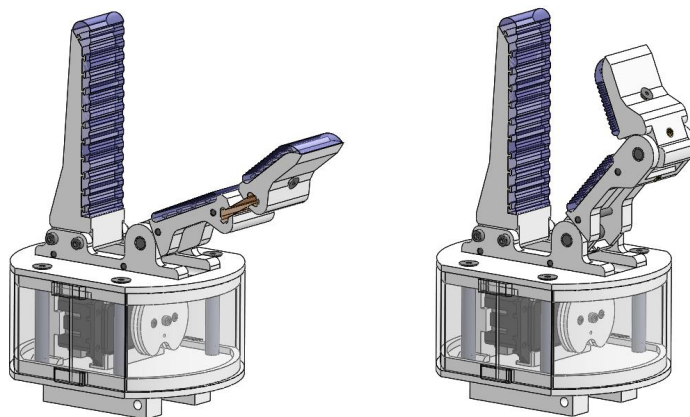
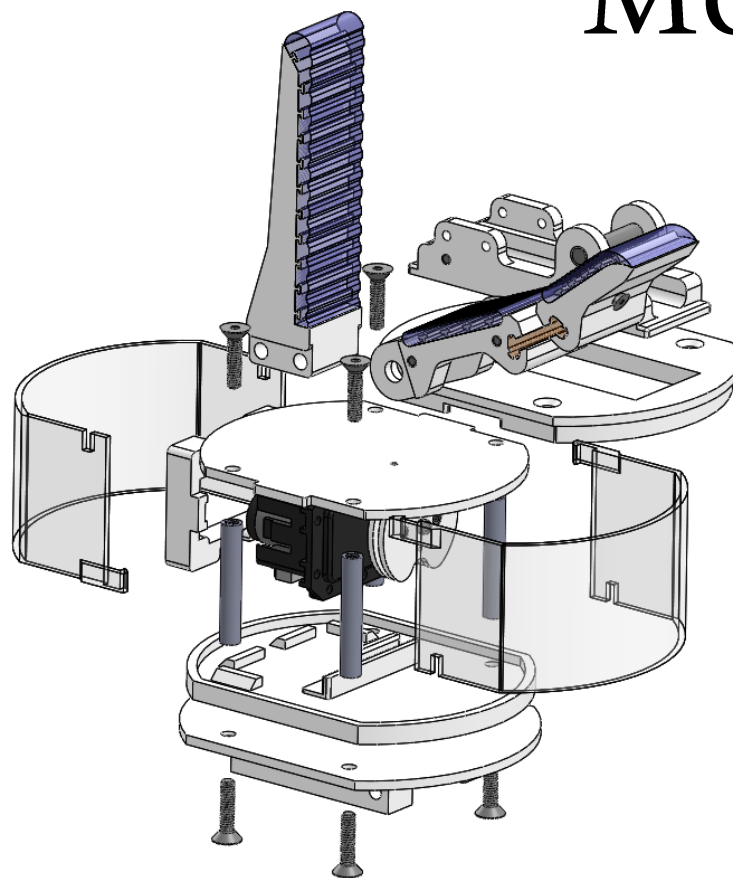




OPENHAND  
**MODEL M**

VERSION 1.0



# ASSEMBLY INSTRUCTIONS

LAST UPDATED: FEBRUARY 19, 2015



# OTS PARTS LIST

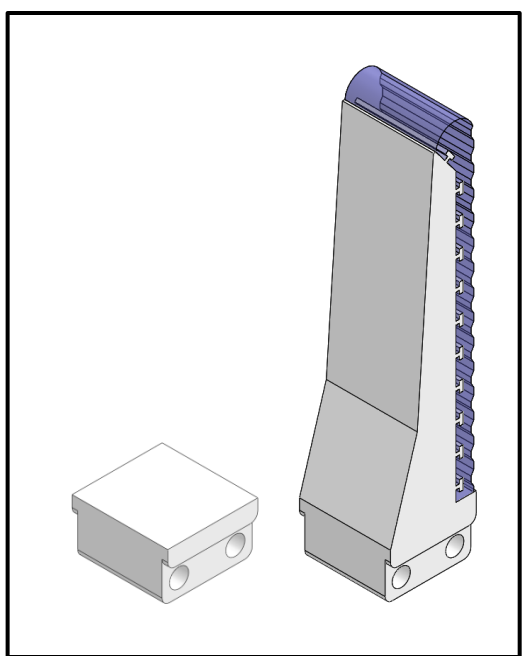
Part Name	Quantity	Description	Vendor
Power Pro Spectra	1	Tendon	Amazon <a href="#">[link]</a>
PMC-780 Urethane	1	Finger Joint Urethane	Smooth-On <a href="#">[link]</a>
Vytaflex 30 Urethane	1	Finger Pad Urethane	Smooth-On <a href="#">[link]</a>
Ø1/4", L1-1/2", 8-32 zinc-plated female standoff	4	Support	McMaster <a href="#">[93330A482]</a>
Ø1/4", L1-1/4" steel dowel pin	2	Joint pin	McMaster <a href="#">[98381a544]</a>
Ø1/8", L1-1/4" steel dowel pin	4	Routing pin	McMaster <a href="#">[98381A477]</a>
M3, L8mm bolt	4	Thumb mounting bolt	McMaster <a href="#">[91292A112]</a>
M3, L6.4mm heat-set insert	4	Insert for mounting bolt	McMaster <a href="#">[94180A333]</a>
8-32, L3/4" countersunk bolt	8	Support bolt	McMaster <a href="#">[92210A197]</a>
M2.5, L8mm bolt	1	Center bolt for Dynamixel (included w/ Dynamixel)	McMaster <a href="#">[91292A012]</a>
M2, L5mm bolt	2	Mounting bolts for Dynamixel	McMaster <a href="#">[91290A012]</a>
4-40, L0.135" heat-set insert	3	Insert for fingers	McMaster <a href="#">[93365A120]</a>
4-40, L1/4" countersunk screw	3	Tendon/spring anchors	McMaster <a href="#">[91253A106]</a>
Torsion spring, 0.340" OD, 0.028" wire diameter	1	Return spring, alternative to extension springs	McMaster <a href="#">[9271k605]</a>
Extension spring, 0.188" OD, L3/4", 0.016" wire diameter	3	Return spring, alternative to torsion spring at proximal	McMaster <a href="#">[9654k955]</a>
Dynamixel RX/MX-28, or RX24-F	1	Actuator, alternative to Power HD servo	Various <a href="#">[Link]</a>
Power HD 1501 MG Servo	1	Actuator, alternative to Dynamixel	Various <a href="#">[Link]</a>

\* **Note** \* There are certainly other combinations of fasteners that may work with these designs. We do not even claim that the parts list provided here is optimal for these designs. They are merely the components that we have used in past builds.

