1 second before the final key point is set.

General Usage

As a user of the device, you provide the device a single button input.

In the home position, holding the input will cause the bowl/plate to spin until you release the input.

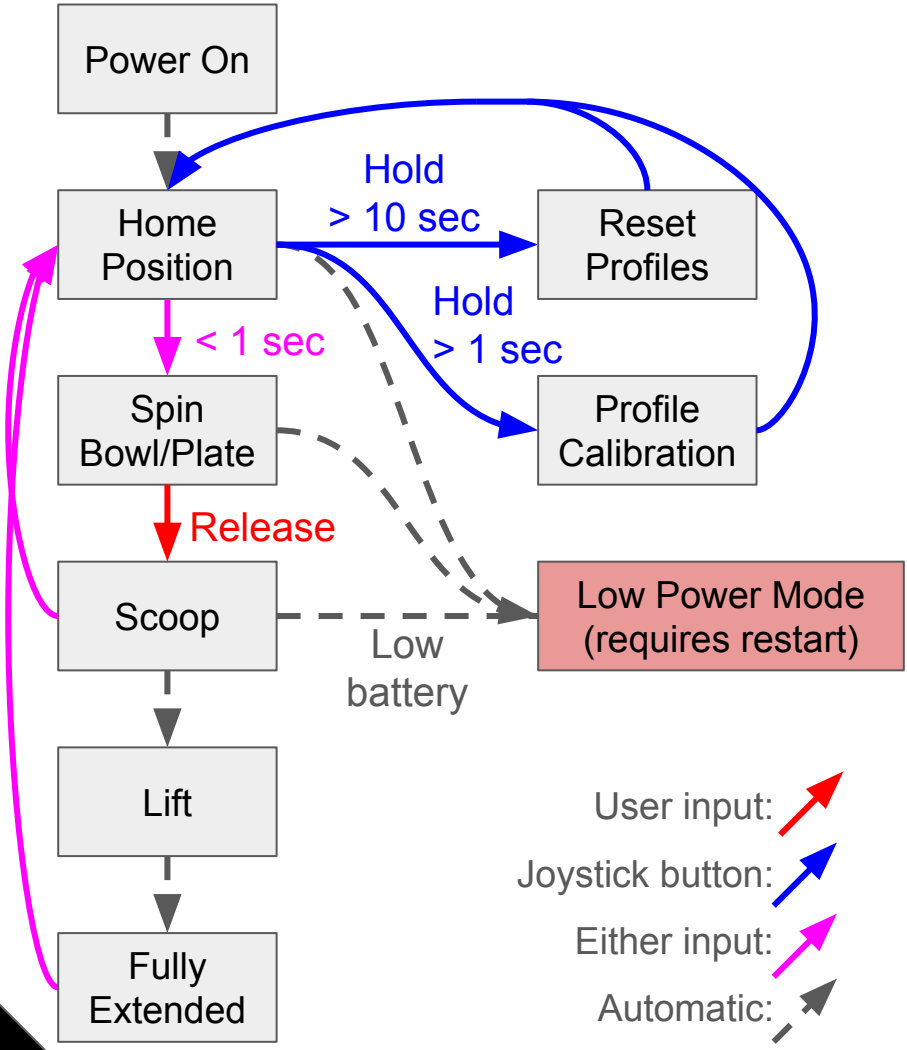
Clicking the input will cause the spoon to scoop some food from the bowl/plate. You can activate your input again to finish the scoop early.

Once the scoop is complete, the spoon will be lifted to your mouth, where you can take a bite.

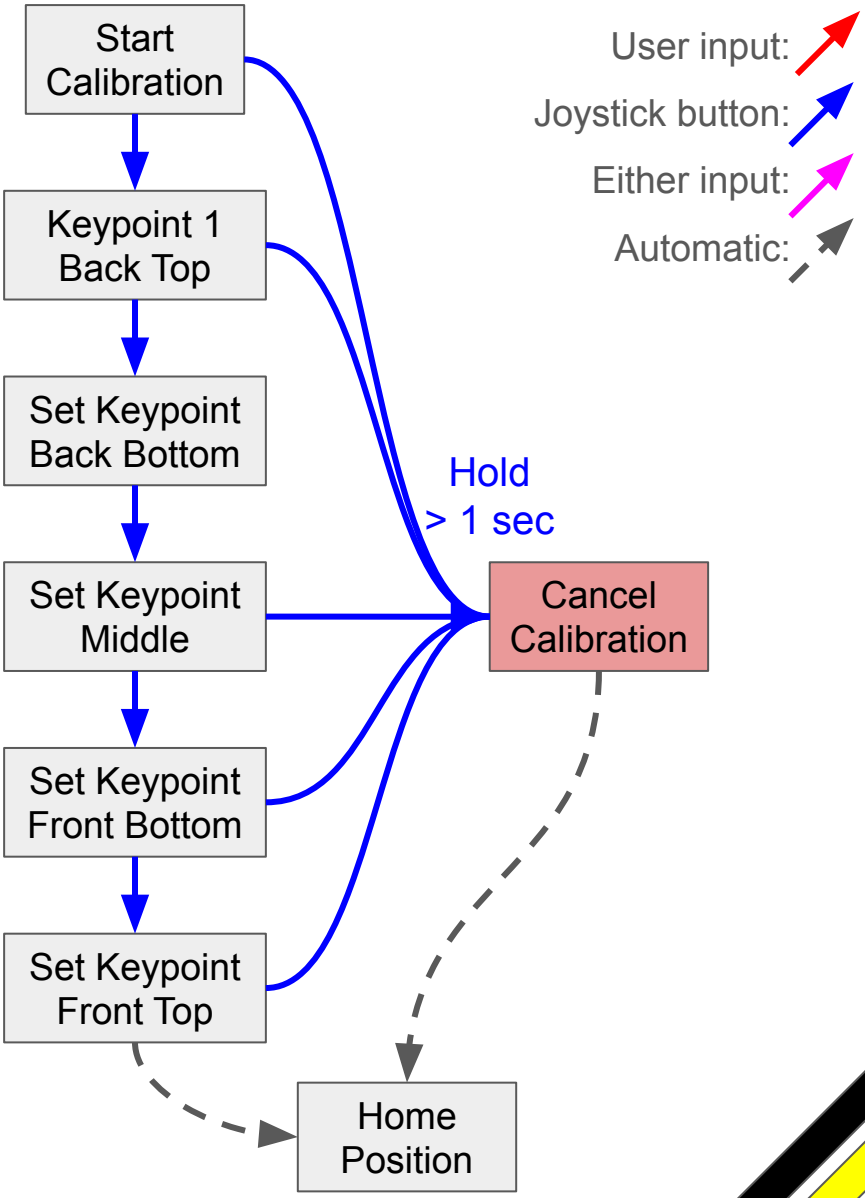
You can activate your switch once more to return the spoon to its starting position.

Behavior Graph

This chart shows what state the device can be in at any given time, and how it transitions between states based on user input.



Behavior Graph: Profile Calibration



Behavior Graph: Low Power Mode

Low Power Mode
(requires restart)

Low power mode is entered when battery voltage gets too low to power the servos.

Running the servos at low voltage is dangerous because their movement becomes erratic. It can result in food being flung off the table or the robot damaging itself.

Low power mode will cut power to the servo motors until the robot is fully powered off. This is to encourage replacing the batteries while the device is powered off.