

# Gen1 Open Source Hand Work Instruction

by  TetherIA

# Useful Tools

**Tools:**

1mm drill bit  
2mm drill bit  
2.1mm drill bit  
Hand drill  
Exacto Knife  
Flash Cutters  
File  
Soldering Iron  
Needle Nose Pliers  
Phillips Driver  
Torx Driver  
Measuring Tape  
Marker  
Scissors

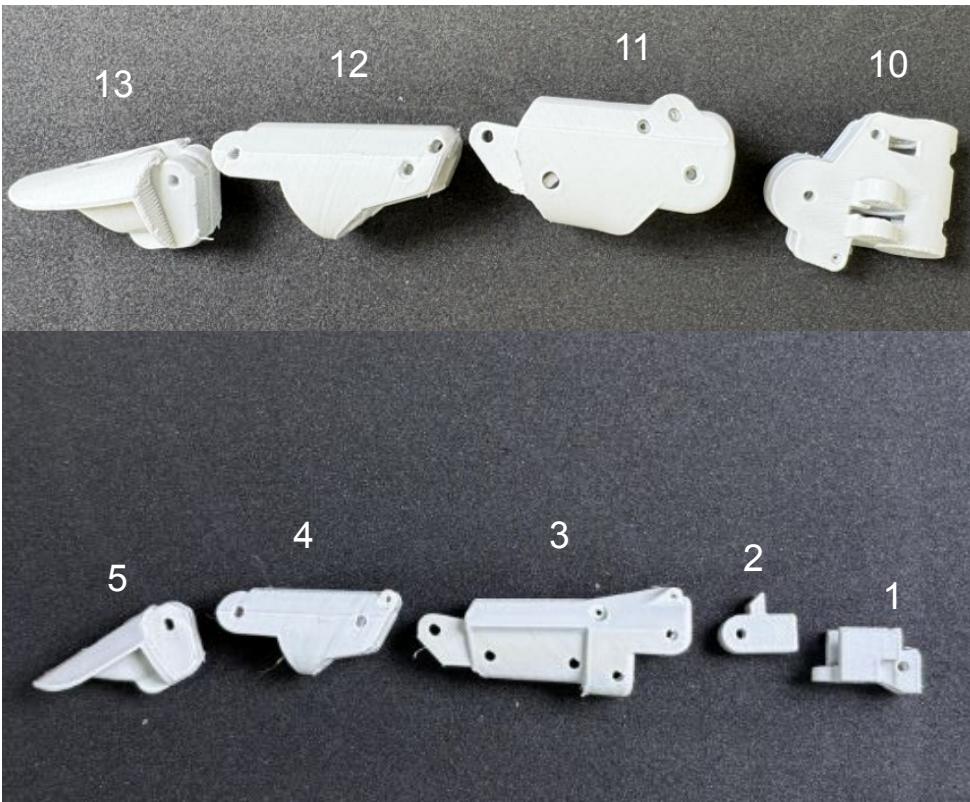
**Consumables:**

Super Glue  
Loctite (blue 496)

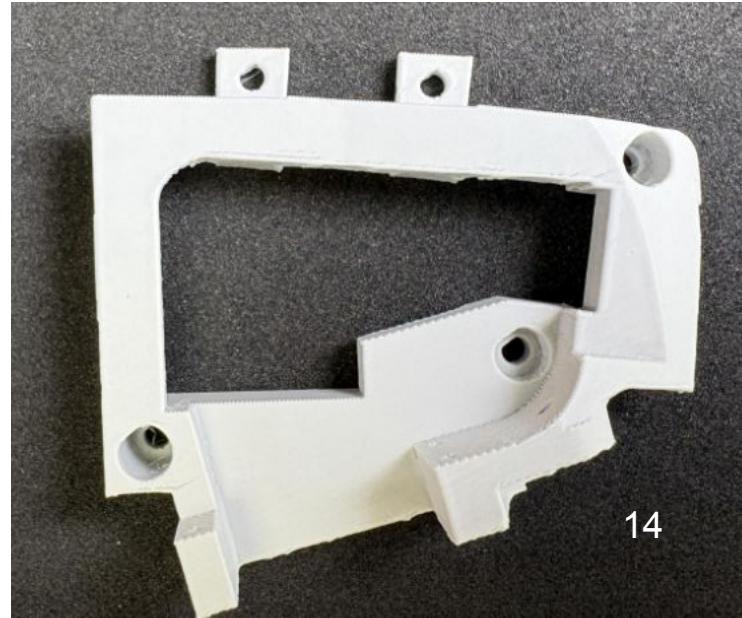
**Optional:**

2-Part Expansion Foam  
Foam Molds  
Mold Release Agent  
Hot Glue  
Finger Tip Silicone Cover  
Protoboard  
22awg solid core wire  
Reset tactile button  
Solder Flux  
Solder  
Hot Glue Gun  
Heat Insert Tip  
Molex 3pin female Connector  
Palm Foam  
Sandpaper

# 3D Printed Parts



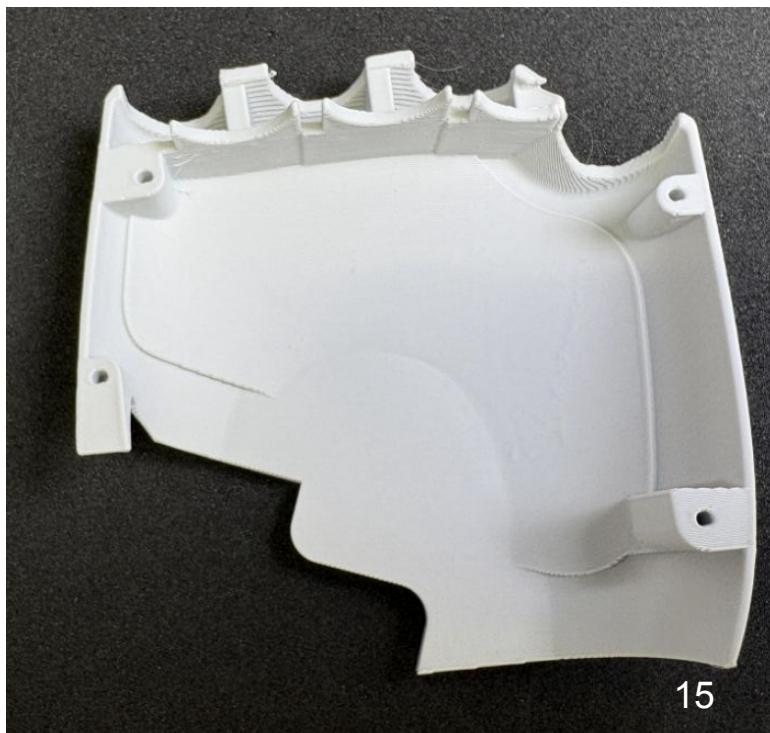
PN	Name	QTY
01	Finger Base	4
02	Finger MCP	4
03	Finger Proximal	4
04	Finger Medial	4
05	Finger Distal	4
10	Thumb CMC Base	1
11	Thumb MCP	1
12	Thumb Proximal	1
13	Thumb Distal	1



14



16



15

PN	Name	QTY
14	Servo Frame	1
15	Palm Front Frame	1
16	Palm Rear Frame	1

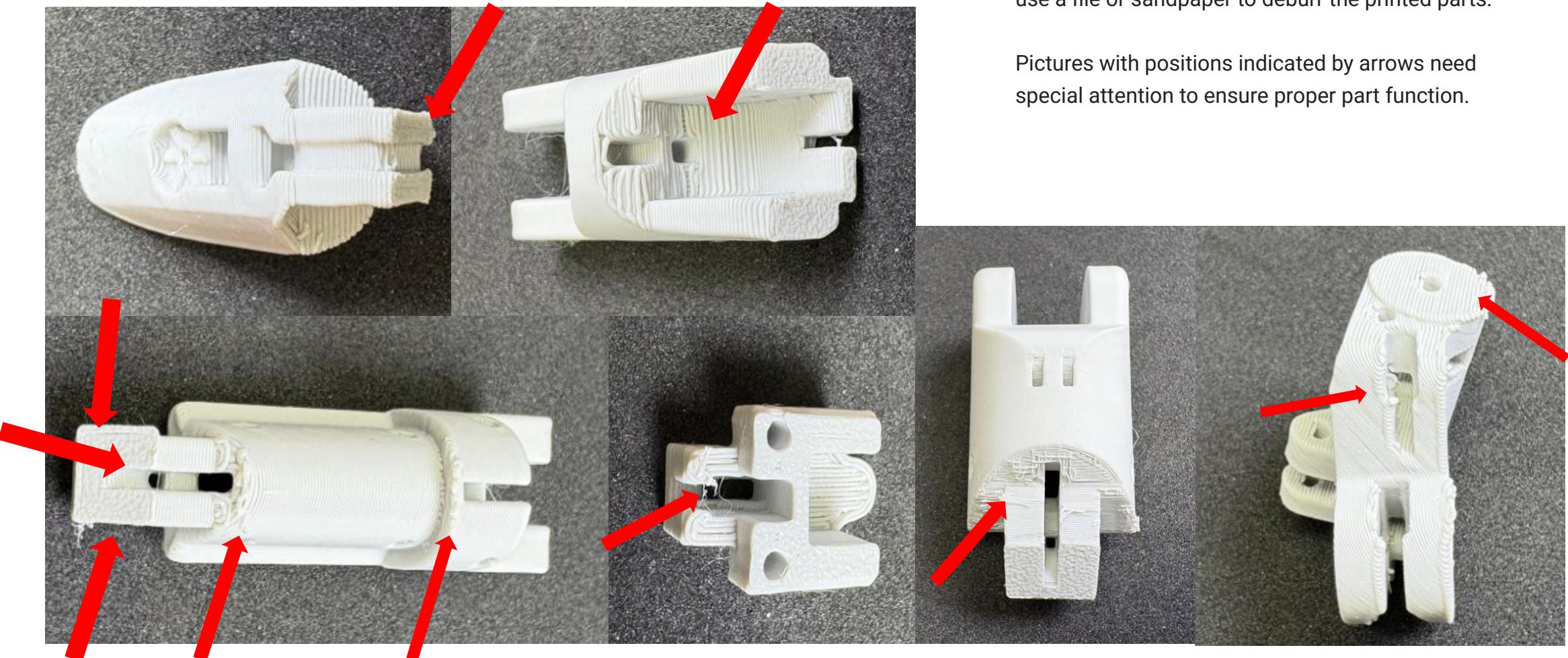
# 3D Print Cleanup

## Tools:

File  
Sandpaper  
Flash Cutter  
Hand Drill (1mm, 2mm, 2.1mm)

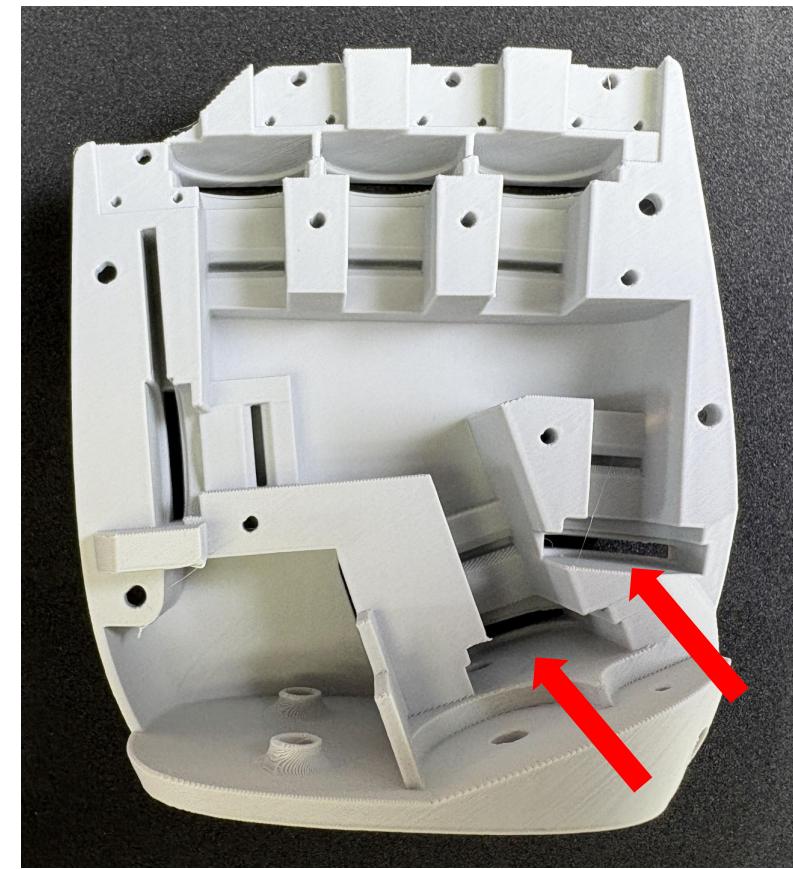
Name	Part Number	QTY
Finger Base	1	4
Finger MCP	2	4
Finger Proximal	3	4
Finger Medial	4	4
Finger Distal	5	4
Thumb CMC Base	10	1
Thumb MCP	11	1
Thumb Proximal	12	1
Thumb Distal	13	1
Servo Frame	14	1
Palm Front Frame	15	1
Palm Front Frame	16	1

# Debur 3D Printed Components



Use a flush cutter to remove the supports. Then, use a file or sandpaper to deburr the printed parts.

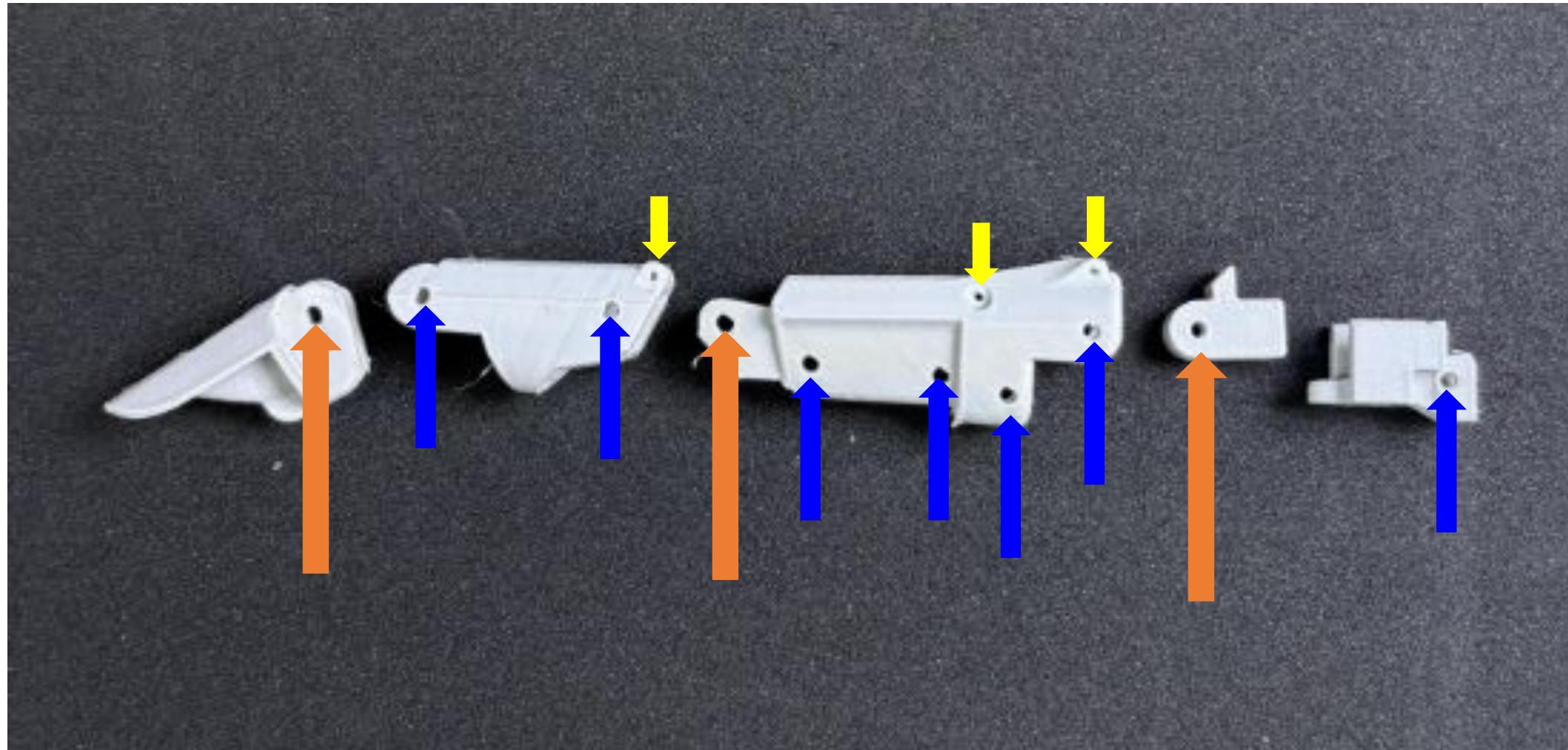
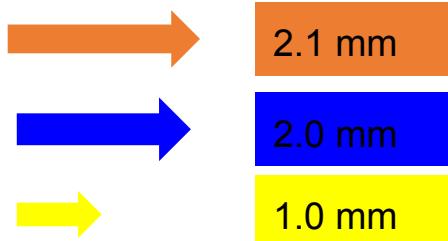
Pictures with positions indicated by arrows need special attention to ensure proper part function.