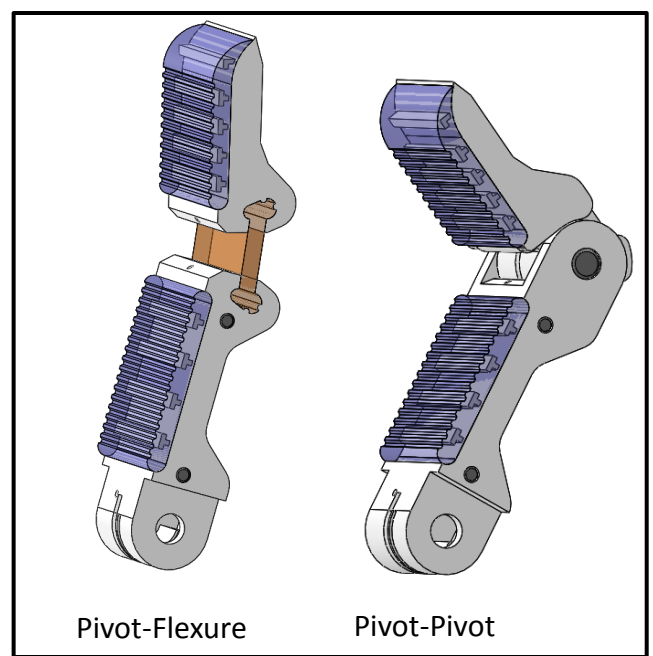


# OVERVIEW

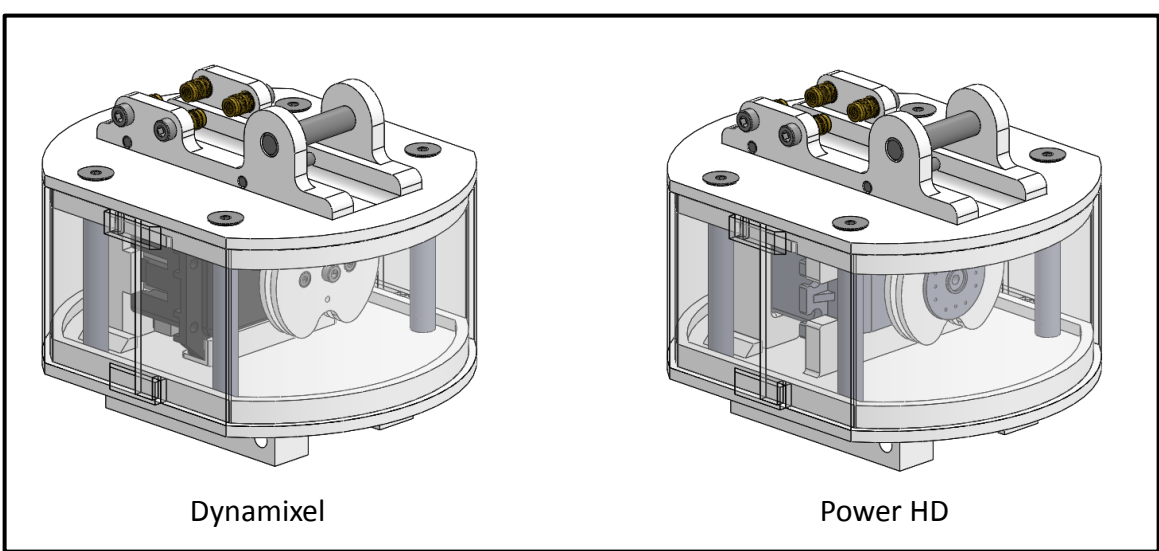
### Thumb



### Forefinger



### Actuator Base





# THUMB SUB-ASSEMBLY

## THUMB FABRICATION

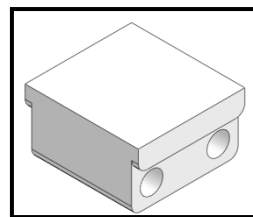
### Parts

thumb1.stl

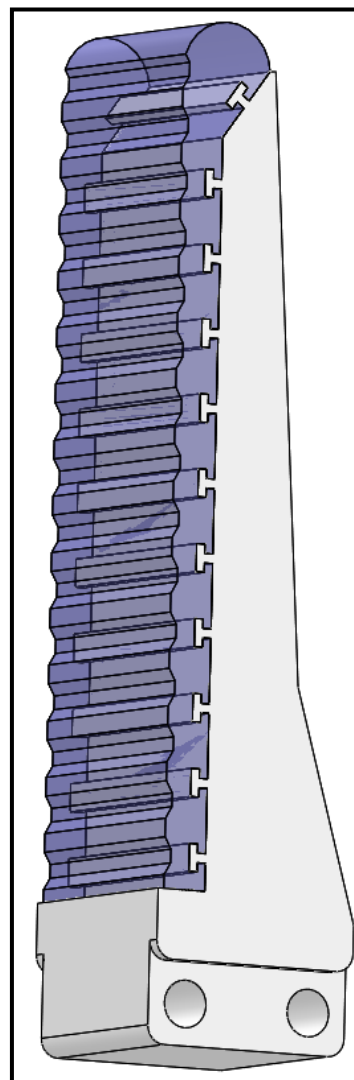
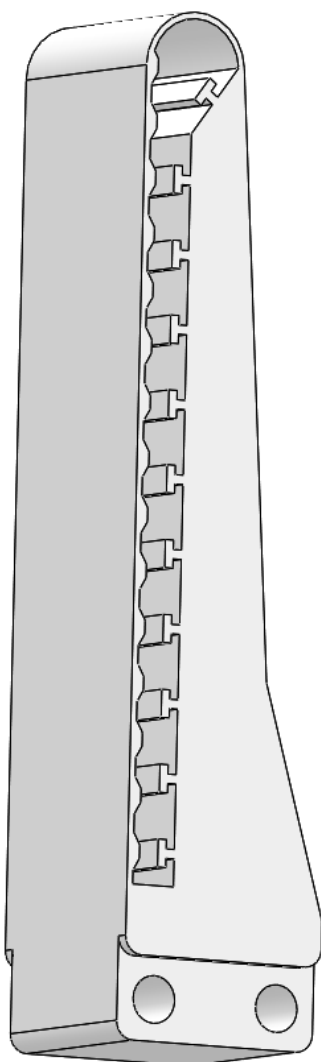


Vytaflex 30 urethane (1:1)

The thumb design can easily be swapped with alternative designs. Each alternative thumb only needs to implement the interface found in *thumb\_base.sldprt*. Refer to the *OpenHand Finger Guide* for more detail on casting these pads.



*thumb\_base.sldprt*





# THUMB SUB-ASSEMBLY

## THUMB FABRICATION

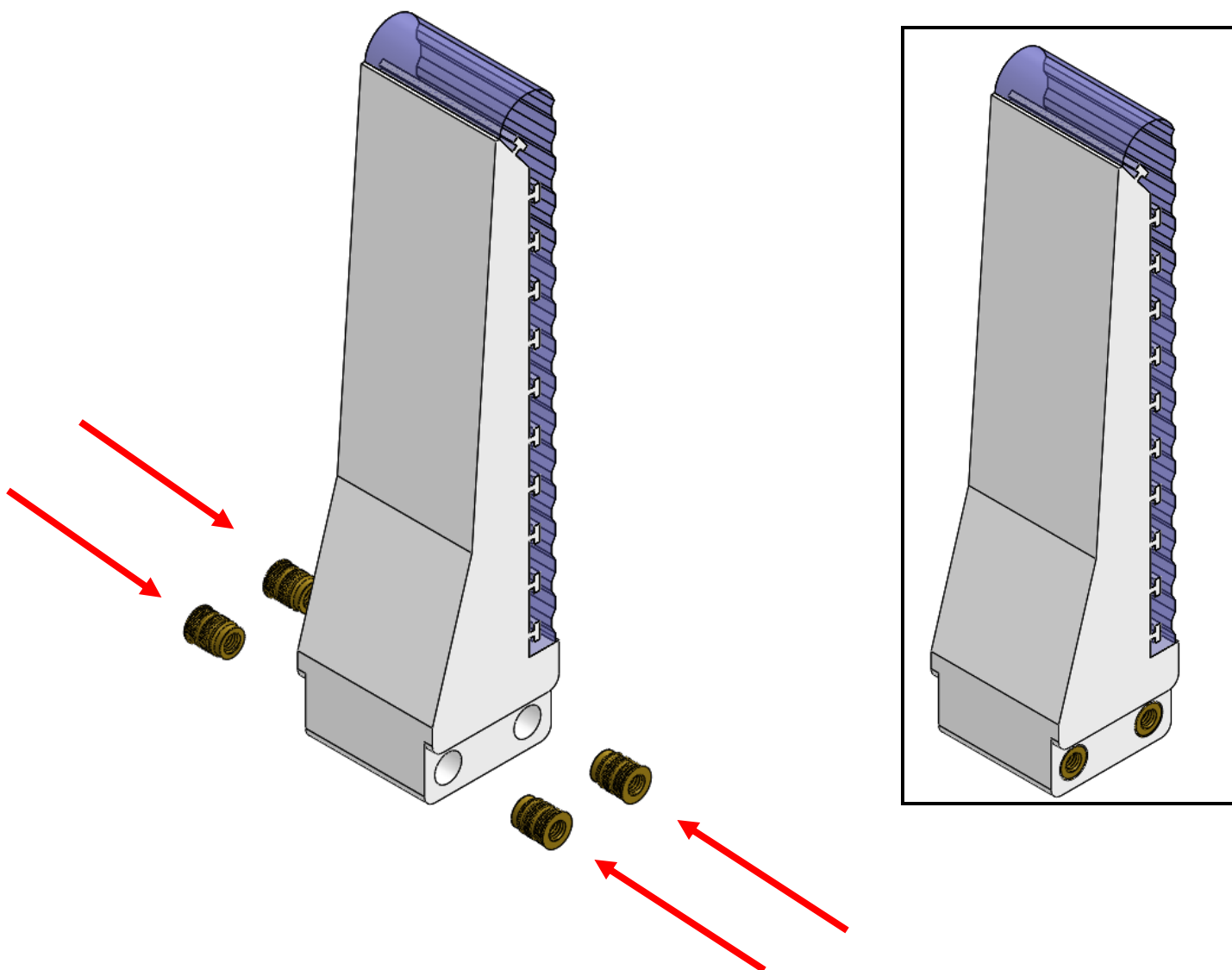
### Parts

Thumb from page 3

M3, L6.4 heat-set insert (x4)



Use a soldering iron to install heat-set inserts in the plastic body of the thumb





# FOREFINGER SUB-ASSEMBLY

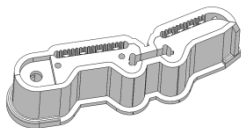
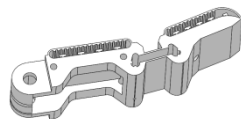
## PIVOT-FLEXURE

### Parts

finger\_pf\_torsion\_m.stl  
 - or -  
 finger\_pf\_ext\_m.stl  
 - or -  
 finger\_pf\_torsion\_mold1\_A\_m.stl  
 finger\_pf\_mold1\_B\_m.stl  
 finger\_pf\_mold[2-4]\_m.stl  
 - or -  
 finger\_pf\_ext\_mold1\_A\_m.stl  
 finger\_pf\_mold1\_B\_m.stl  
 finger\_pf\_mold[2-4]\_m.stl

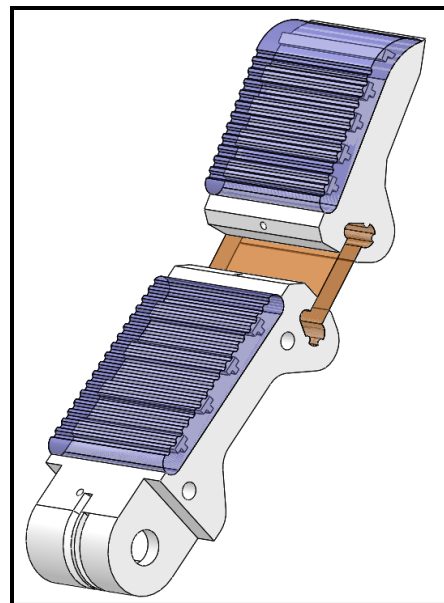
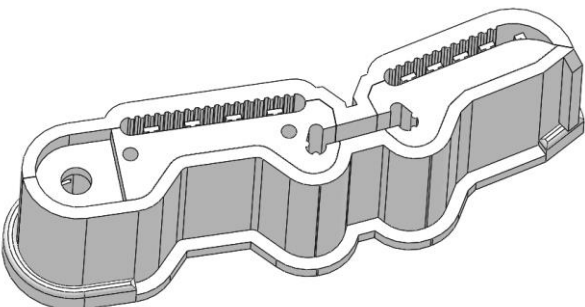
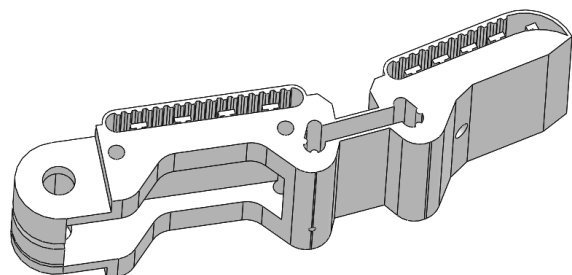
PMC-780 (2:1)