# Drill

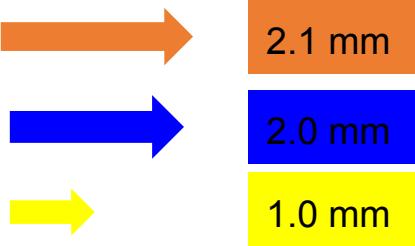
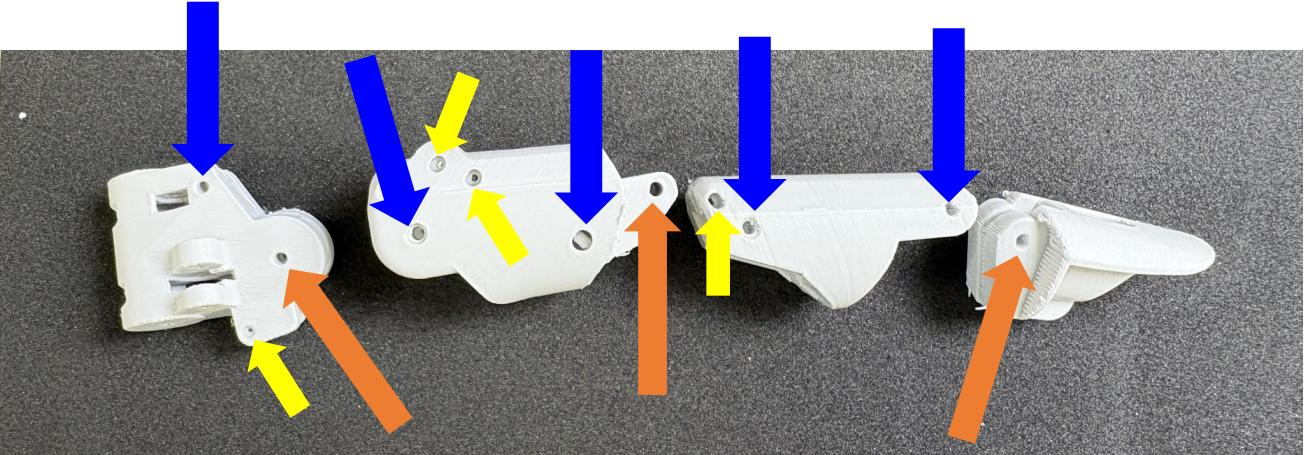
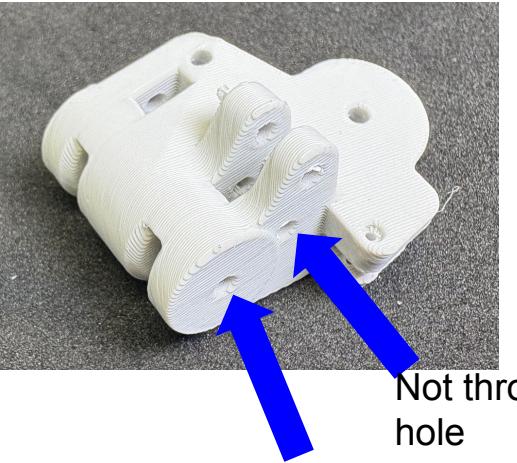
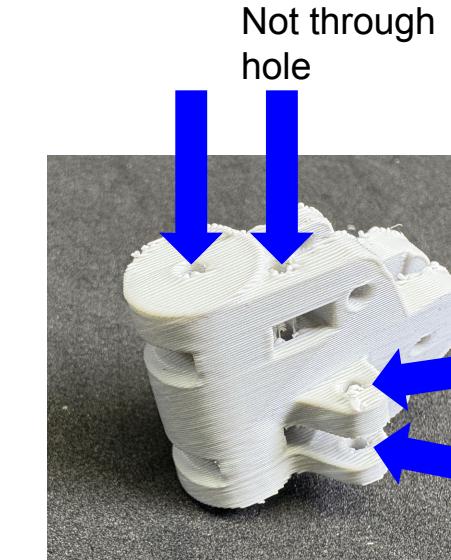
1. Drill out holes in finger joints for all four fingers

Note: All holes are through holes



# Drill

1. Drill out holes in thumb joints



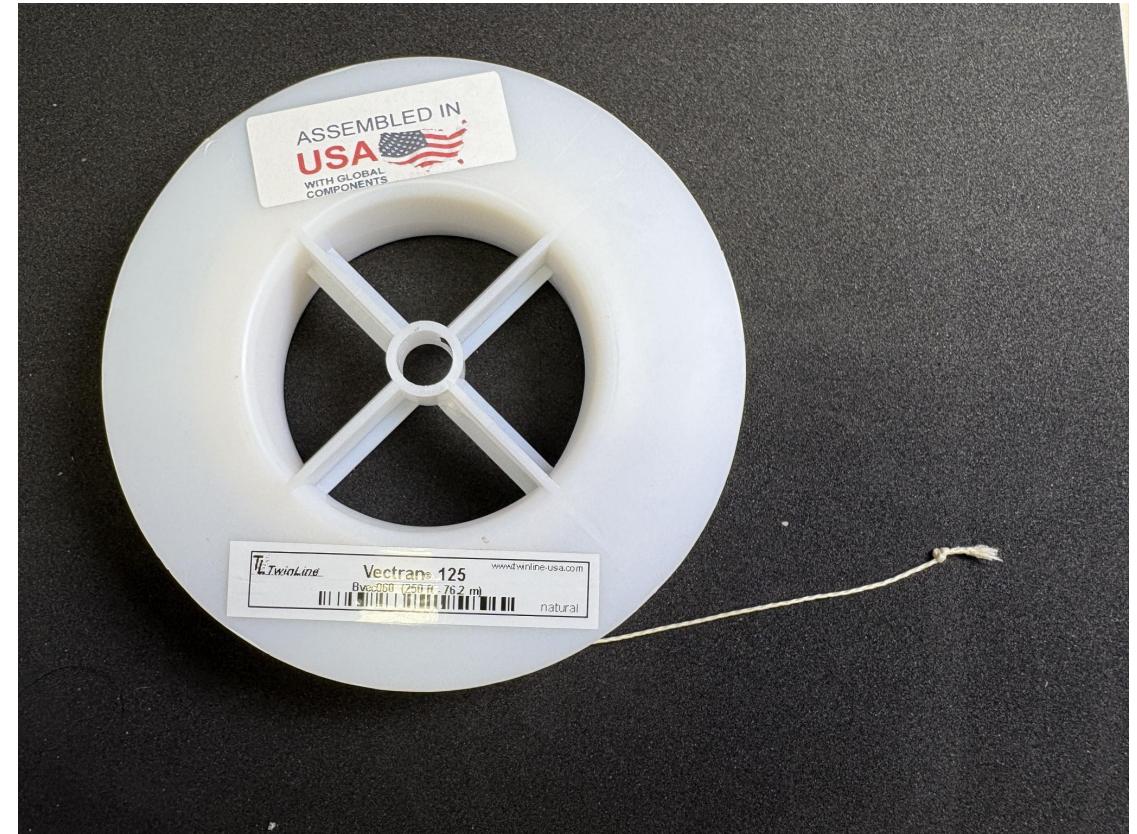
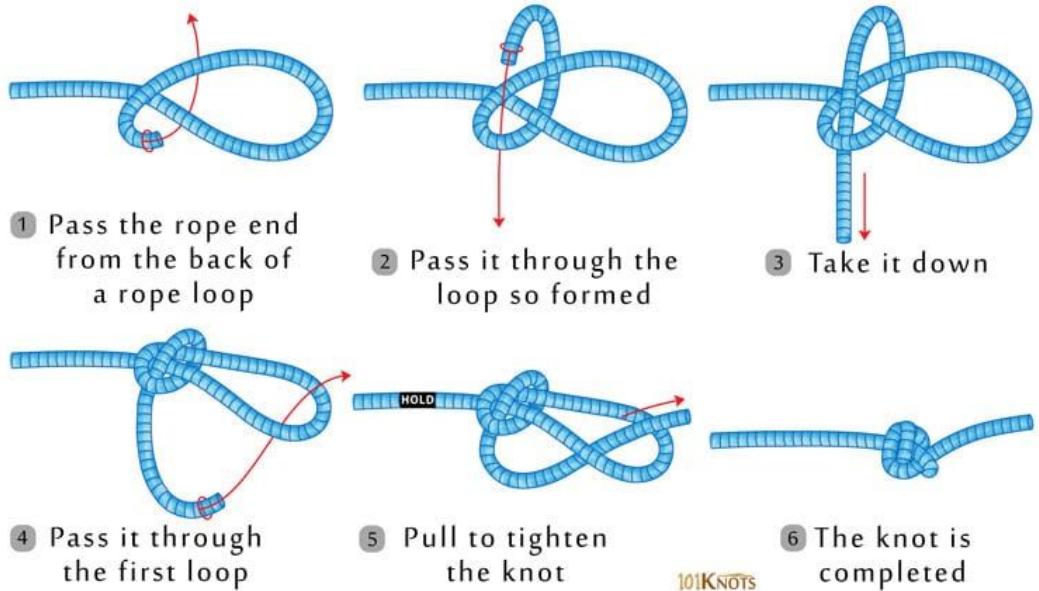
# Cable Pre-assembly

**Tools:**  
Scissors  
Measuring Tape

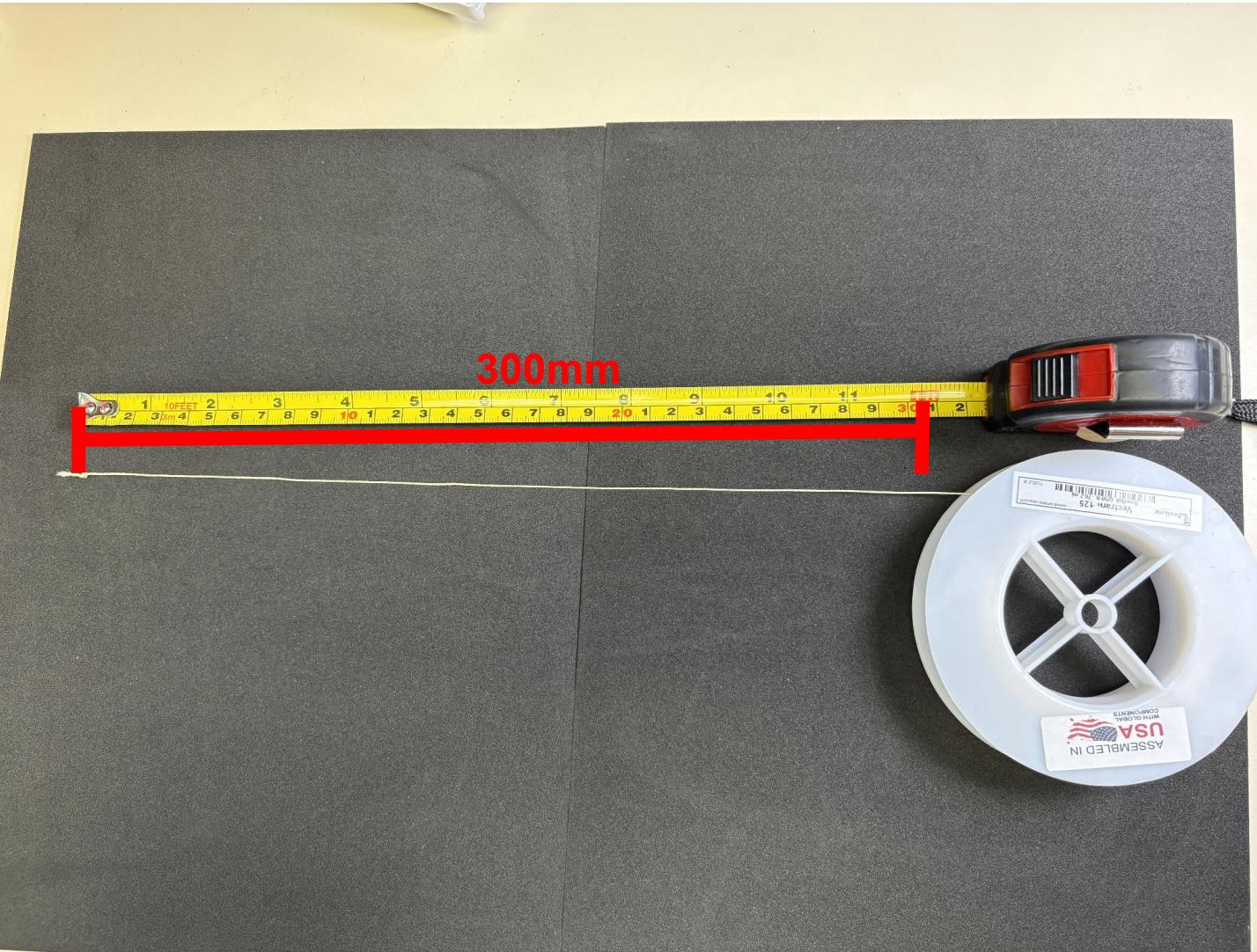
Name	Servoid #	QTY	Total Length (mm, from knot)	Marked Length (mm from spool exit)
Finger Pull Cable	5,8,11	3	300	130
Pinky Pull Cable	14	1	300	150
Finger Coupling Cable	NA	4	300	None
Thumb CMC Flex Cable	1	1	300	90
Thumb Pull Cable	2	1	300	150
Thumb Coupling Cable	NA	1	300	None

1. Tie ashley stopper knot on the end of vectran spool

### Ashley Stopper Knot Instructions



2. Cut vectran 300mm from knot
3. Repeat 10 more times, creating a total of 11 cables



5. Trim the tail of the ashley stopper knot to <5mm  
for all cables



# Finger Assembly

**Tools:**

Threading Tool  
Pliers  
Torx Driver

Name	Part Number	QTY
Finger Base	1	4
Finger MCP	2	4
Finger Proximal	3	4
Finger Medial	4	4
Finger Coupling Cable	26	4
UNDERSIZED 2x10 Pin	32	16
2x5x2.5 bearing	30	16
1x10 Pin	31	12
M2x6 Flanged Torx Self Tapping Screw	38	4
Finger Proximal/MCP Return Spring	22	4
Finger Distal/Medial and Thumb Proximal/Distal Return Spring	21	4

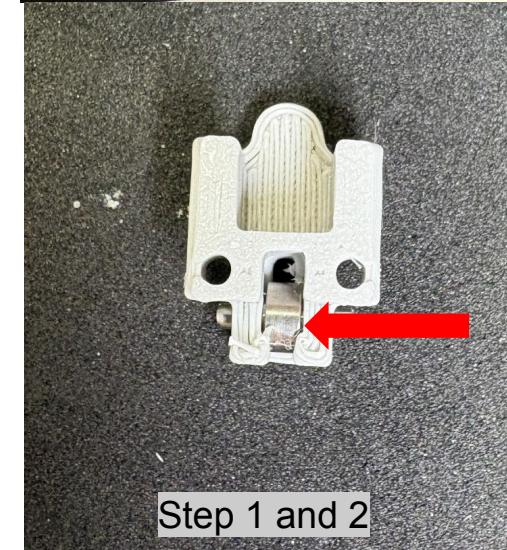
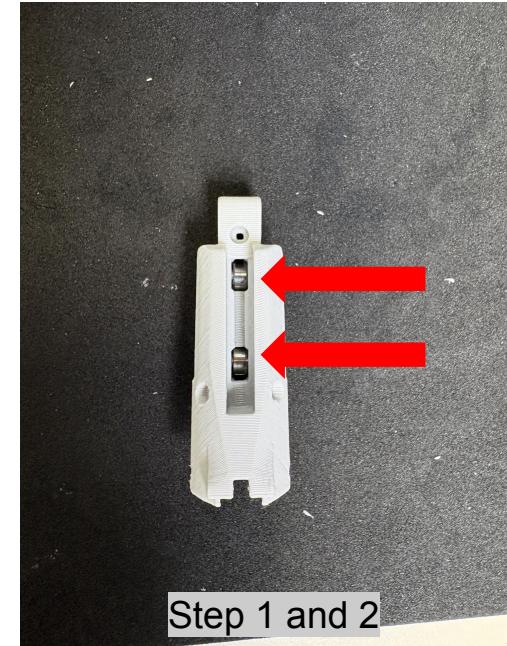
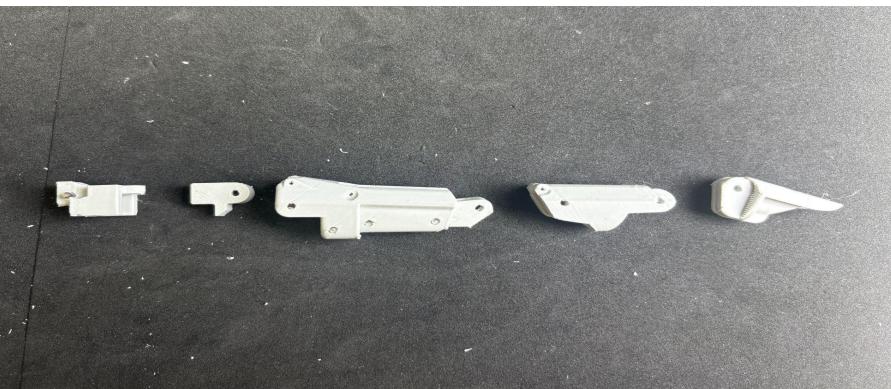
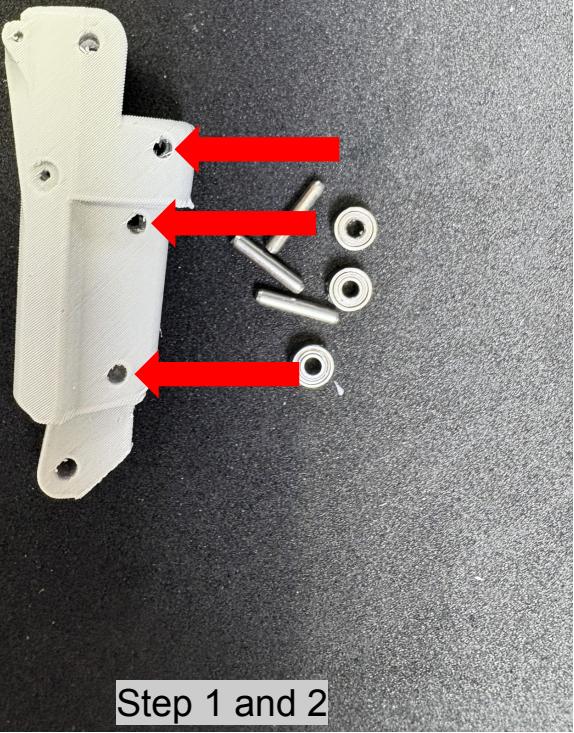
# Bearings

1. Place four bearings (30) in finger proximal (3) and finger base (1) components

2. Secure using 2x10mm pins (32)

3. Repeat for all fingers

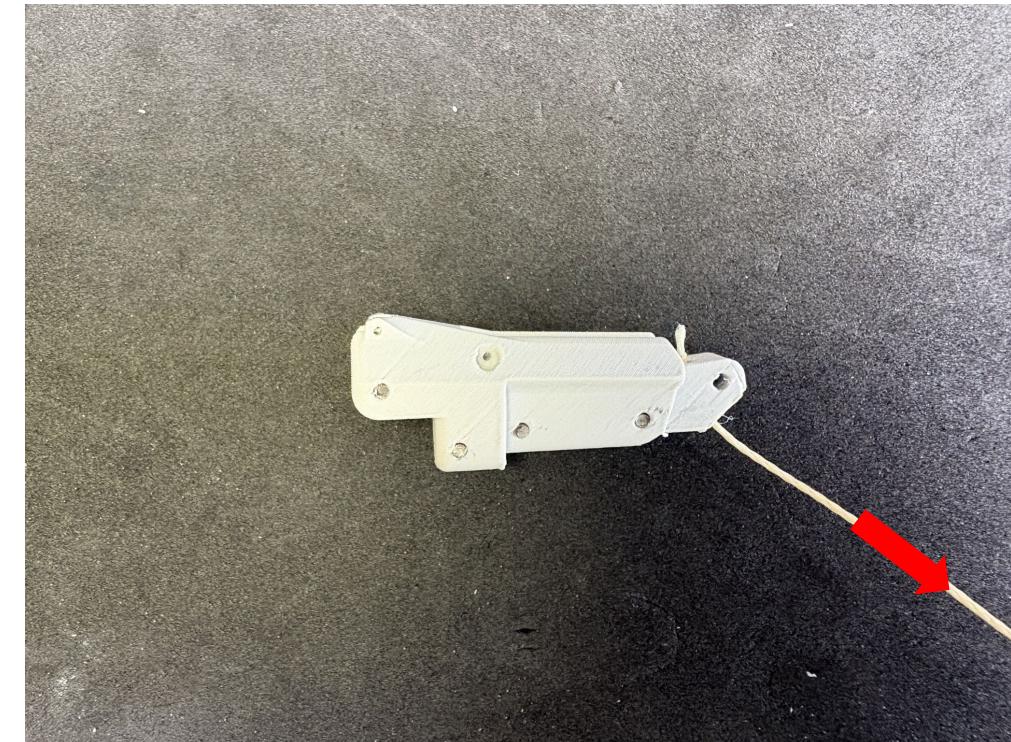
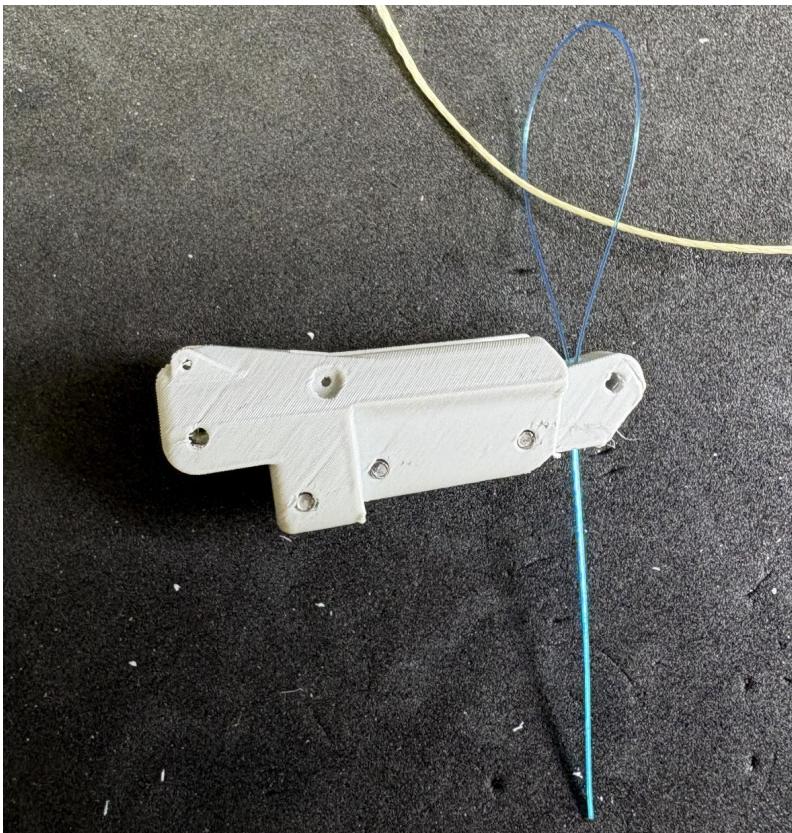
NOTE: Ensure all bearings spin, if not file/sand/deburr plastic



# Finger Coupling Cable

4. Route a non-marked cable through hole at end of Finger proximal piece

5. Pull tight once routed to pretension/remove any slack that could be present in the ashley stopper knot

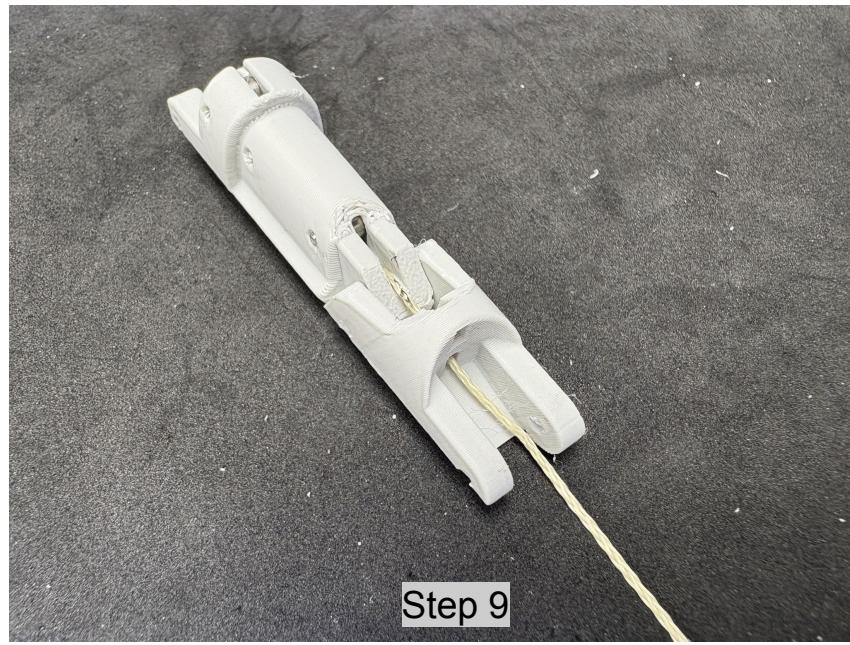
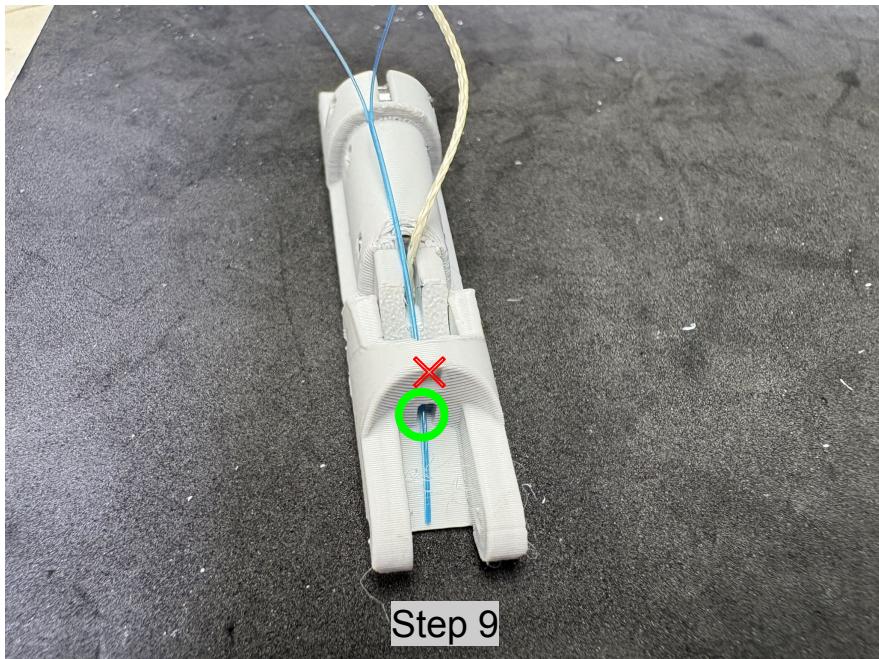
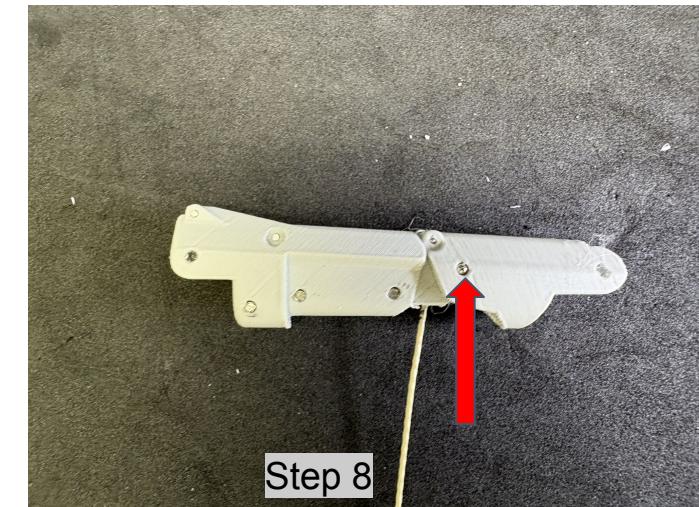
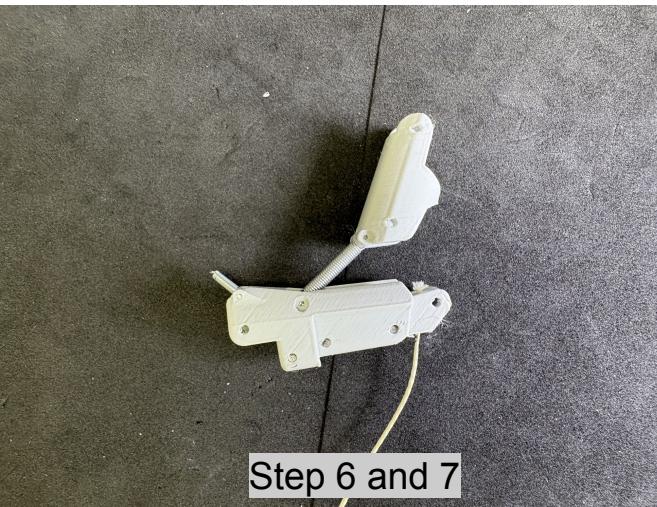


6. Install spring (21) connecting proximal (3) and medial (4) components using two 1x10mm pins (31)

7. Install spring (22) on base of proximal using one 1x10mm pin (31)

8. Connect proximal and medial sections using one 2x14mm pin (34)

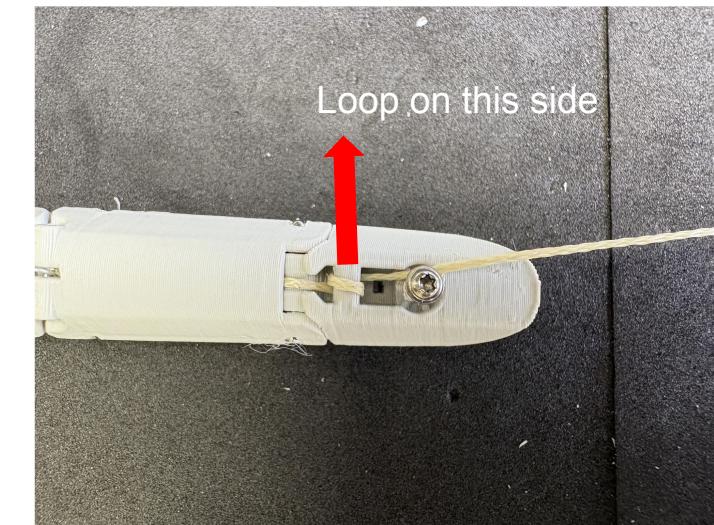
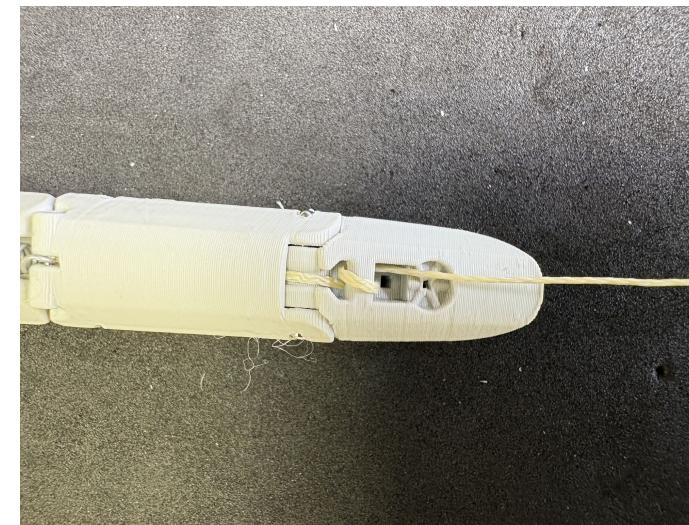
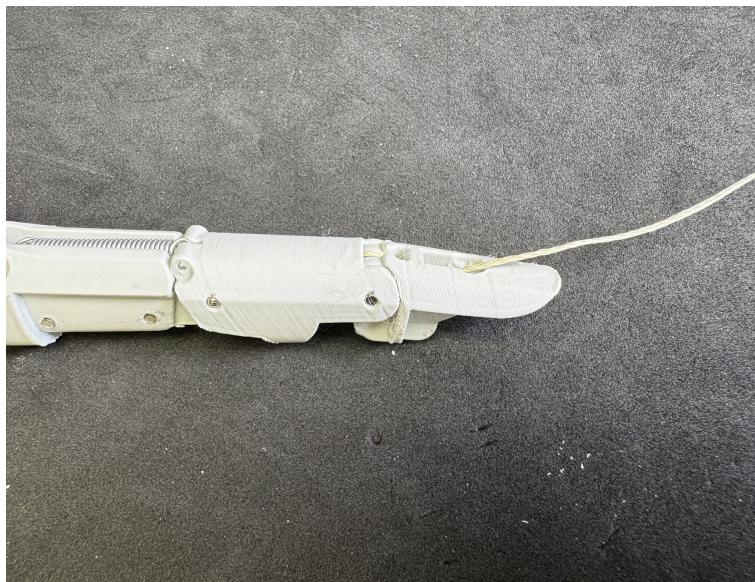
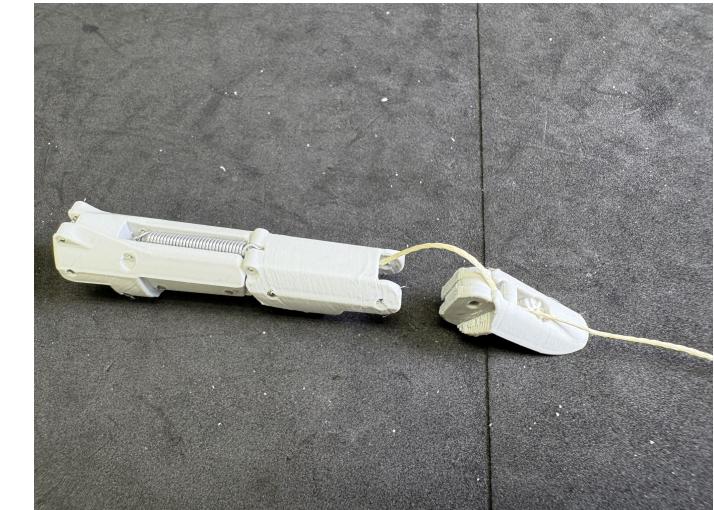
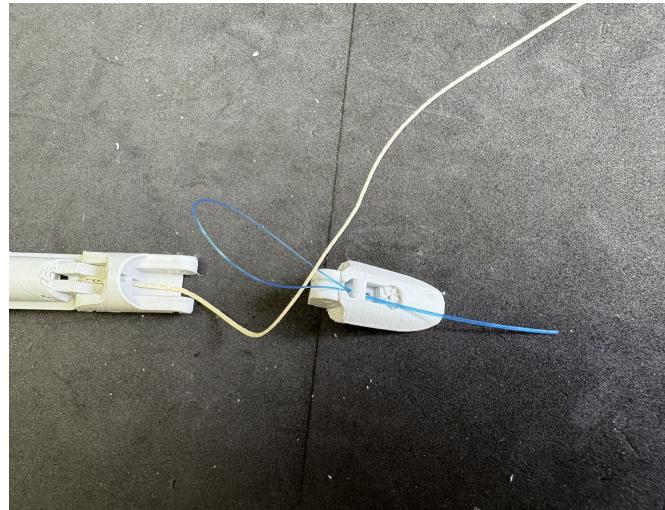
9. Thread coupling cable through bottom hole on medial section