Vytaflex 30 (1:1)



Go to page 7 for Pivot-Pivot Forefinger sub-assembly

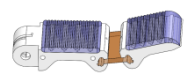


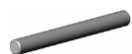
You have a choice of pivot or torsion spring base, and the option of using whether a thin-wall mold or multi-part mold. Refer to the *OpenHand Finger Guide* for more detail on casting these pads and flexures



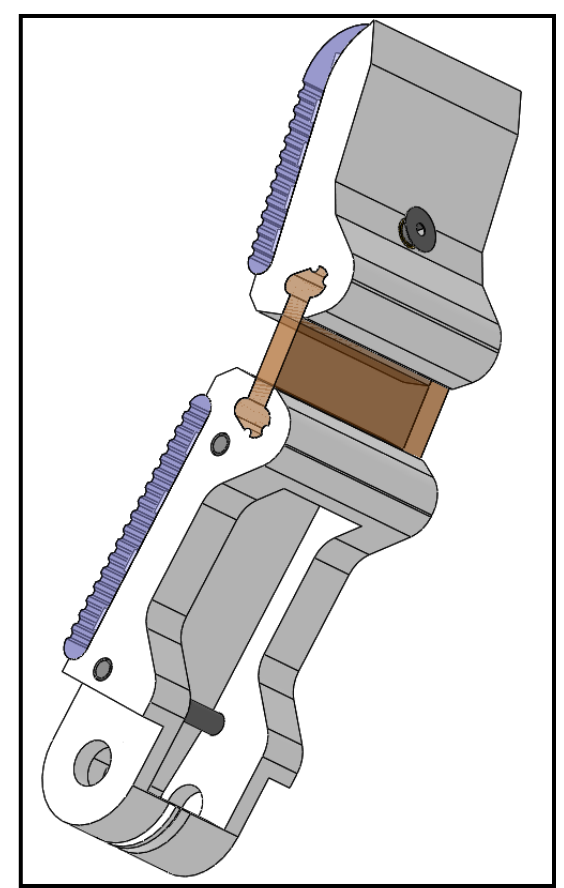
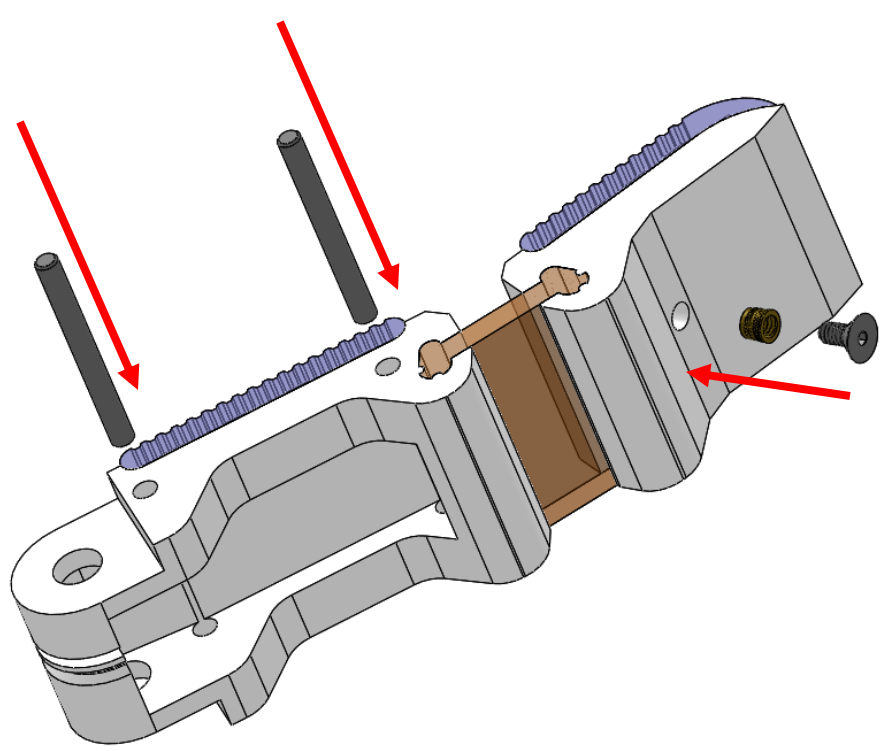


# FOREFINGER SUB-ASSEMBLY

## PIVOT-FLEXURE

Parts	
Pivot-Flexure Forefinger	
4-40, L0.135" heat-set insert	
4-40, L1/4" countersunk screw	
Ø1/8", L1-1/4" steel dowel pin (x2)	

Press fit the 1/8" dowel pins for tendon-rerouting into the proximal link. Use a soldering iron to install the heat-set insert into the distal link. The heat-set insert can be skipped in favor of using a nut for tendon termination.



Skip to page 9



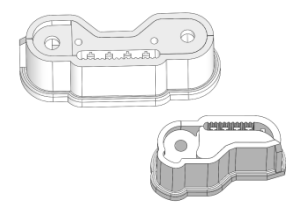
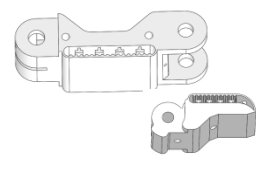
# FOREFINGER SUB-ASSEMBLY