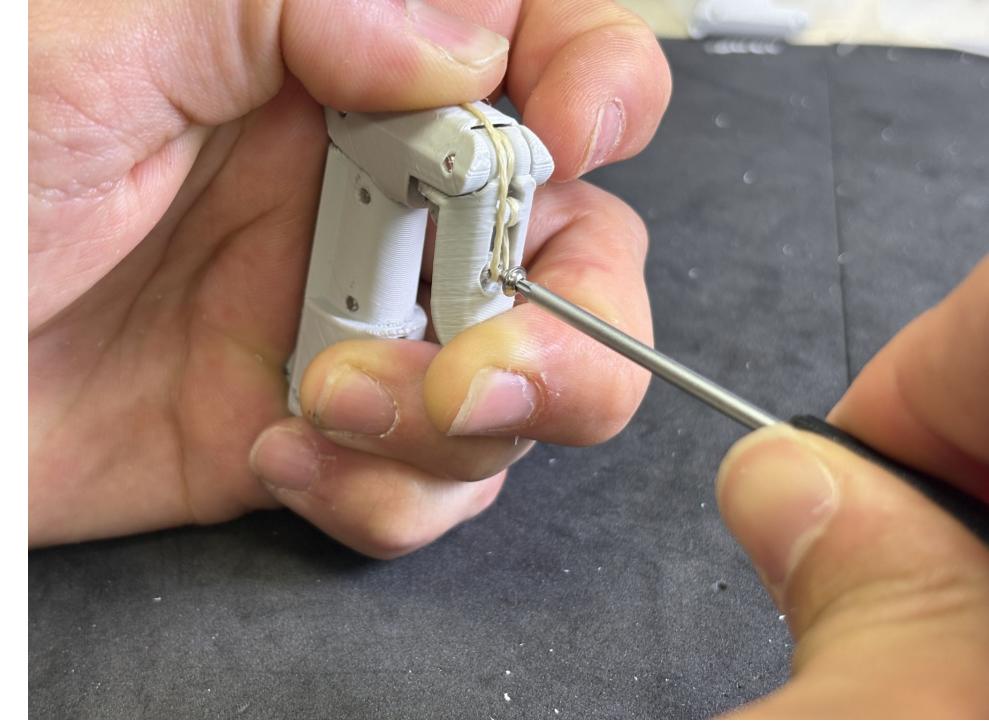
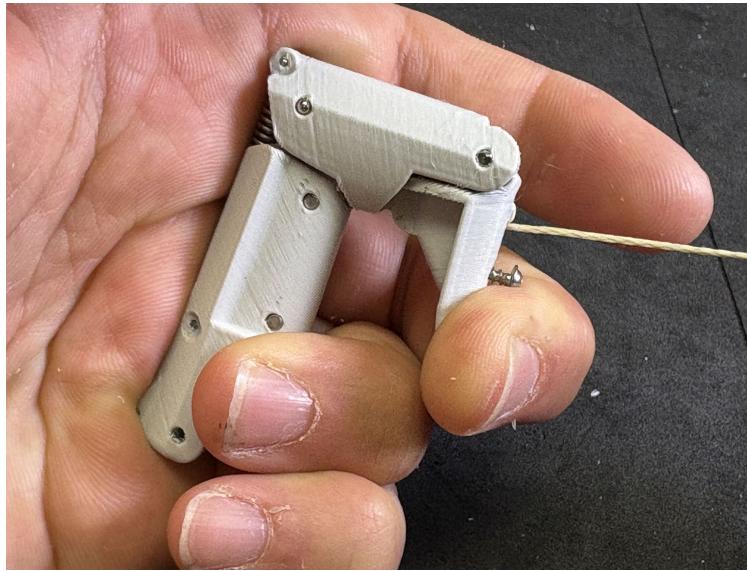
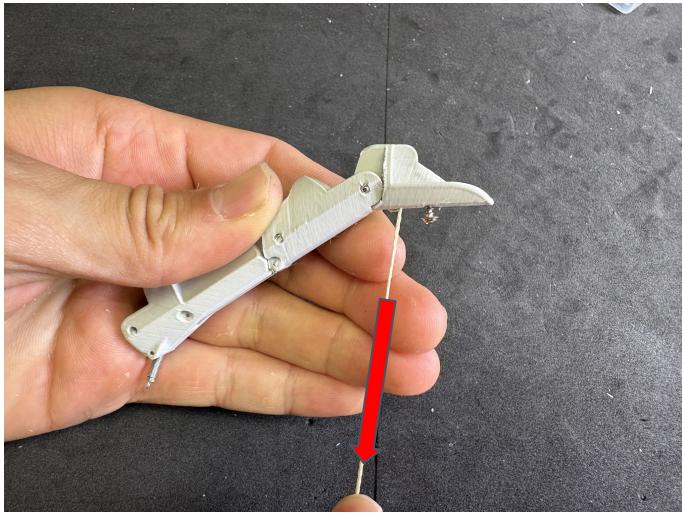


10. Route coupling cable underneath the bar on the distal section

11. Wrap coupling cable around bar once. Ensure that the cable wraps

12. Start to thread M2x6 Torx screw (38) into the distal section





13. Pull cable taut

14. Flex finger while maintaining tension

15. Tighten screw until cable is securely pinched

16. Distal/medial and medial/proximal angle should maintain the same angle when opening/closing the finger. See video

17. Repeat from step 1 for three remaining fingers

Name	Part Number	QTY
Thumb Abduction Upper Servo Disk	7	1
Thumb Abduction Lower Servo Disk	8	1
Thumb Abduction Linkage Bar	9	1
Thumb CMC Base	10	1
Thumb MCP	11	1
Thumb Proximal	12	1
Thumb Distal	13	1
Finger Coupling Cable	26	1
UNDERSIZED 2x10 Pin	32	5
2x5x2.5 bearing	30	5
1x10 Pin	31	2
M2x6 Flanged Torx Self Tapping Screw	38	1
Finger Distal/Medial and Thumb Proximal/Distal Return Spring	21	4
2x10 Pin	33	1
Servo Motor Mount Plate	43	1
Servo Motor Spline Screw M2.3x5	44	6
Servo Motor Plate Screw M2x4	45	1
Thumb CMC/MCP Return Spring	23	1

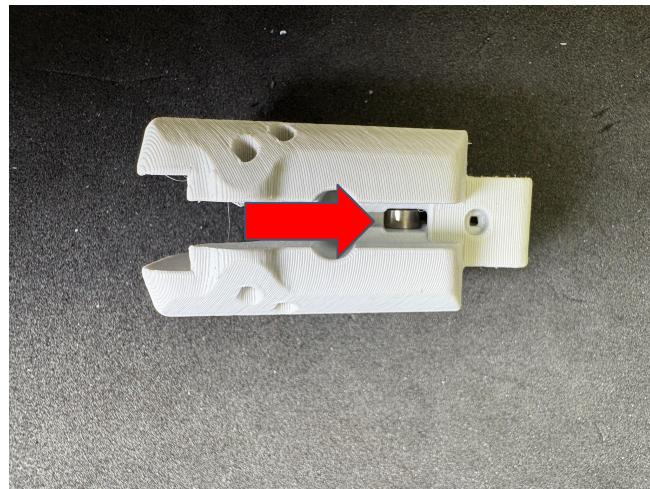
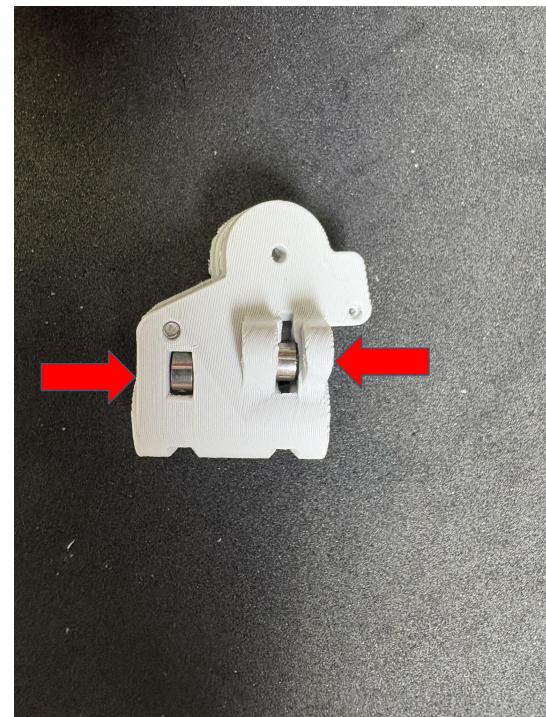
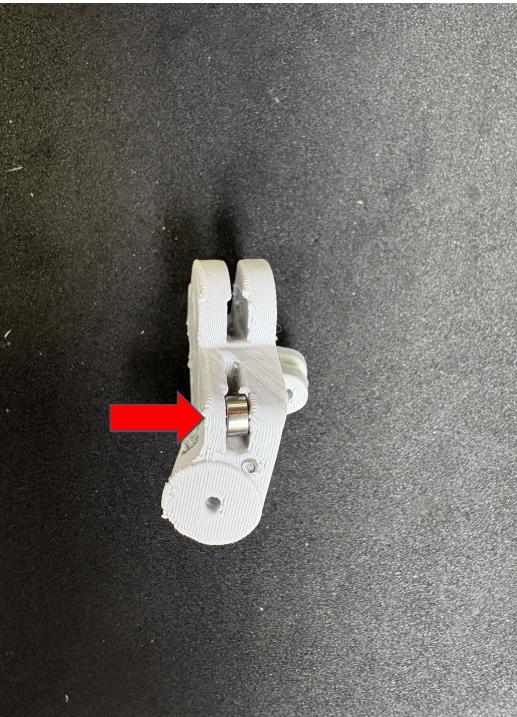
# Thumb Assembly

## Tools:

Threading Tool  
Pliers  
Torx Driver  
Loctite

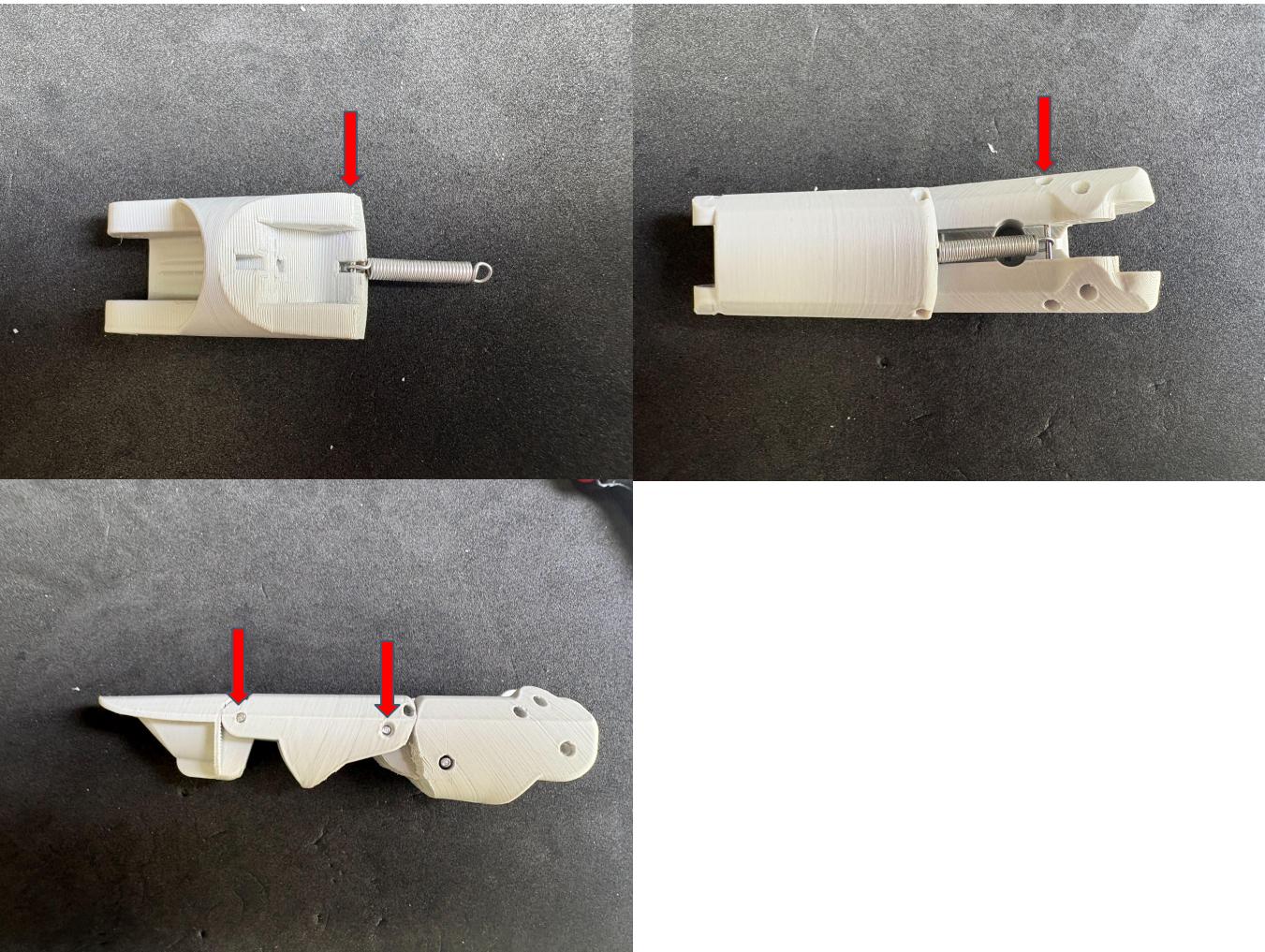
# Thumb Bearings

1. Insert bearings into thumb base (10) and thumb MCP (11)
2. Secure using 2x10mm pins (32)

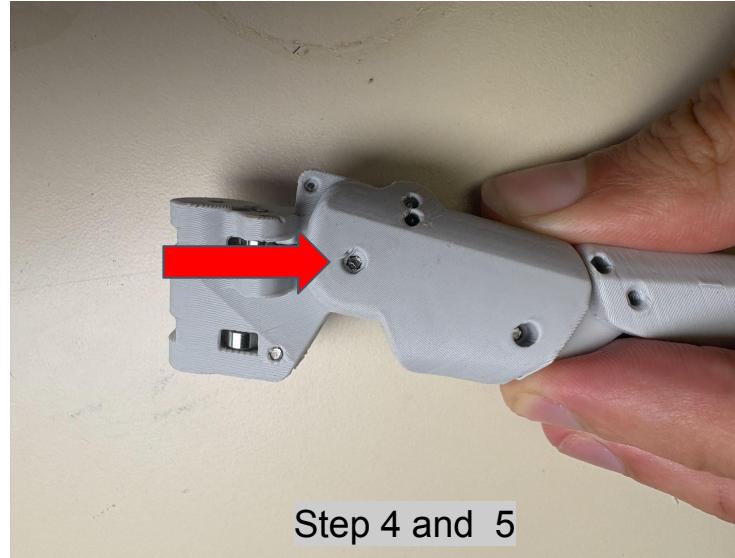


# Thumb Assembly

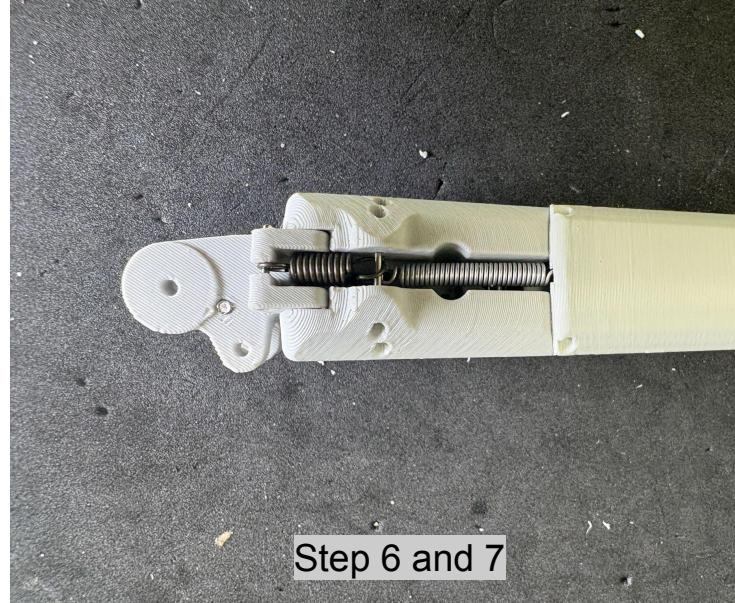
1. Attach spring (21) with 1x10mm pin (31) to proximal
2. Attach other side of spring to MCP using 1x10pin (31)
3. Attach distal, proximal and MCP with 2x20mm pins (36)



4. Insert CMC into MCP. Add bearing between components
5. Secure using 2x20mm pin
6. Add thumb spring (23) between CMC and MCP
7. Secure using 1x10 pin



Step 4 and 5



Step 6 and 7

# Thumb Coupling Cable

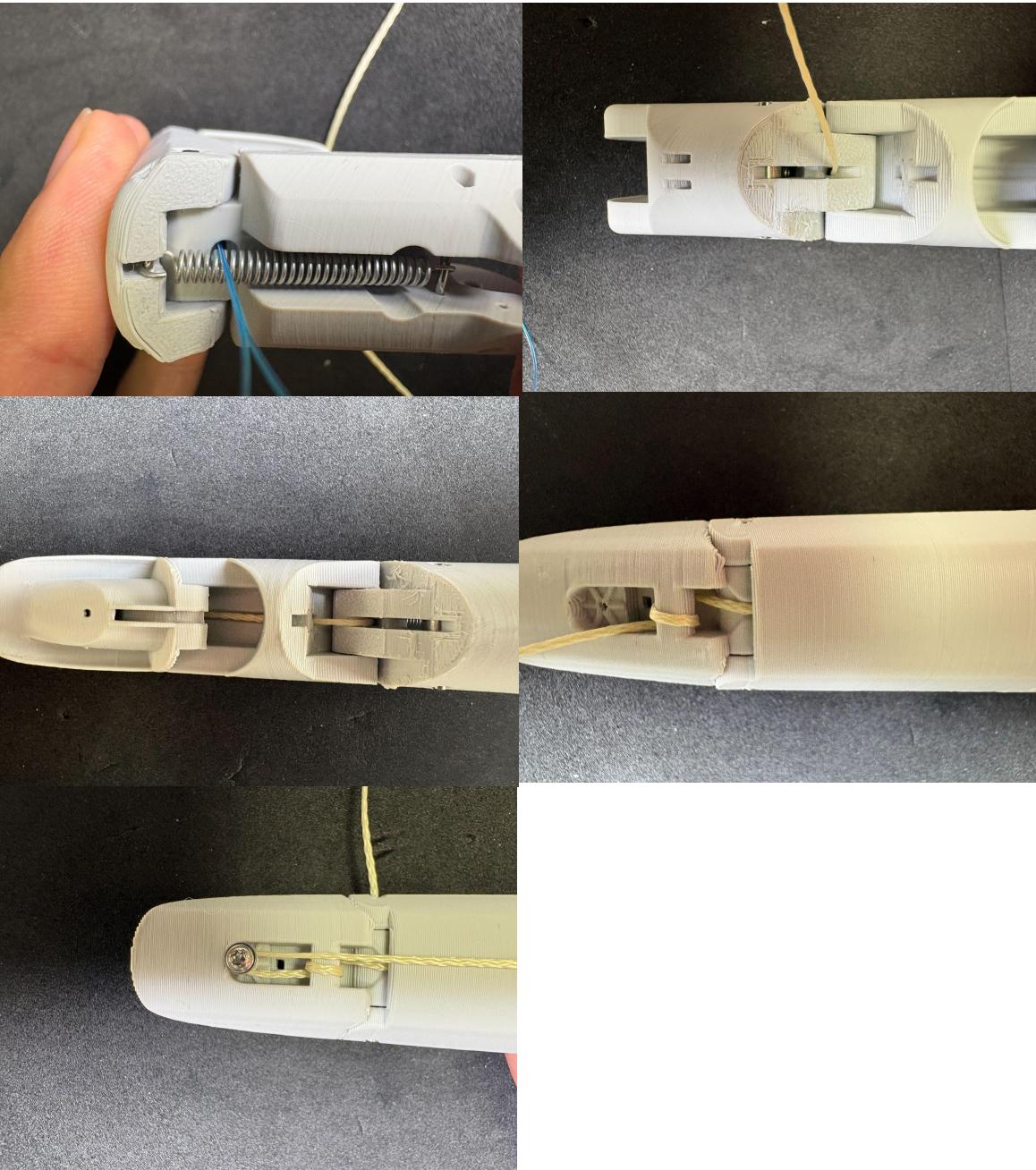
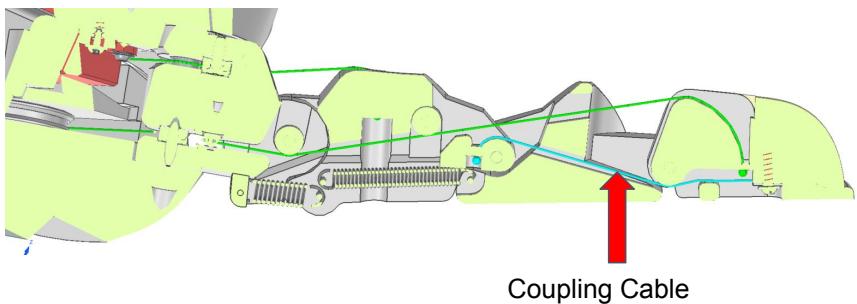
8. Thread a non-marked cable through in MCP

9. Pull taut

10. Thread through lower hole in proximal and over distal

11. Add loop on crossmember.  
Note direction of loop

12. Tension and secure same as fingers with 2x6mm torx screw (38)



# Linkage Assembly

13. Place aluminum disk (43) into thumb servo lower disk (7). Secure using M2x4 screws (45) with loctite
14. Add thumb servo upper disk (8) piece sandwiching the aluminum. Secure using M2x4 screws with loctite
15. Drill linkage holes in disks with 2mm drill (7 and 8)
16. Drill linkage hole in linkage bar with 2.1mm drill (9)
17. Place linkage bar between disks and secure using 2x10 pin (33). Note: direction of linkage is important. Reference image



# Servo ID and Assembly

## Tools:

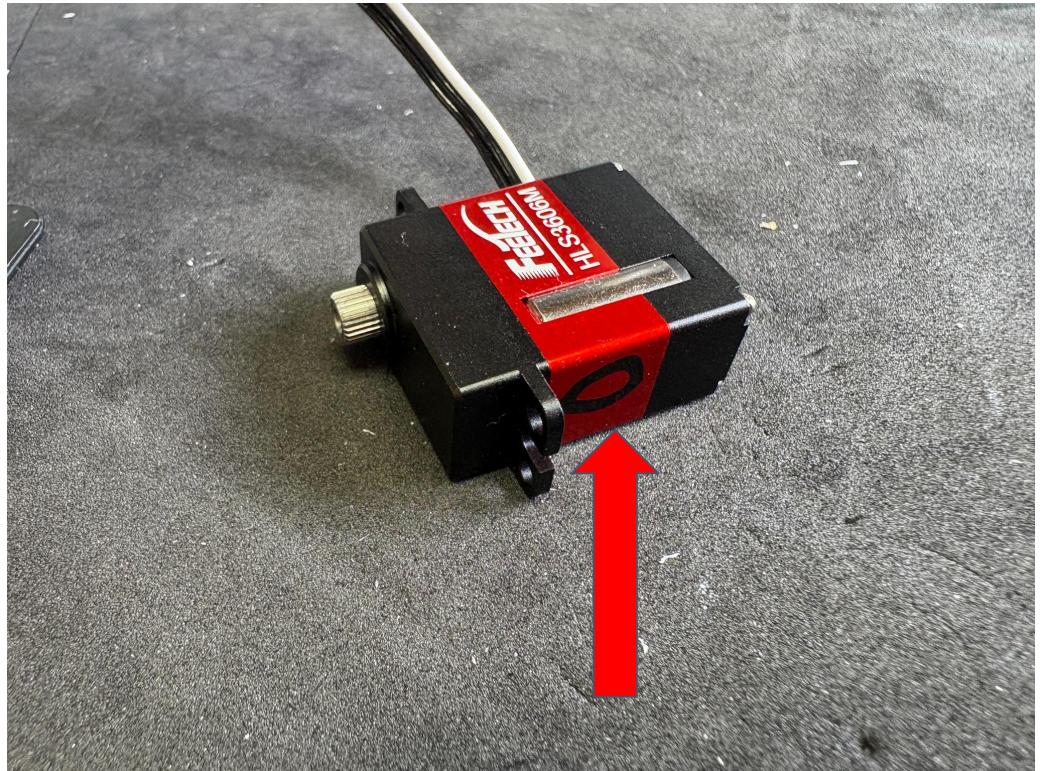
Computer  
Breadboard  
Marker  
Molex Connectors  
Soldering Iron  
Protoboard

Name	Part Number	QTY
Servo Motor	42	7
Cable Spool	6	6
Finger Pull Cable	24	4
Pinky Pull Cable	25	1
Thumb CMC Flex Cable	27	1
Thumb Pull Cable	28	1
Servo Motor Mount Plate	43	6
Servo Motor Spline Screw M2.3x5	44	18
Servo Motor Plate Screw M2x4	45	6
Connection Cable	47	1

# Label Servos

Label all 7 servos with a sharpie or paint marker with an individual number: 0, 1 ,2, 5 ,8, 11, 14

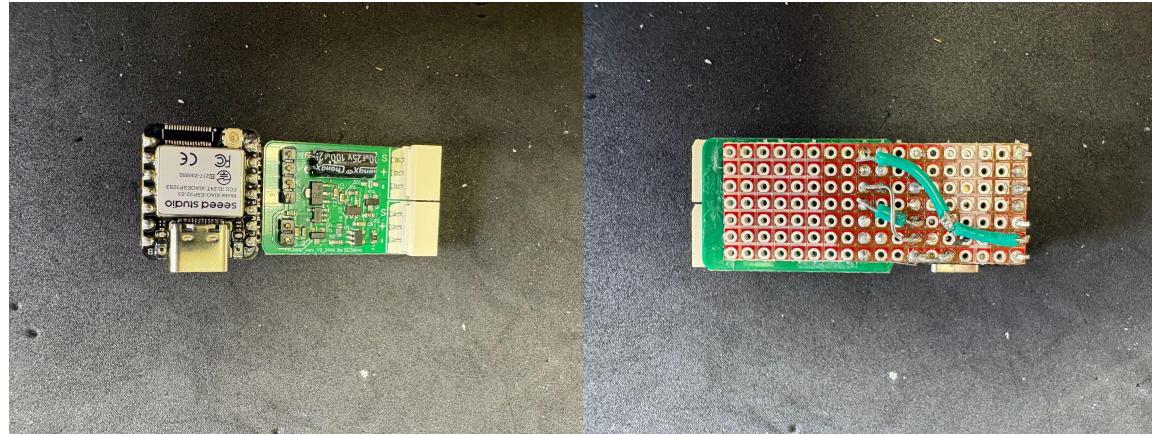
Reference image for location of label



# Control Board

Build a control board using the electrical schematic

Board can be built on a breadboard (no soldering required), custom PCB (coming soon) or protoboard

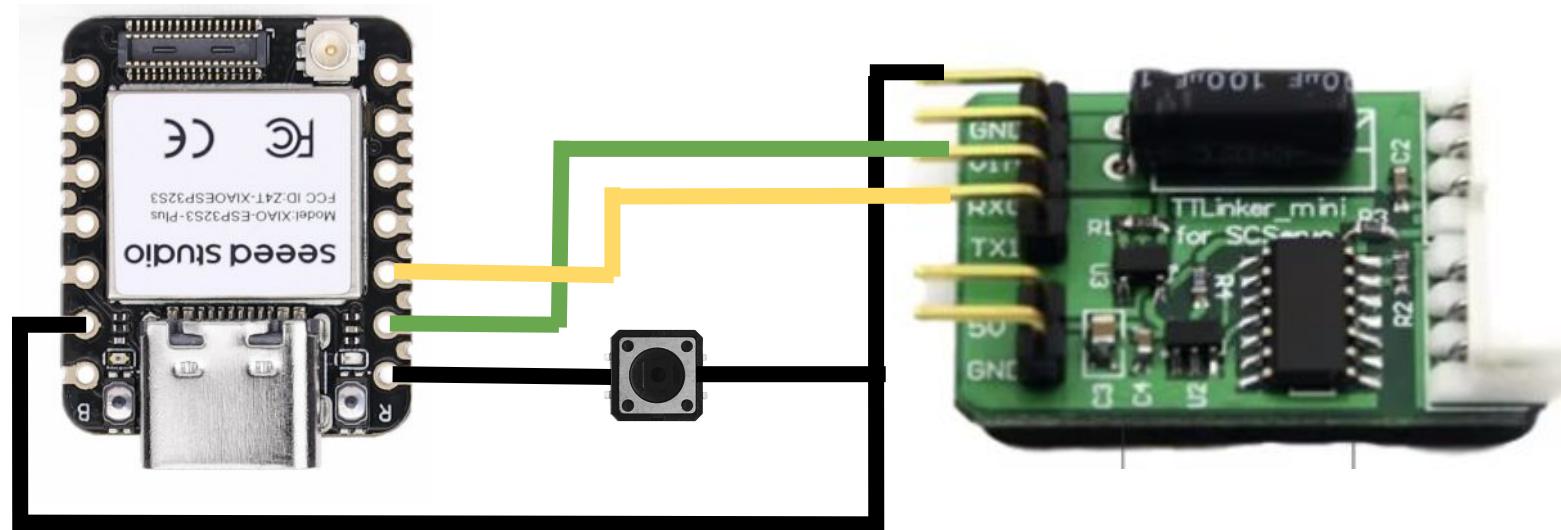


GREEN - RX

YELLOW - TX

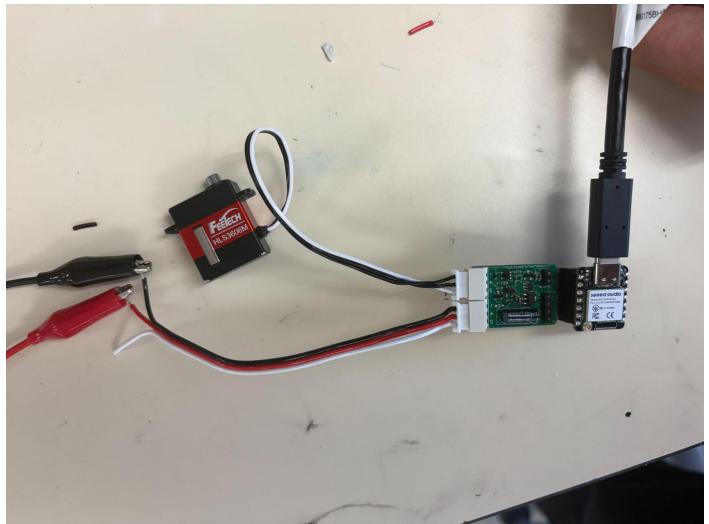
BLACK - GROUND

Example protoboard



# Program Servos

1. Download and install an Arduino IDE (example: <https://www.arduino.cc/en/software/>)
2. Add FTServo and another other libraries that may be required
3. Connect one servo and power supply (6vdc with <2amps) to the driver on board made in previous step
4. Connect ESP32 to computer
5. Run script from repo:  
[https://github.com/TetherIA/tetheria\\_ws/tree/main/firmware/scripts/aerie\\_lite\\_v1\\_0](https://github.com/TetherIA/tetheria_ws/tree/main/firmware/scripts/aerie_lite_v1_0) This will install firmware.
6. Run the .py script from the command prompt
7. Select “Connect”
8. Select “Re-ID Servo”. Type the servo number and select “Set this Servo”. You can test using the the slider bars to control the angle of the servo
9. Remove servo and plug in a different servo
10. Repeat from all servos



updated\_firmware | Arduino IDE 2.3.6

File Edit Sketch Tools Help

XIAO\_ESP32S3

LIBRARY MANAGER

ftservo

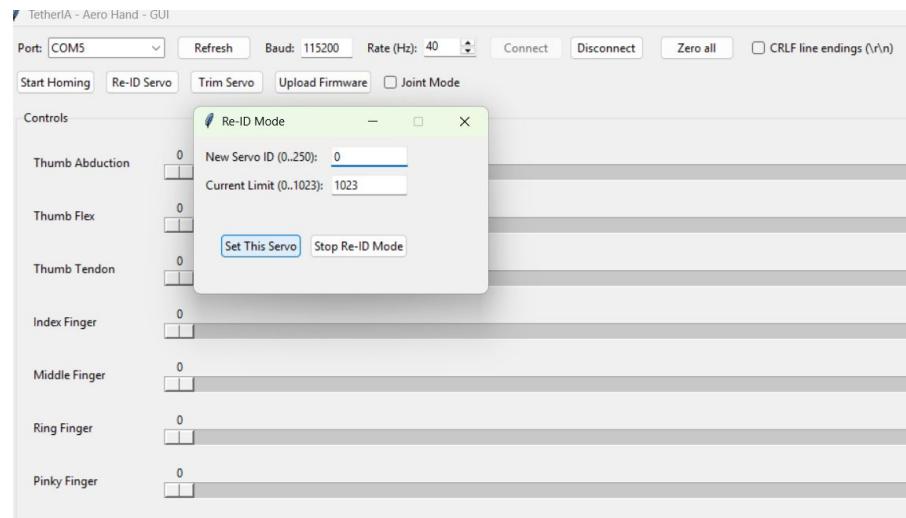
Type: All Topic: All

FTServo by ft servo  
2.0.0 installed

FEETECH BUS Servo library for Arduino and ESP32 This library is compatible with all series of FEETEC...  
More info

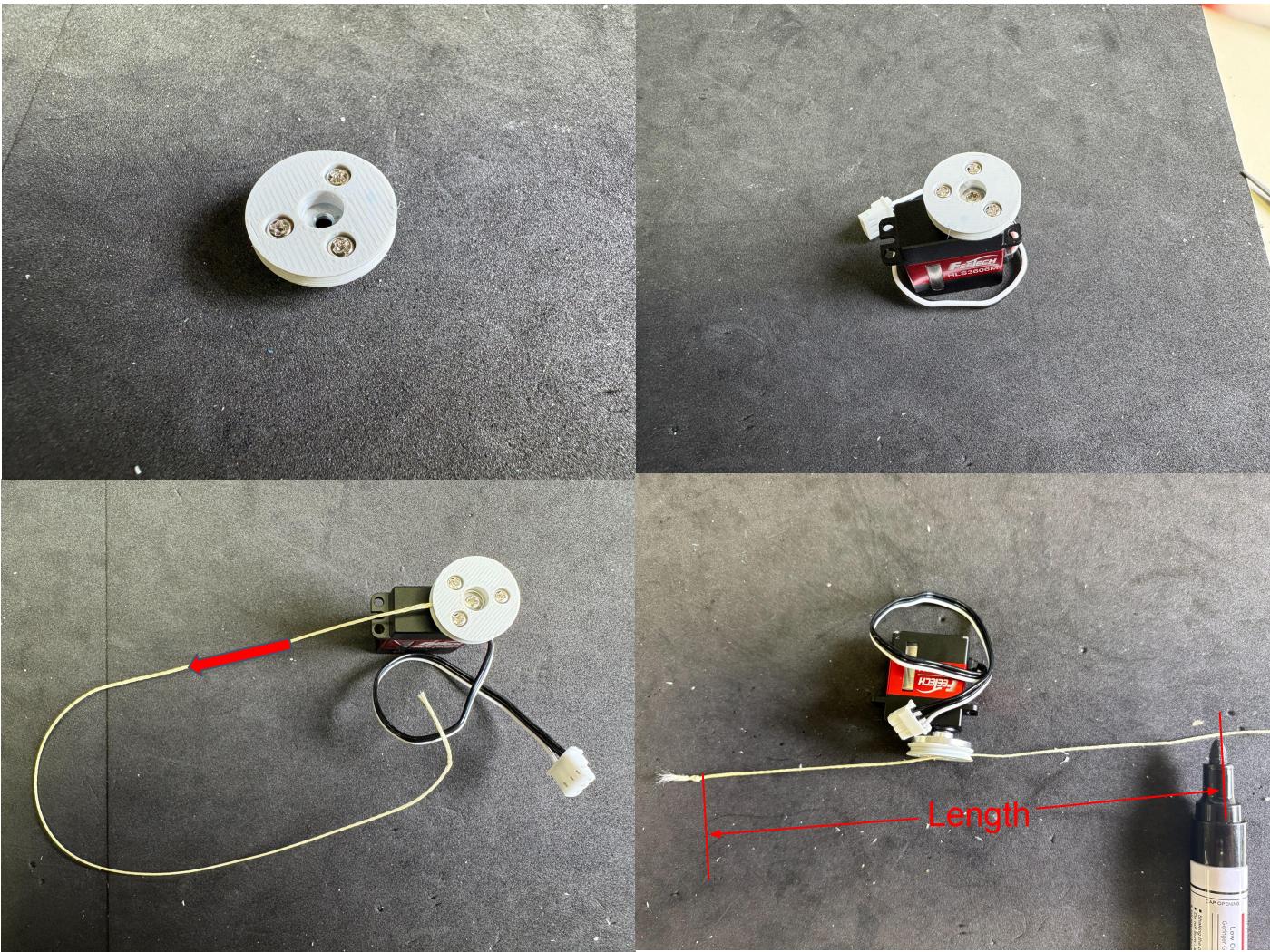
2.0.0 REMOVE

```
1 // use esp32 library version 2.0.17
2 #include <Arduino.h>
3 #include <Wire.h>
4 #include <HLSCL.h>
5 #include <Preferences.h>
6 #include "freertos/FreeRTOS.h"
7 #include "freertos/task.h"
8
9 Preferences prefs;
10 HLSCL hlscl;
11
12 // ----- Config -----
13 #define NUM_CHANNELS 15
14 #define MAX_COMMANDS 40
15 #define MAX_INPUT 255
```