## PIVOT-PIVOT

### Parts

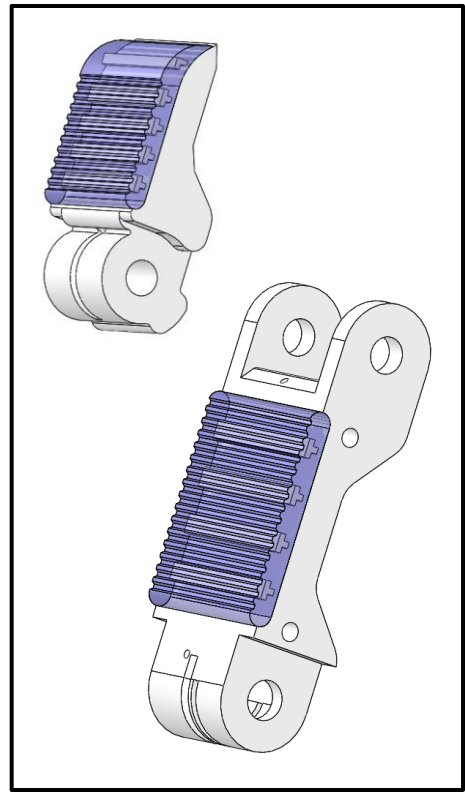
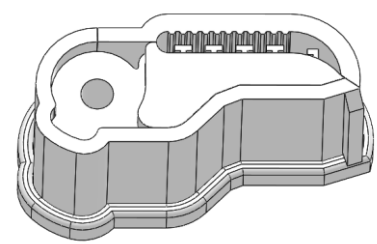
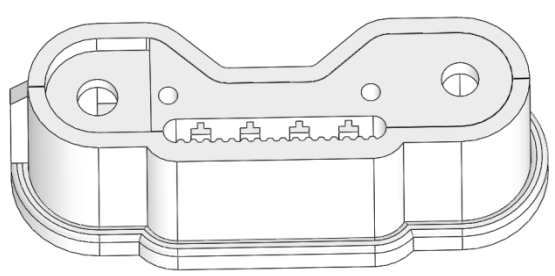
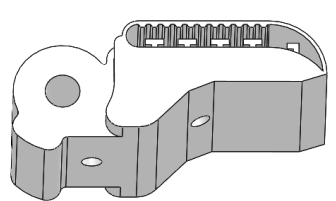
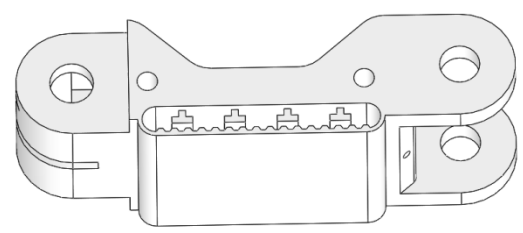
- finger\_pp\_torsion\_A\_m.stl
- finger\_pp\_B\_m.stl
- or -
- finger\_pp\_ext\_A\_m.stl
- finger\_pp\_B\_m.stl
- or -
- finger\_pp\_torsion\_mold1\_A\_m.stl
- finger\_pp\_mold[2-4]\_A\_m.stl
- finger\_pp\_mold1\_B\_m.stl
- finger\_pp\_mold[2-4]\_B\_m.stl
- or -
- finger\_pp\_ext\_mold1\_A\_m.stl
- finger\_pp\_mold[2-4]\_A\_m.stl
- finger\_pp\_mold1\_B\_m.stl
- finger\_pp\_mold[2-4]\_B\_m.stl

Vytaflex 30 (1:1)



Go back to page 5 for Pivot-Flexure Forefinger sub-assembly

You have a choice of pivot or torsion spring base, and the option of using whether a thin-wall mold or multi-part mold. Refer to the *OpenHand Finger Guide* for more detail on casting these pads. There are no flexures needed for Pivot-Pivot finger design

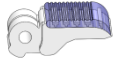
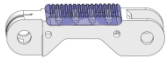











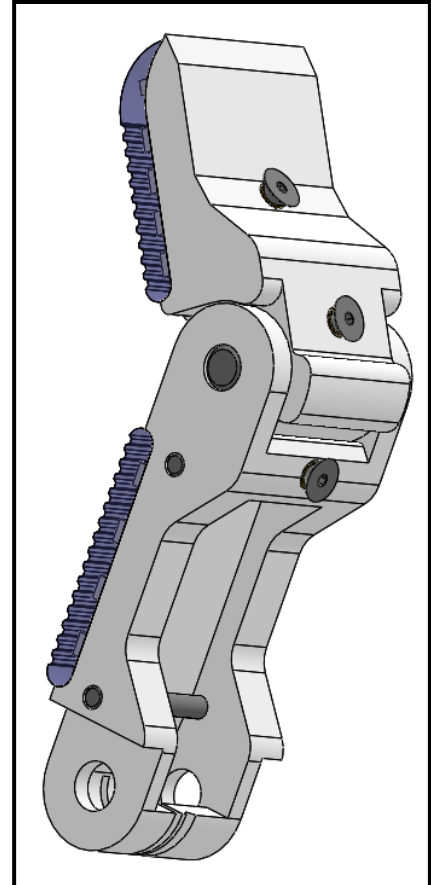
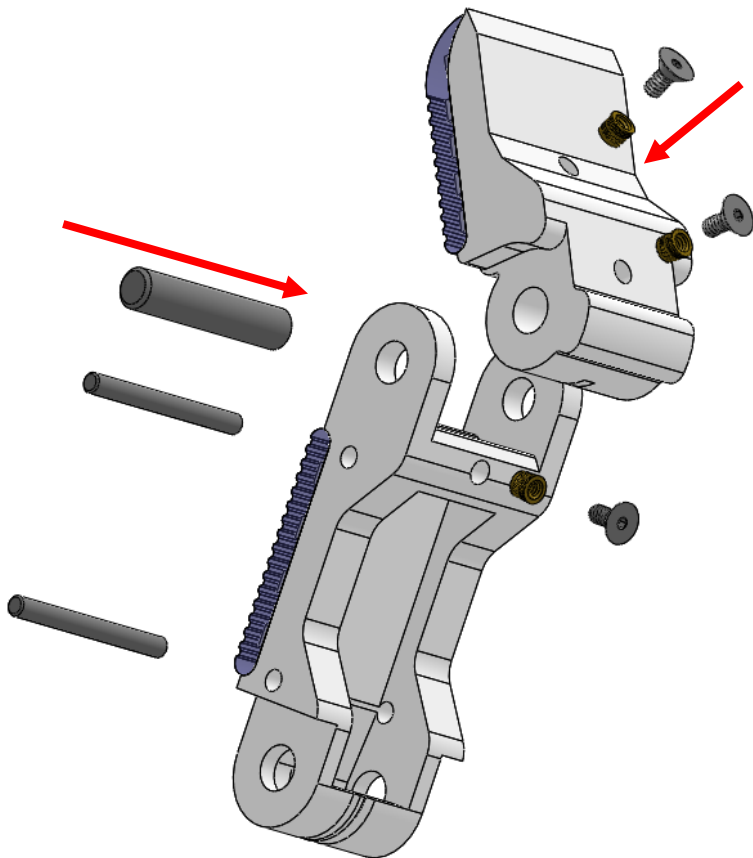
# FOREFINGER SUB-ASSEMBLY

## PIVOT-PIVOT

Parts	
Pivot-Pivot finger distal link	
Pivot-Pivot finger proximal link	
4-40, L0.135" heat-set insert (x3)	
4-40, L1/4" countersunk screw (x3)	
Ø1/8", L1-1/4" steel dowel pin (x2)	
Ø1/4", L1-1/4" steel dowel pin	
Extension spring	

Install the 4-40 inserts for the distal joint spring and the distal tendon anchor. You can alternatively thread a bolt directly into the specified points. An extension spring or elastic band should be anchored on bolts threaded into the inserts closest to the distal joint.