# Servo Spools

10. Screw cable spool (6) into aluminum servo mount (43) using three screws (45). Apply loctite to threads before installing



11. Attach mount to servo using large screw (44) and loctite

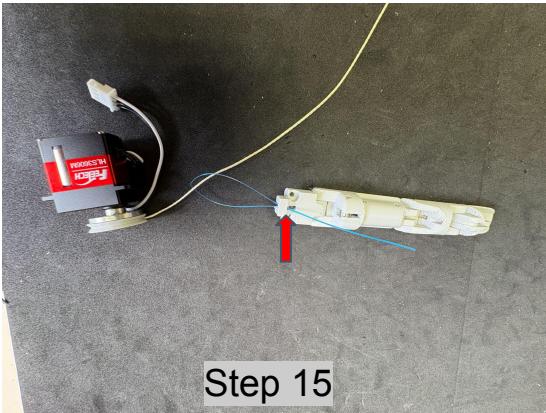
12. Thread a cable into servo

13. Mark length based on servo number (example: servo #1 = length 90mm)

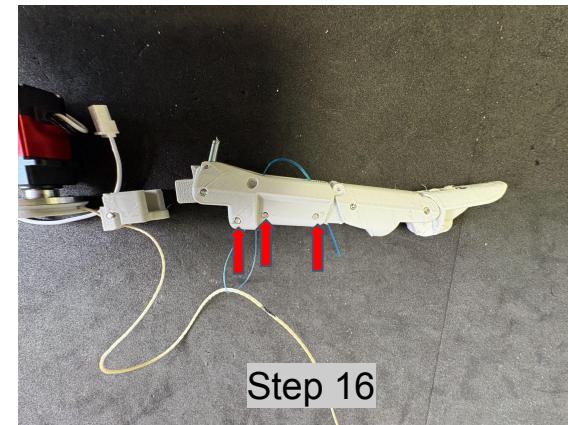
14. Repeat for servos 1, 2, 5, 8, 11 and 14

# Thread finger servo cable

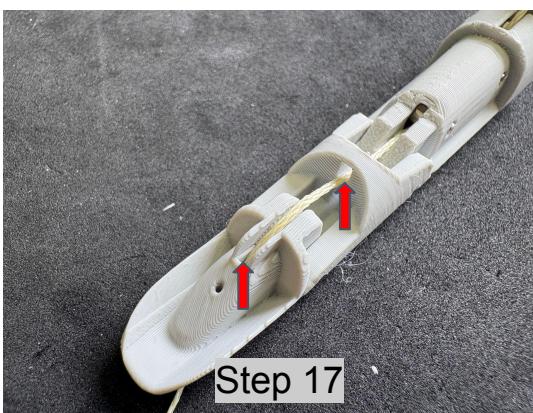
15. Thread the servo 14 cable through a finger base



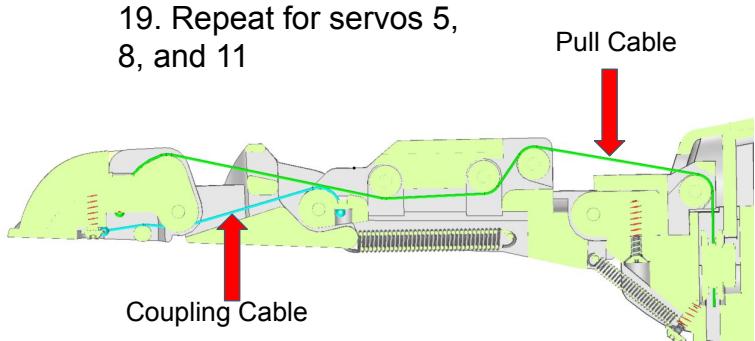
16. Thread between bearings on distal



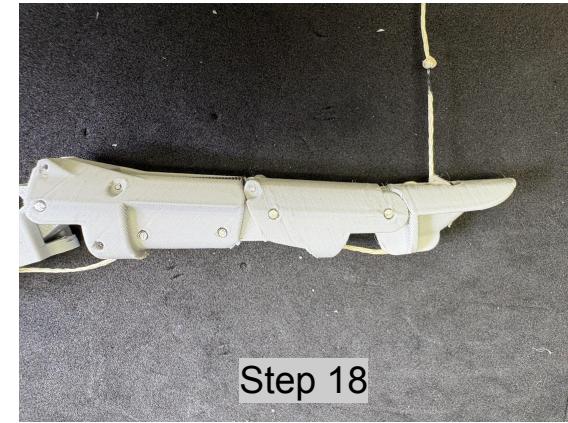
17. Thread through top medial hole and distal



18. Tie ashley stopper knot at mark



19. Repeat for servos 5, 8, and 11



# Servo Busbar

20. Cut 7x8 protoboard

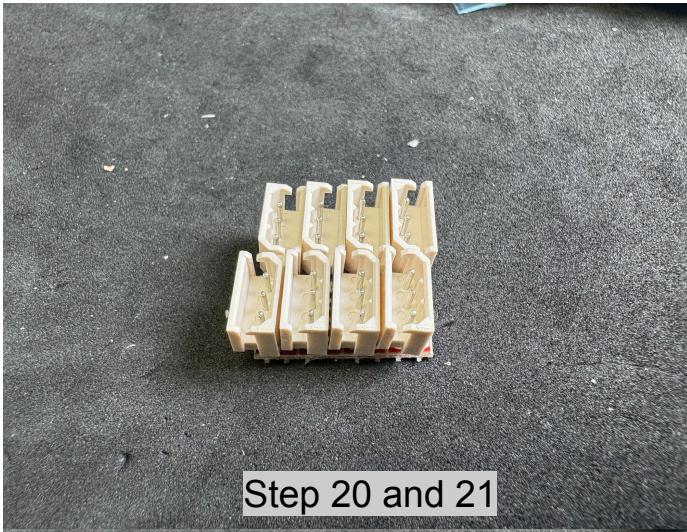
21. Place molex connectors as in image. Note orientation.

22. Solder together using 22awg solid wire as in image

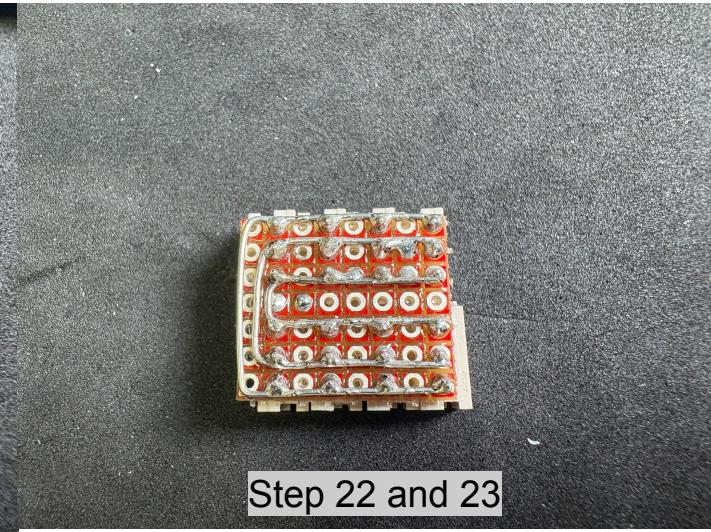
23. Clean board to remove residual flux

24. Cover wires in hot glue or liquid electrical tape to protect against electrical shorting

NOTE: This step can be skipped by simply daisy chaining the servos together using the 3-way connects supplied with the servos



Step 20 and 21



Step 22 and 23



Step 24

# Hand Base

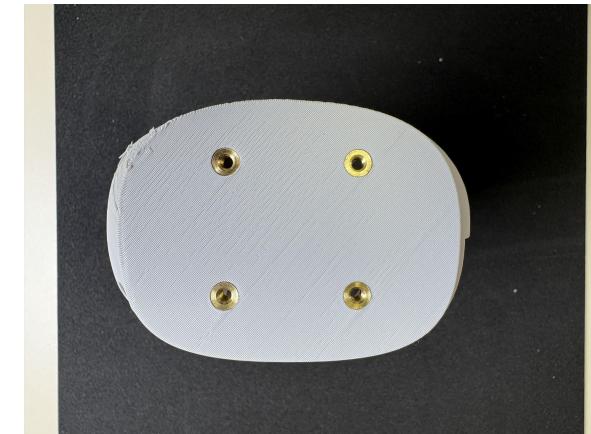
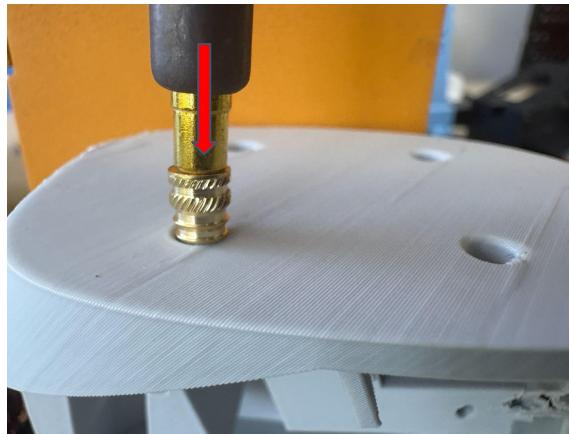
**Tools:**

Soldering Iron  
Torx Driver  
Philips Driver

Name	Part Number	QTY
Servo Frame	14	1
Palm Front Frame	15	1
Palm Rear Frame	16	1
M3x6.4 Heat set insert	41	4
M2x10 Countersunk Torx Self Tapping Screw	39	12
M2x6 Flanged Torx Self Tapping Screw	38	14
2x20 Pin	36	1
UNDERSIZED 2x30 Pin	37	1

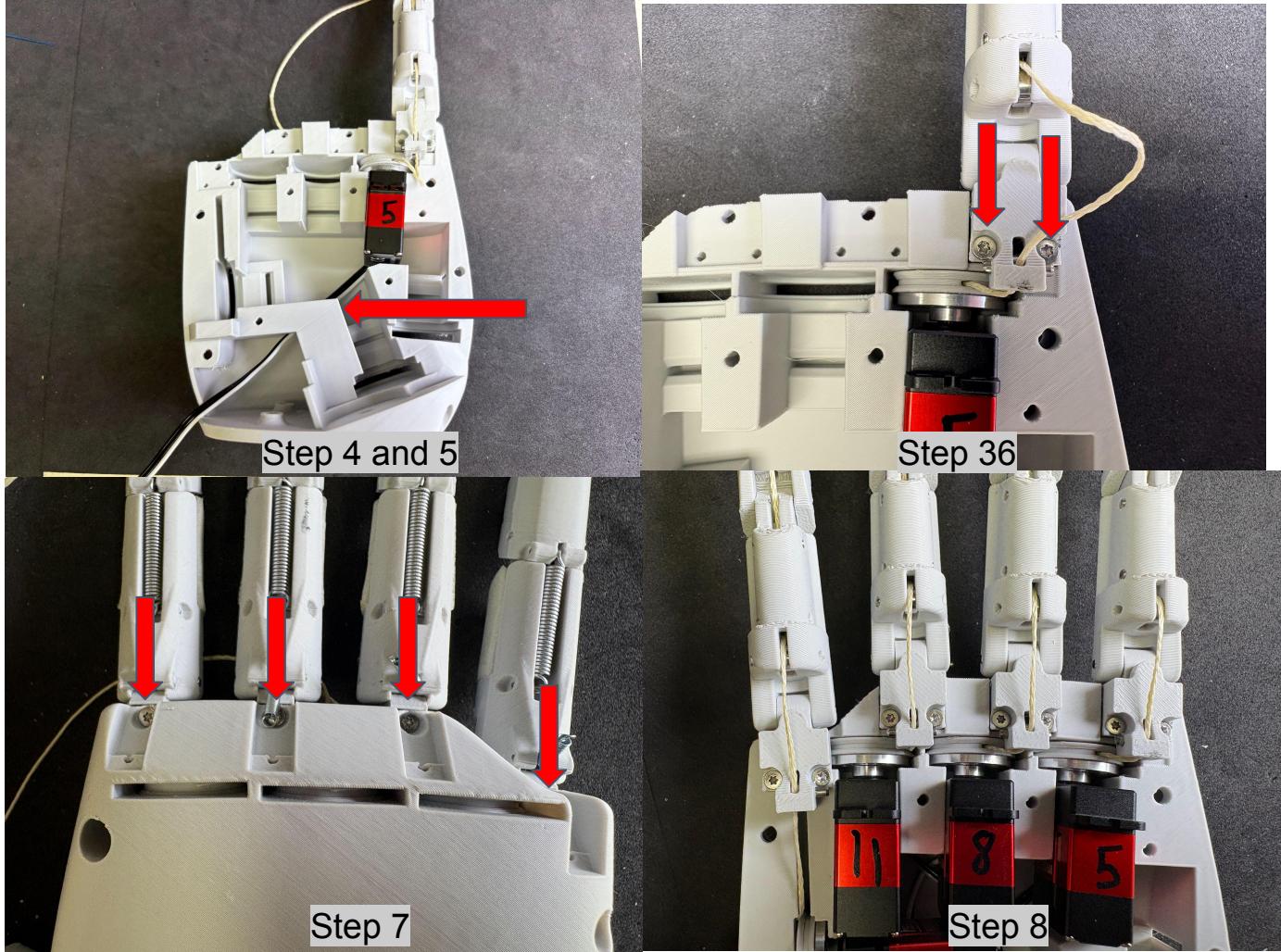
# Threaded Heat Inserts

1. Warm up a soldering iron with a heated insert tip
2. Gentle apply force on the heat insert using the iron
3. Make insert flush with surface of print



# Install Finger Servos

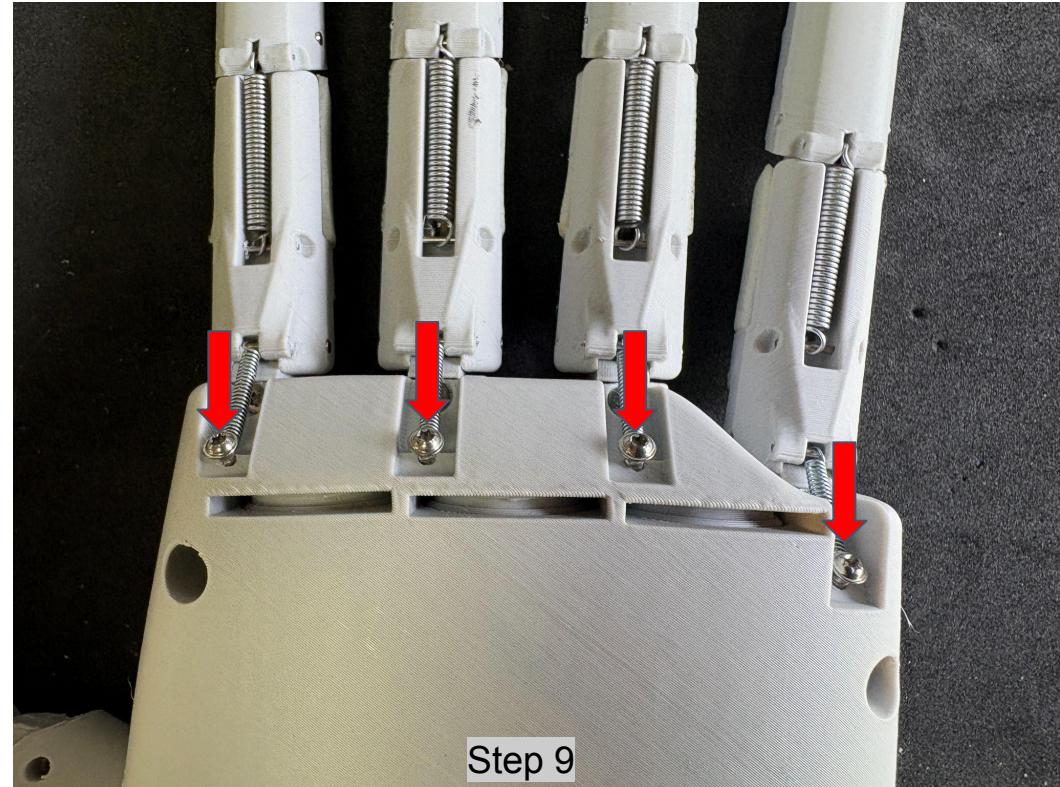
4. Place servo 5 into pointer finger position with number side visible
5. Feed wire under bar in palm hand (16)
6. Secure using M2x10 (39) countersunk screws
7. Flip hand over and secure finger with M2x10 countersunk screw
8. Repeat for servos 8, 11, and 14