Tendon routing pins (1/8") and joint pin (1/4") can be pressed in by hand, but a large pair of pliers or a vice may be helpful.



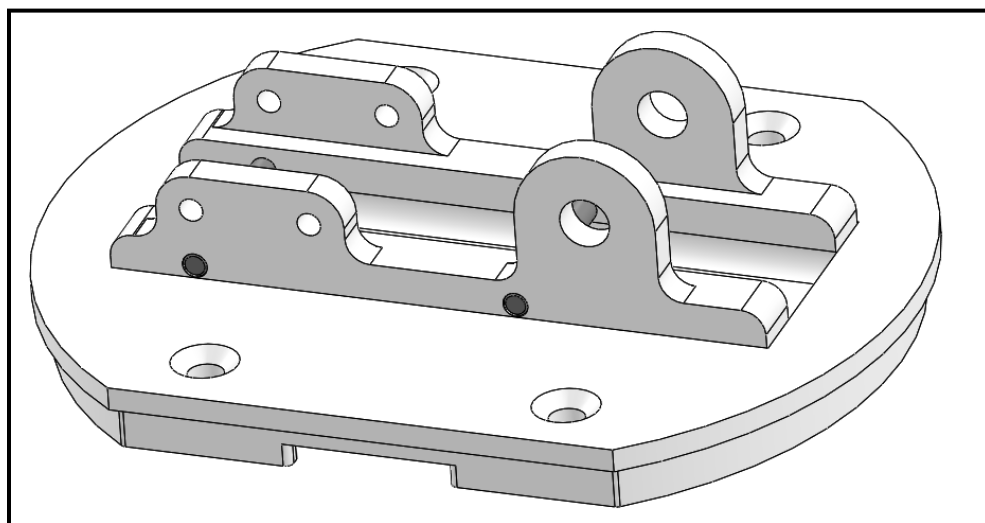
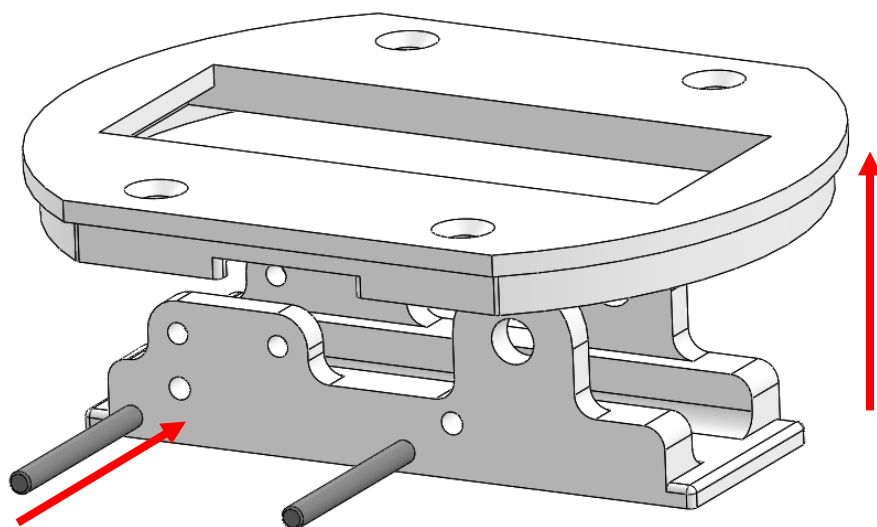


# ACTUATOR SUB-ASSEMBLY

## TOP BASE

Parts	
c1_m.stl	
a1_m.stl	
Ø1/8", L1-1/4" steel dowel pin (x2)	

Insert the 1/8" pins first into the finger base part *c1\_m.stl*. Then insert through the clearance of top piece *a1\_m.stl*.



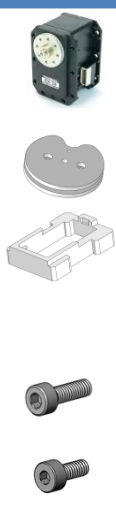


# ACTUATOR SUB-ASSEMBLY

## DYNAMIXEL

### Parts

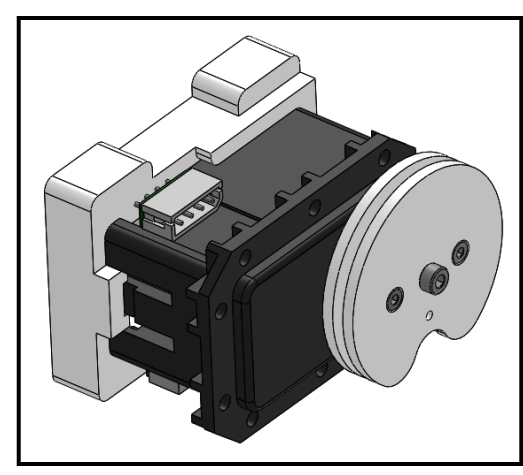
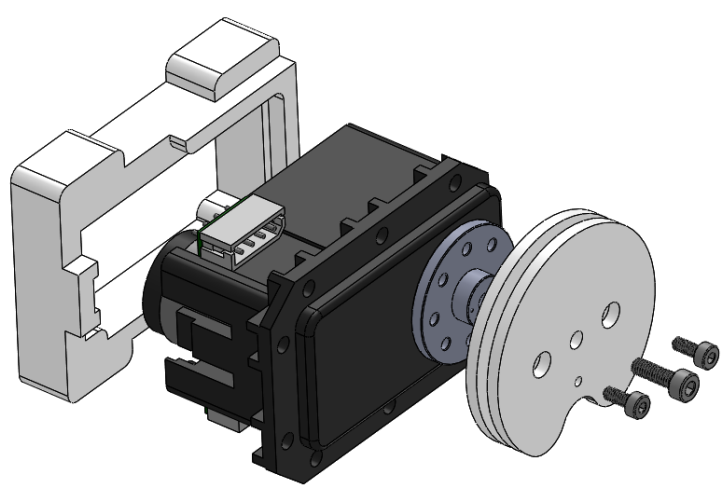
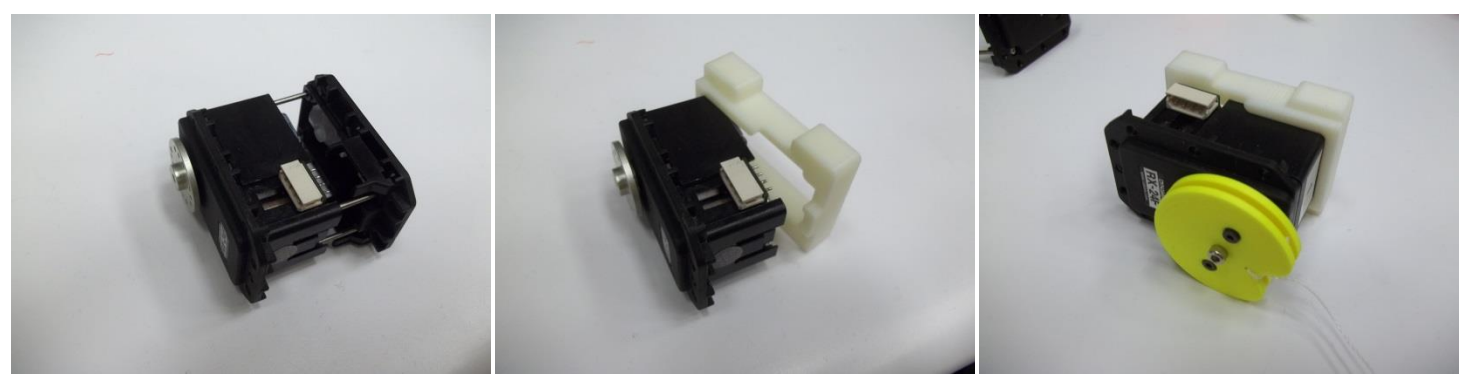
Dynamixel RX-28 or MX-28 or RX24-F
b1_dynamixel_m.stl
b2_dynamixel_m.stl
Spectra tendon line
M2.5, L8mm bolt
M2, L5mm bolt (x2)



Go to page 12 for Power HD servo actuator sub-assembly

Either the RX-28 or MX-28 or RX24-F can be used as the Dynamixel actuator. Take the back off of the Dynamixel servo by unscrewing the 4 main bolts. Snap on piece *b2\_dynamixel\_m.stl* as the servo's new back.

Tie about a foot (~30cm) of tendon line to the servo pulley *b1\_dynamixel\_m.stl* through the non-bolt hole.





# ACTUATOR SUB-ASSEMBLY

## DYNAMIXEL

### Parts

Dynamixel sub-assembly from page 10

Top sub-assembly from page 9

a2\_dynamixel\_m.stl

a3\_dynamixel\_m.stl

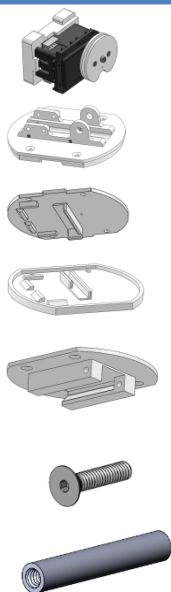
a4\_coupling\_m.stl

- or -

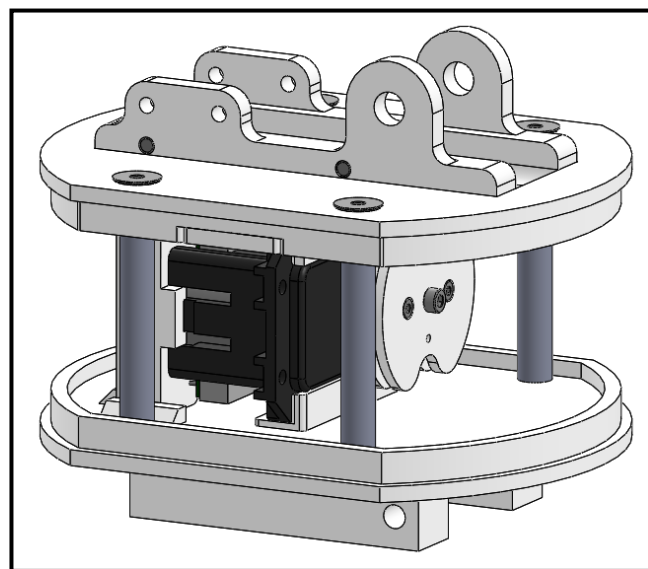
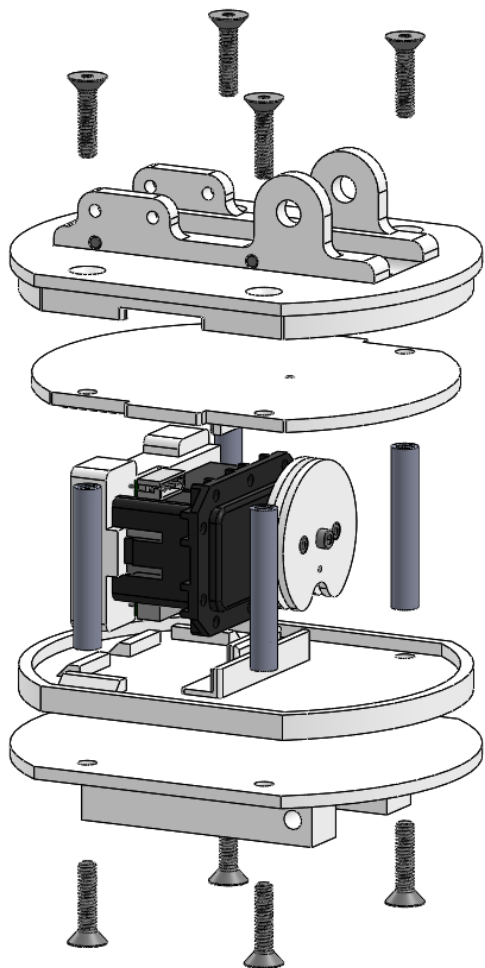
a4\_blank\_m.stl

8-32, L3/4" countersunk bolt (x8)

∅1/4", L1-1/2", 8-32 zinc-plated female standoff (x4)



The final actuator sub-assembly is sandwiched together as shown. The Dynamixel sub-assembly should be oriented such that positive rotation (clockwise) of the servo will pull the tendon downwards.