# Distal Springs

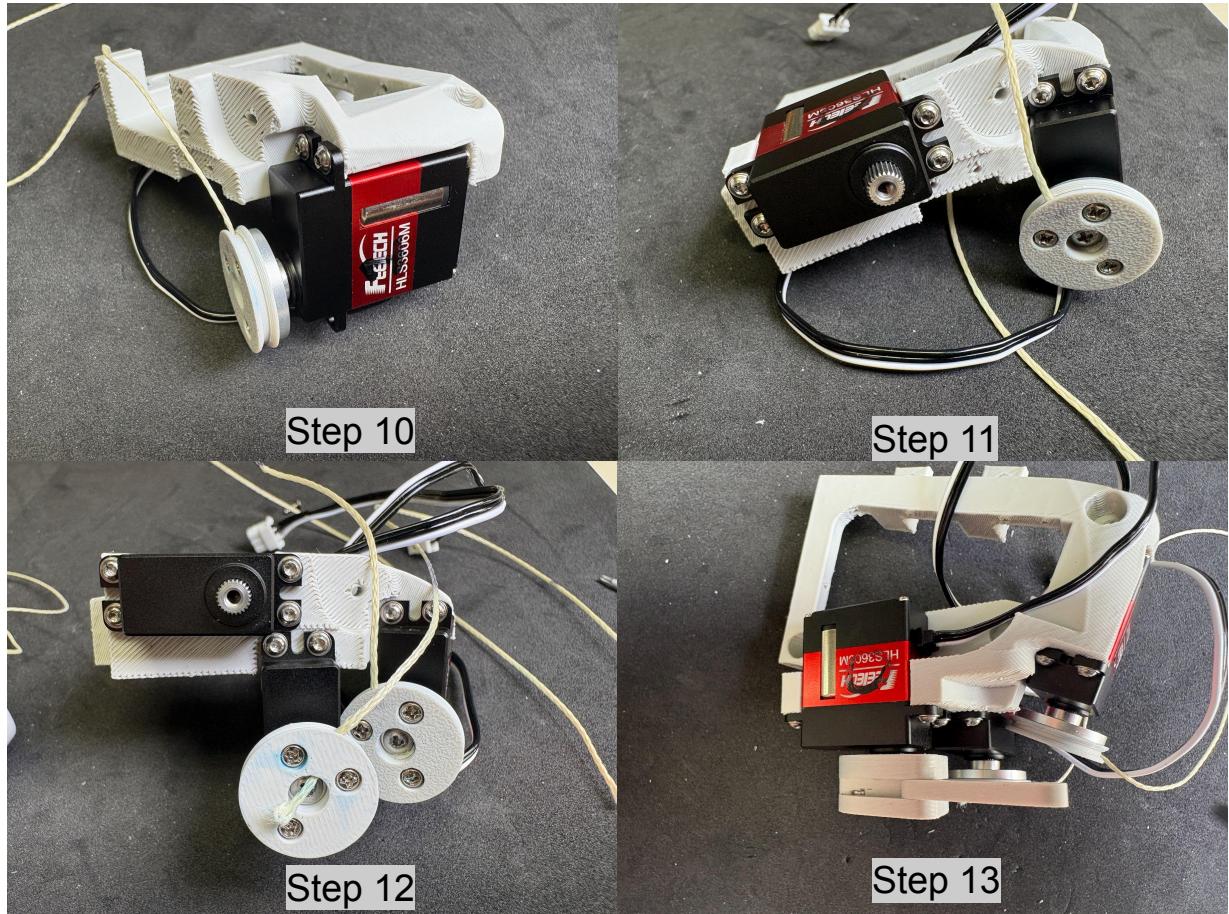
9. Secure springs (22) to rear palm using 2x6 self tapping torx (38)

Note: Do not over extend springs to avoid permanent deformation



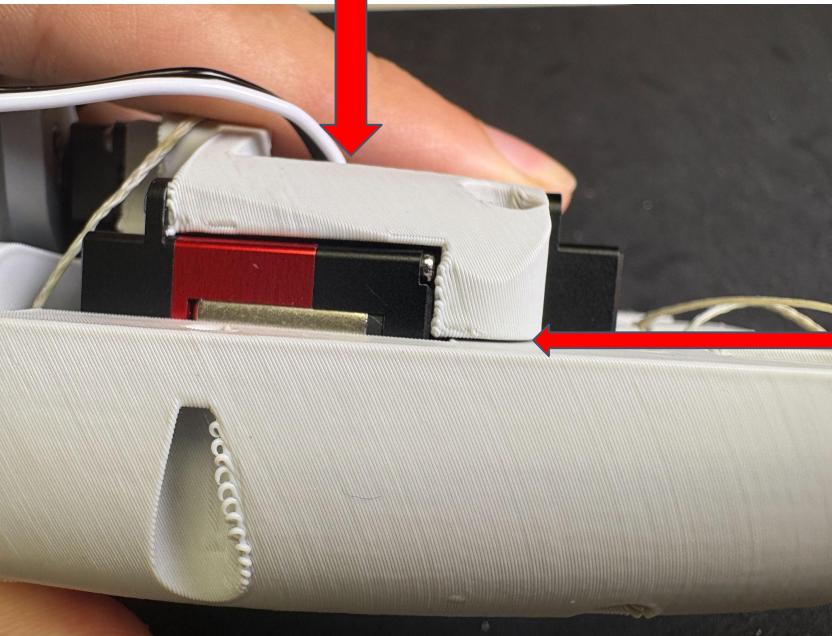
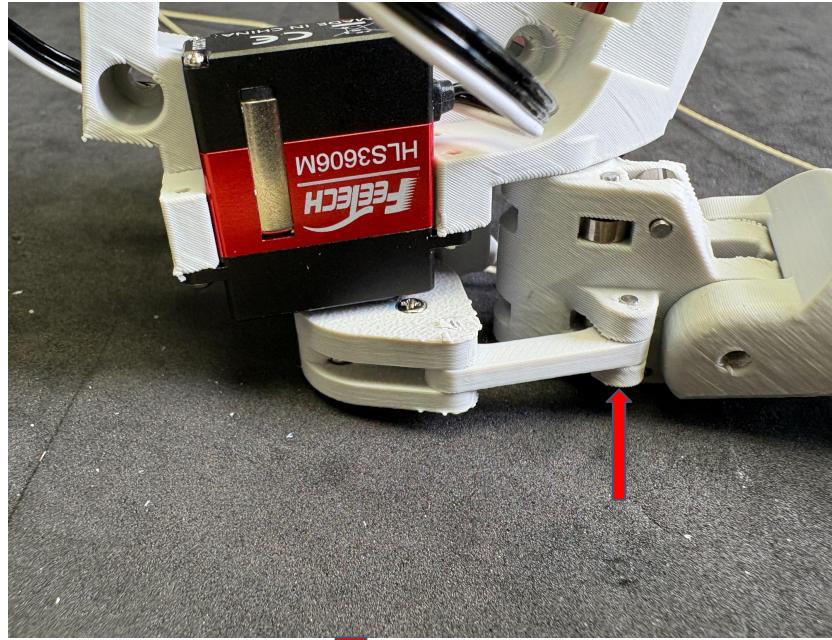
# Servo Frame

10. Place servo 1 onto servo frame (14) and secure with two M2x6 self tapping screws (38)
11. Place servo 0 onto frame and secure with four M2x6 self tapping screws
12. Place servo 2 onto frame and secure with two M2x6 self tapping screws
13. Add linkage to servo 0 using screw (provided with servo) with loctite



# Servo Frame Install

14. Insert 2x10 pin (34) between servo linkage and thumb CMC base (10)
15. Slide frame into hand
16. Ensure components are flush



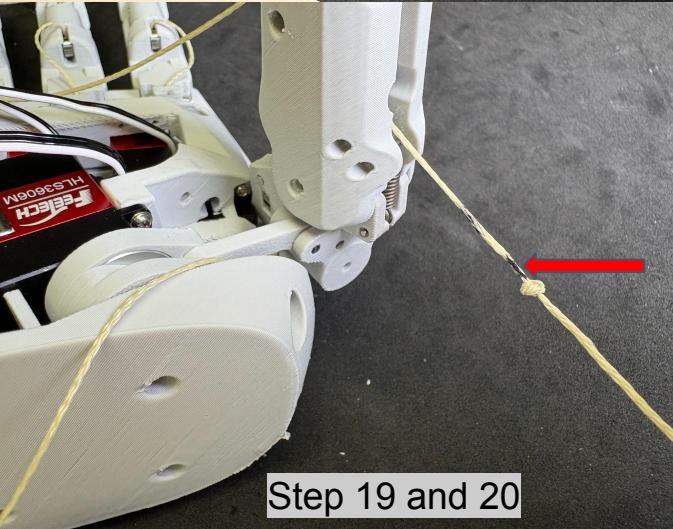
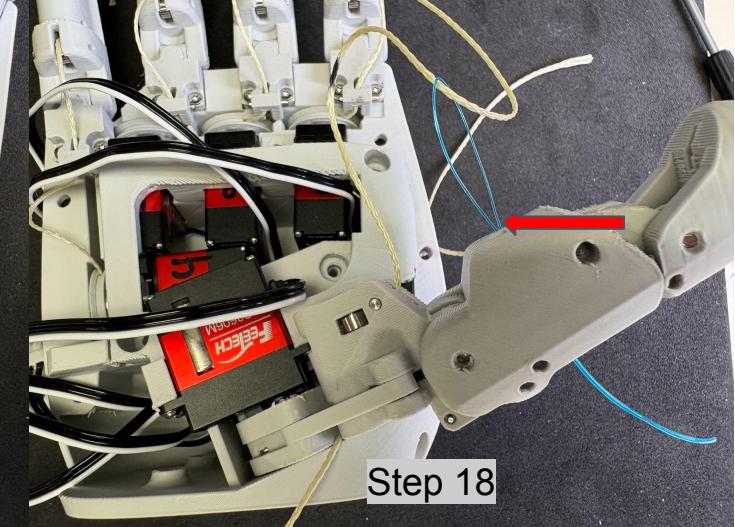
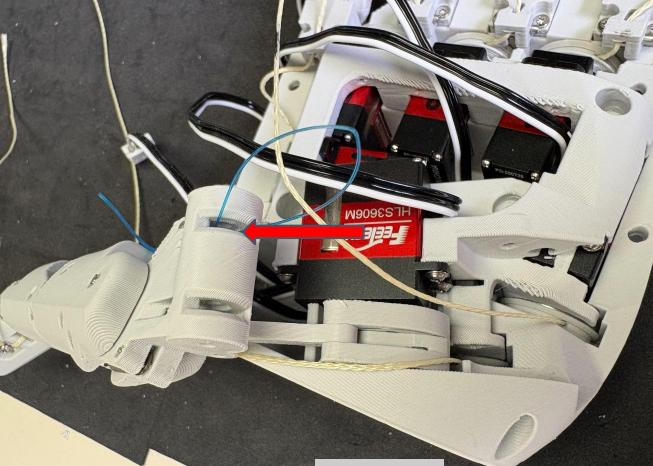
# Thumb CMC Flex Cable

17. Thread cable from servo 1 as seen in image

18. Thread through hole closer to back of palm on thumb MCP (11)

19. Tie ashley stopper knot at mark

20. Pull string tight



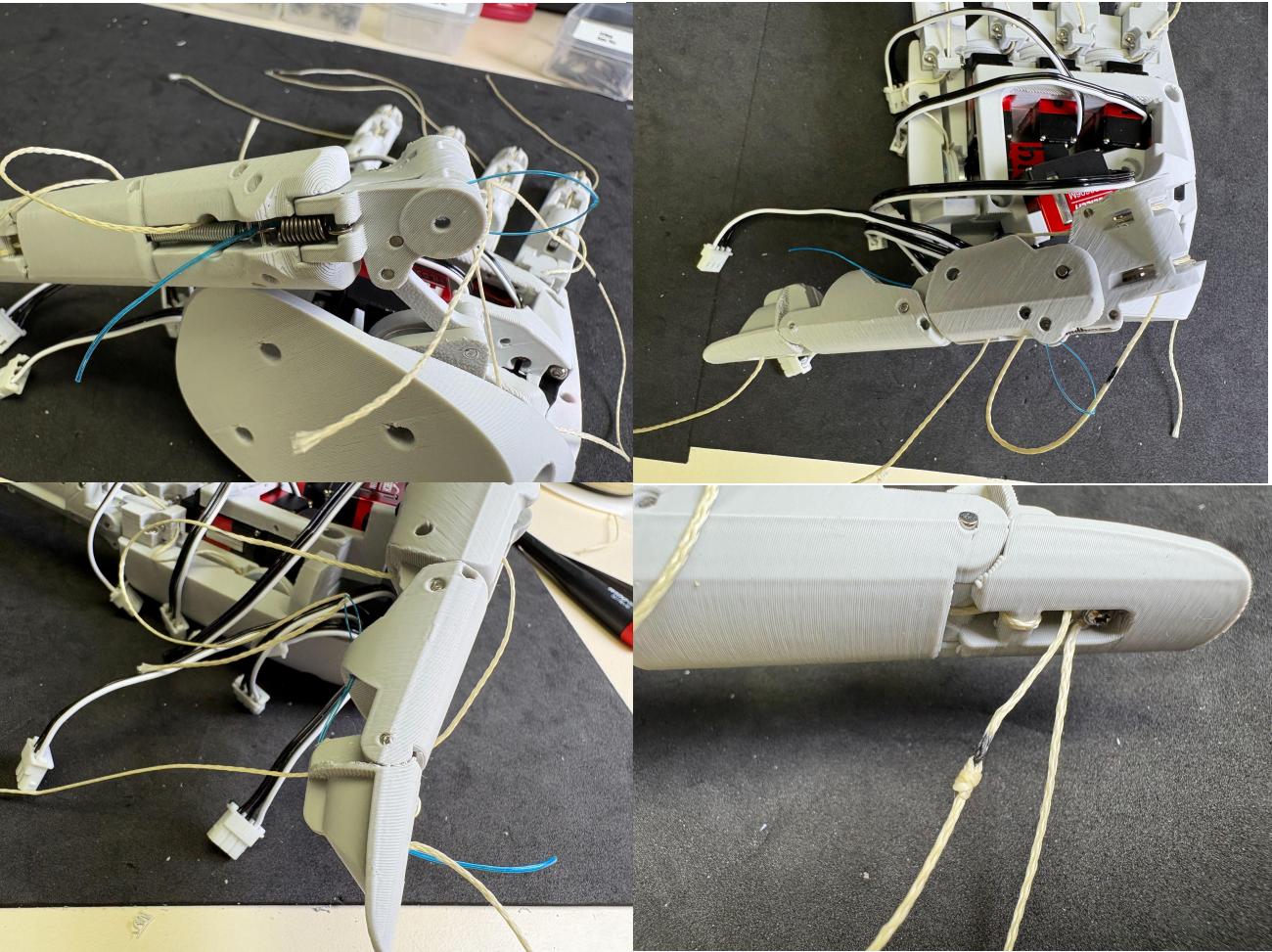
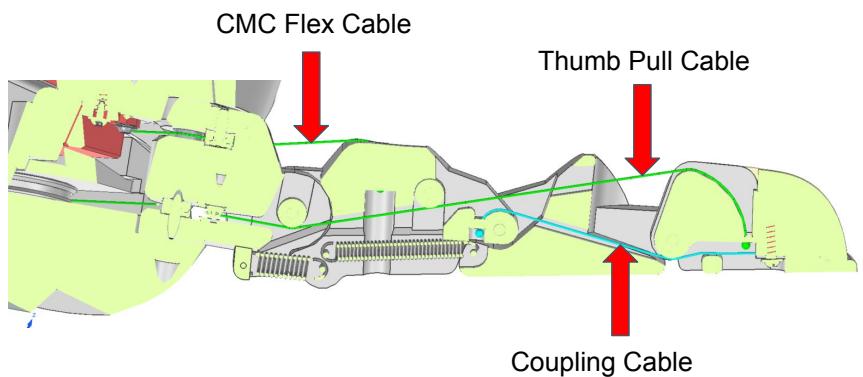
# Thumb Pull Cable

21. Thread cable from servo 2 as seen in image

22. Thread through MCP (10) around bearing

23. Thread through top hole in thumb proximal (12)

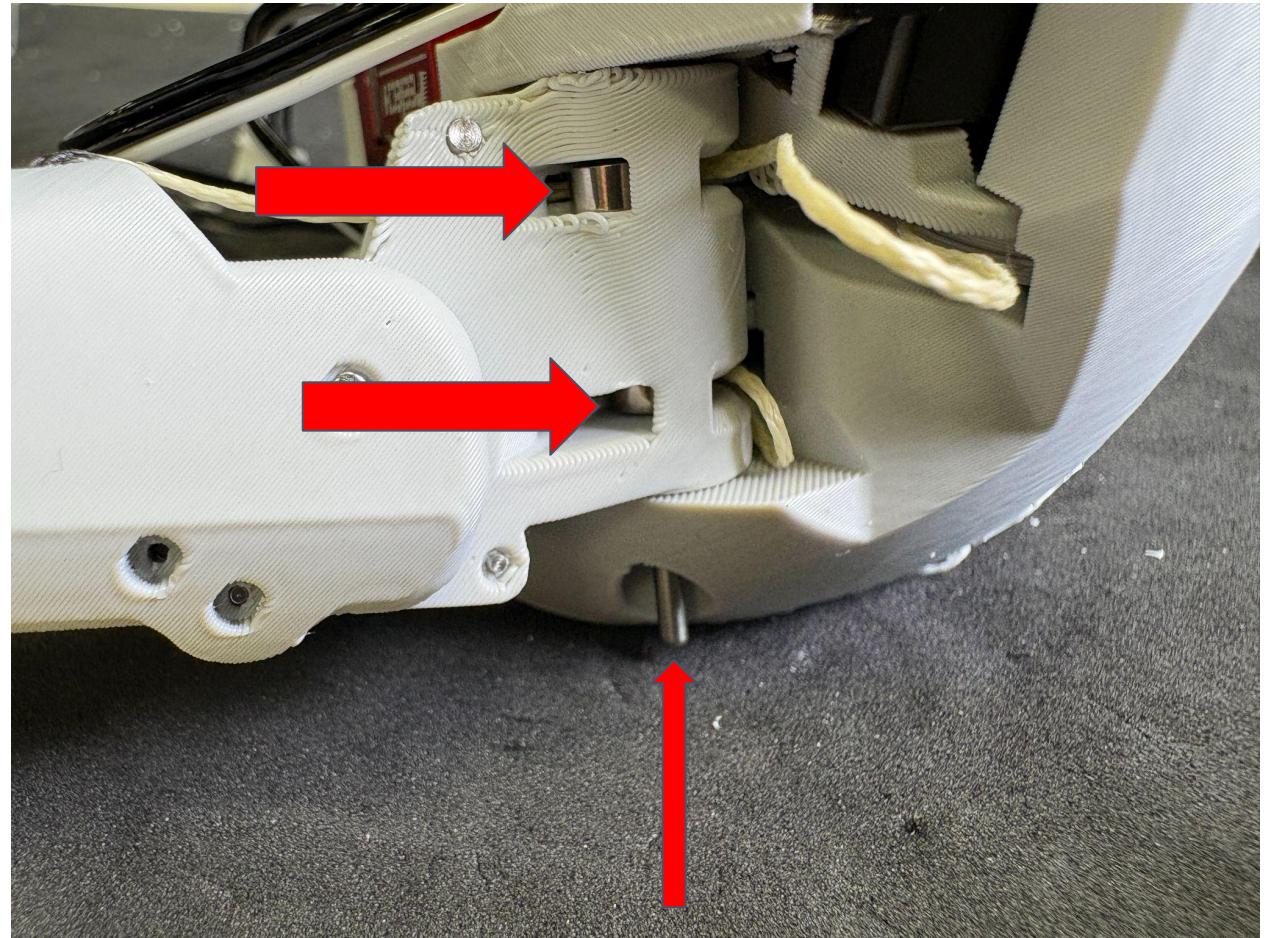
24. Tie ashley stopper knot at mark and pull tight



# Thumb Bearings

25. Insert bearings (30) into CMC base and push in as far in as possible
26. Insert 2x30mm pin (37) from bottom until it is flush with the top surface

Note: applying pressure on bearings while installing pin will ensure they don't fall out



# Final Touches

**Tools:**

Hot Glue  
Super Glue

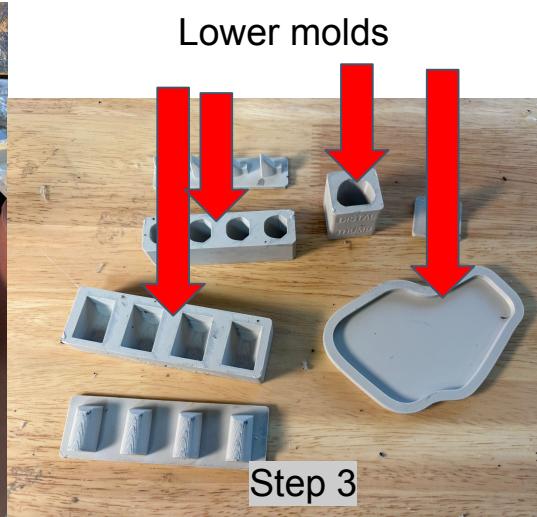
Name	Part Number	QTY
Palm Foam	20	1
3x10 self tapping	40	9
2x6 self tapping	36	8
M2x10 Countersunk Torx Self Tapping Screw	39	12
M2x6 Flanged Torx Self Tapping Screw	38	14
UNDERSIZED 2x30 Pin	37	1
Connection Cable	47	1
TTLinker	48	1

# Silicone Inserts Molds (optional)

1. Place 3D printed molds on a flat/hard surface. Placing on a baking tray will make cleanup easier.
2. Mix a batch of silicone using instructions on bottles. 40grams total is enough to make one set of parts for a hand.
3. Fill lower molds ~80%. Let sit for 5minutes to allow bubbles to escape.
4. Add top half of mold to bottom half for distal and proximal molds. Push until flush. Silicone should leak out if filled correctly.
5. Let sit upright for 3h until fully cured. Then remove from molds.
6. Remove flash from edges of components



Step 2



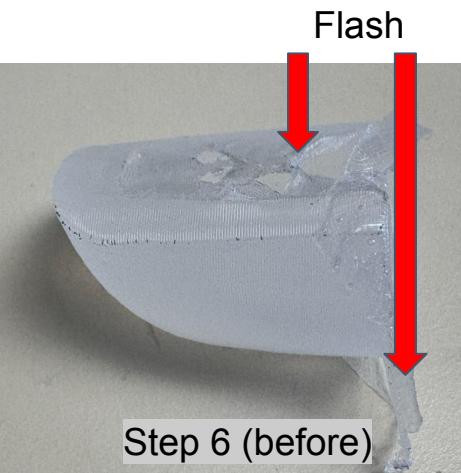
Step 3



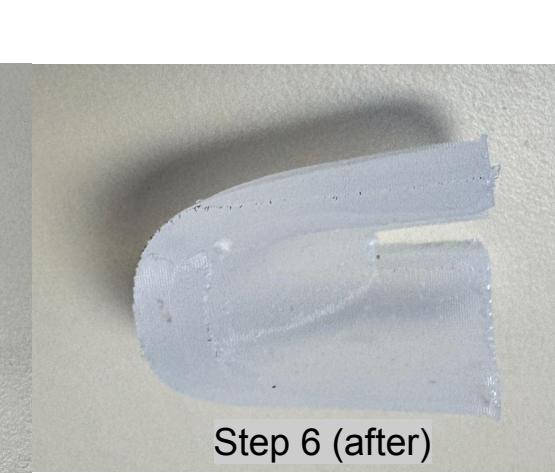
Step 4



Step 5



Step 6 (before)



Step 6 (after)

# Silicone Inserts (optional)

7. Apply super glue to internal side of distal and proximal components

8. Spread around to create a uniform layer on the plastic

9. Gently press on foam and hold for 30seconds, until glue solidifies

10. Repeat for all fingers and thumb



# Silicone Inserts (optional)

11. Apply even/thin layer of silicone adhesive to plastic. Spread to edges of offset surface.

12. Put on silicone pad to palm and gently apply force for 30seconds to allow to glue to cure



Step 11



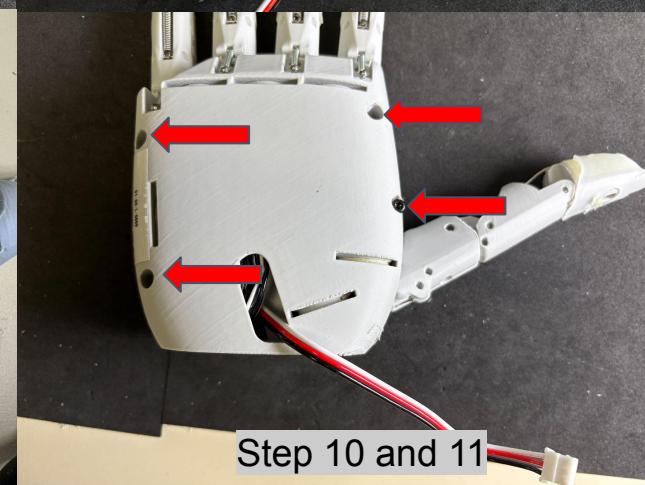
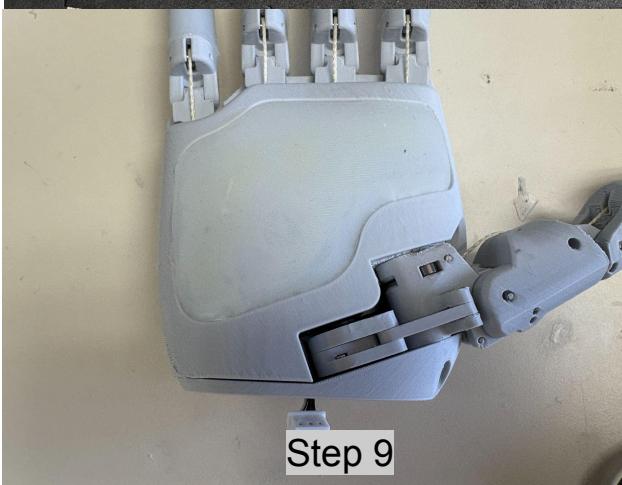
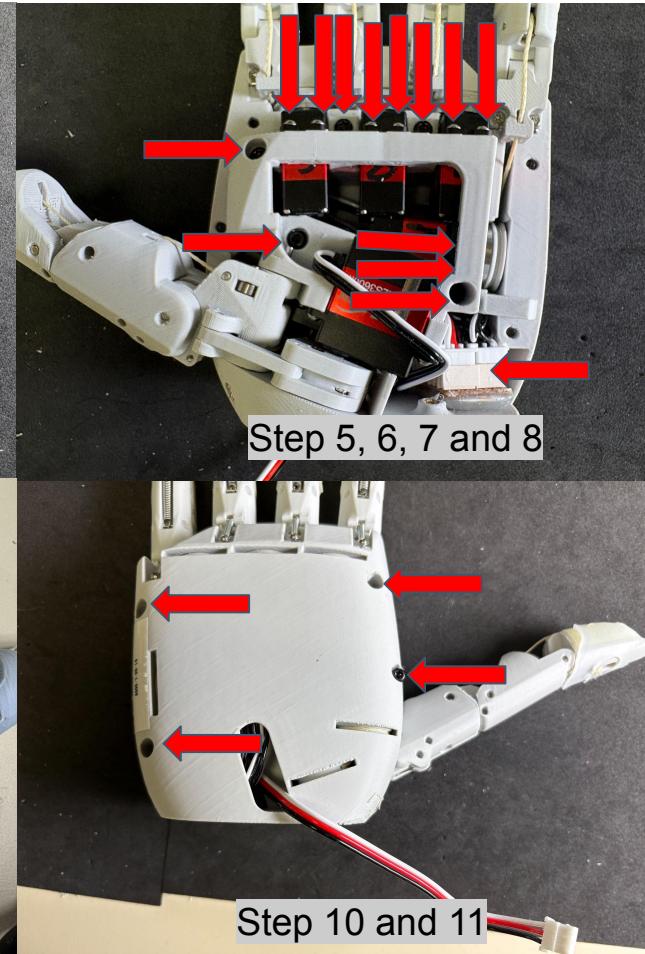
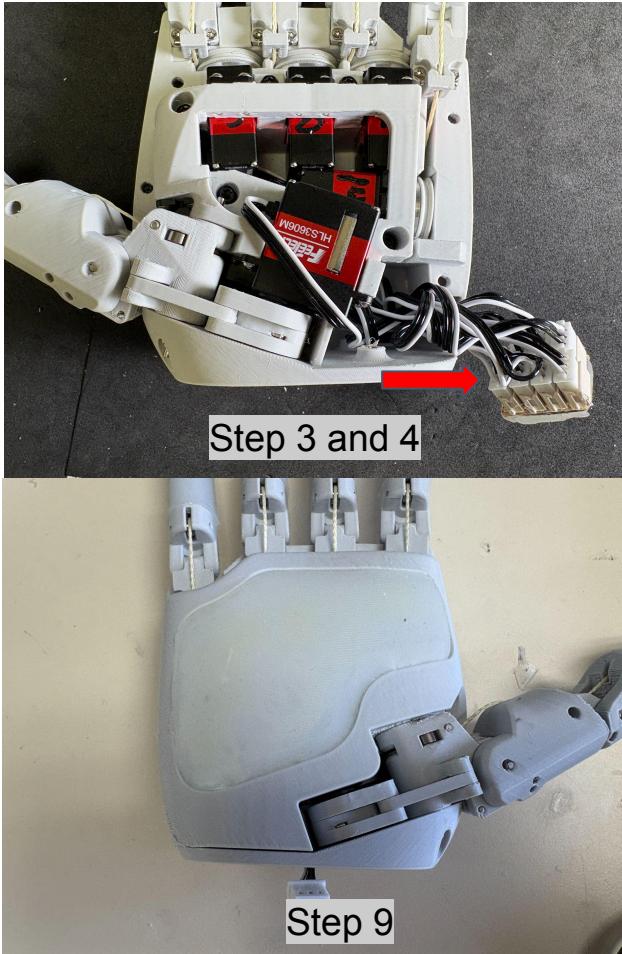
Step 11



Step 12

# Servo Connection

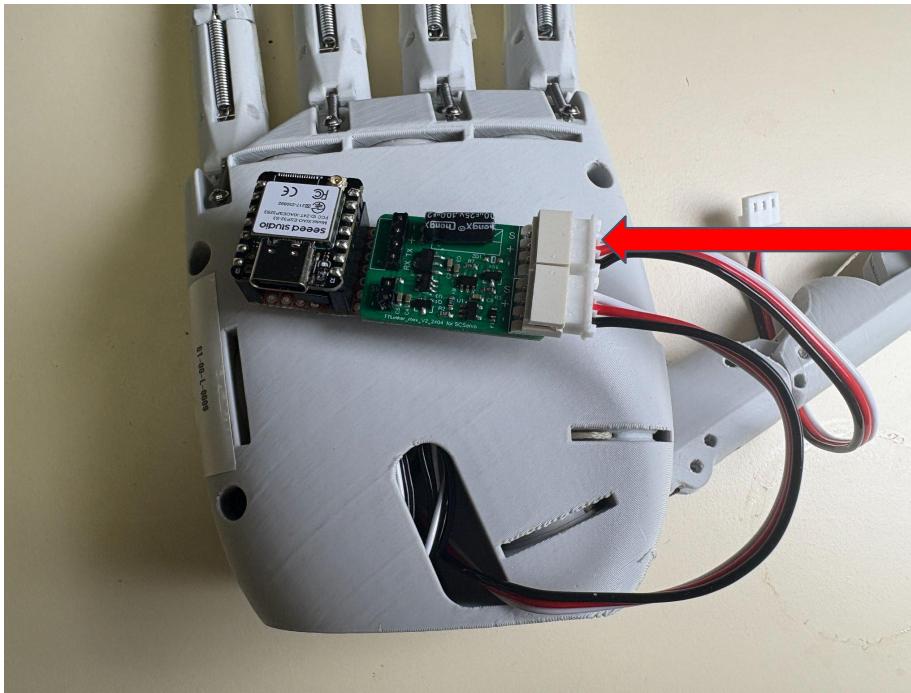
13. Route wires from servos 1, 2, 5, 8, 11, and 14 together through the hand and into the open area. This may require some rearranging
14. Connect all servos and one extension cable to the servo busbar
15. Push cables and busbar into space in the corner
16. Feed extension cable out of the back of the hand
17. Secure the frame using five 3x10 self tapping screws (40)
18. Secure servos 5, 8, 11, and 14 to servo frame using eight 2x6 self tapping torx screws (38)
19. Add front palm
20. Secure with four 3x10 self tapping screw on back of hand
21. Trim all cables 5mm from knot



# Control Board

22. Installation location of TTlinker (48)  
does not matter

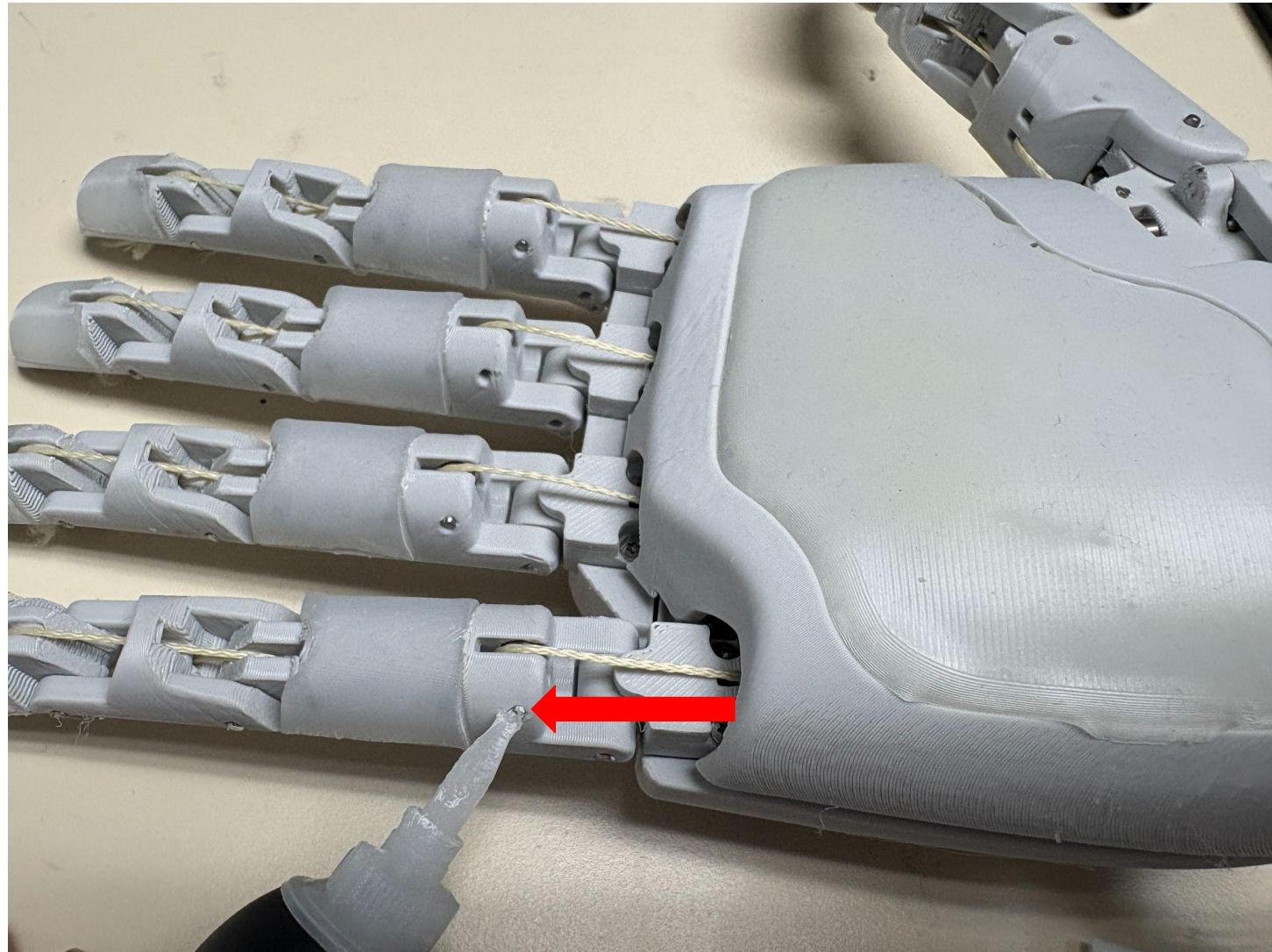
23. Connect a power cable (47) to the  
second female connector on the driver to  
power the servos



Power/Ground  
Connection

# High Cycling Protection (optional)

24. If using for high cycling >10,000 cycles per joint, apply superglue to every pin on both sides. This will secure them from sliding out.



Congratulations, you made it!

Your Aero hand is ready to meet the world. Let us know what you think of the hand.

<https://tetheria.ai>