Skip to page 14



# ACTUATOR SUB-ASSEMBLY

## POWER HD SERVO

### Parts

Power HD servo (or any other servo with same dimensions)

b1\_power\_m.stl

b2\_power\_m.stl

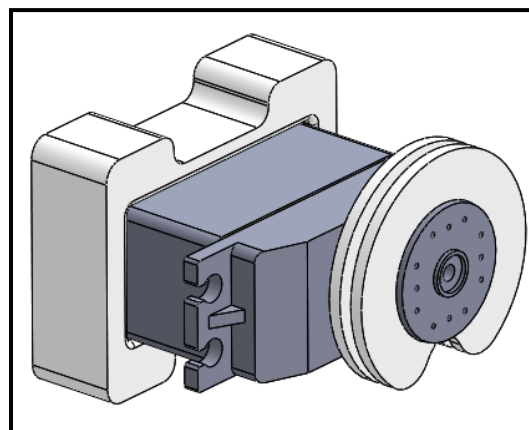
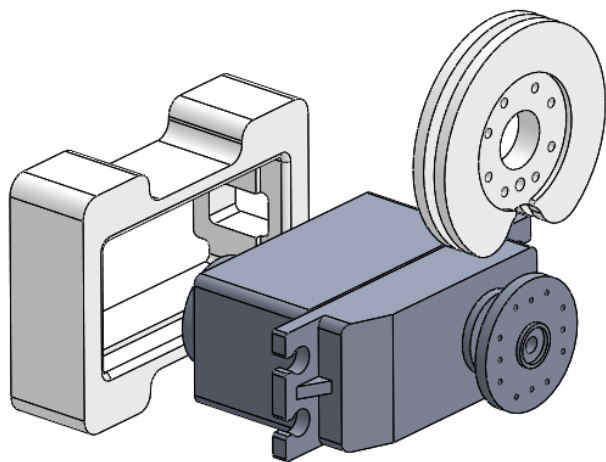
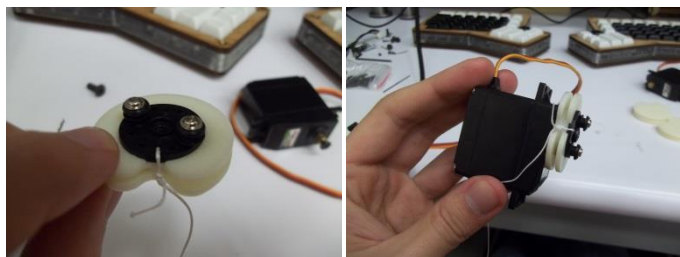
Spectra tendon line



Go back to page 10 for Dynamixel actuator sub-assembly

The Power HD servo is assembled into the actuator sub-assembly much like the Dynamixel is. Take off the back covering and replace it with part *b2\_power\_m.stl*. The pulley part *b1\_power\_m.stl* is assembled counter-intuitively. The part will sit between the servo body and the round servo horn that comes with the Power HD servo. You can choose to secure the printed pulley to the default servo horn however you like, but we chose to use the screws and bolt included with the servo.

Tie about a foot (~30cm) of tendon line to the servo pulley *b1\_dynamixel\_m.stl* through the non-bolt hole.





# ACTUATOR SUB-ASSEMBLY

## POWER HD SERVO

### Parts

Power HD sub-assembly from page 12

Top sub-assembly from page 9

a2\_power\_m.stl

a3\_power\_m.stl

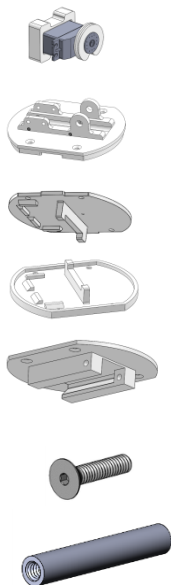
a4\_coupling\_m.stl

- or -

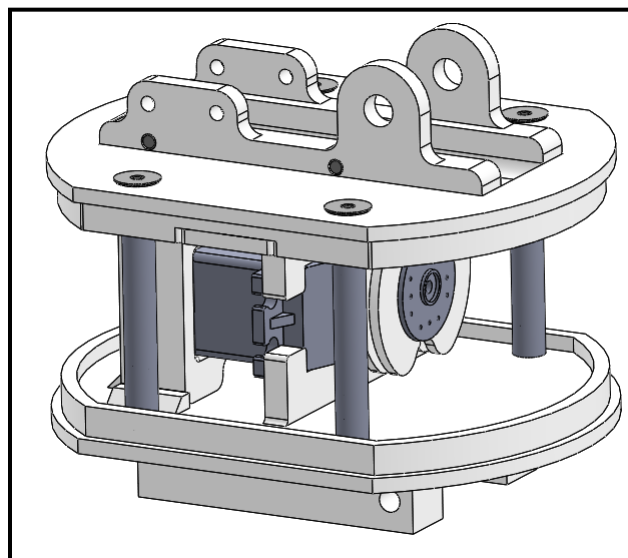
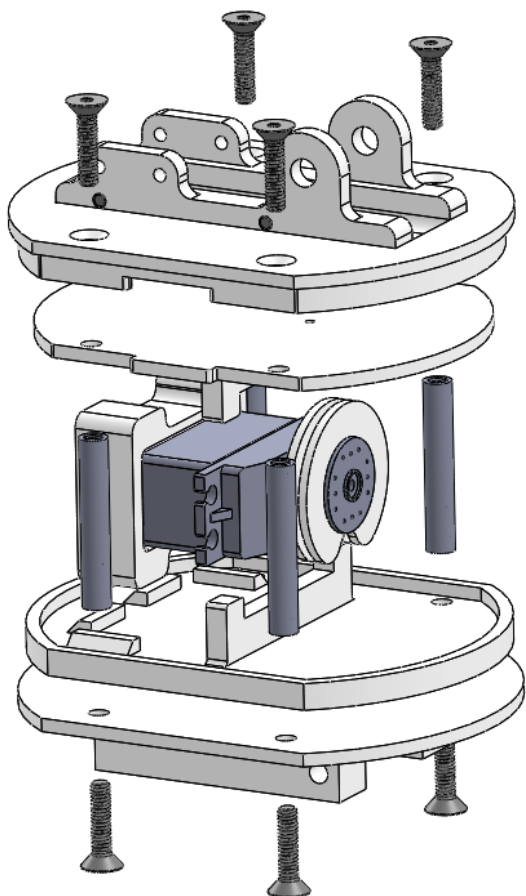
a4\_blank\_m.stl

8-32, L3/4" countersunk bolt (x8)

∅1/4", L1-1/2", 8-32 zinc-plated female standoff (x4)



The final actuator sub-assembly is sandwiched together as shown. The Power HD sub-assembly should be oriented such that positive rotation (clockwise) of the servo will pull the tendon downwards.





# FINAL ASSEMBLY

## HAND FRAME

### Parts

Actuator sub-assembly (Dynamixel)  
from page 11

- or -

Actuator sub-assembly (Power HD)  
from page 13

Thumb

Pivot-Flexure Forefinger from page 6

- or -

Pivot-Pivot Forefinger from page 8

M3, L8mm bolt (x4)

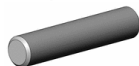
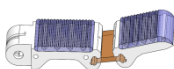
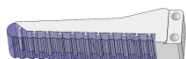
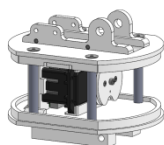
Ø1/4", L1-1/4" steel dowel pin

Torsion spring

- or -

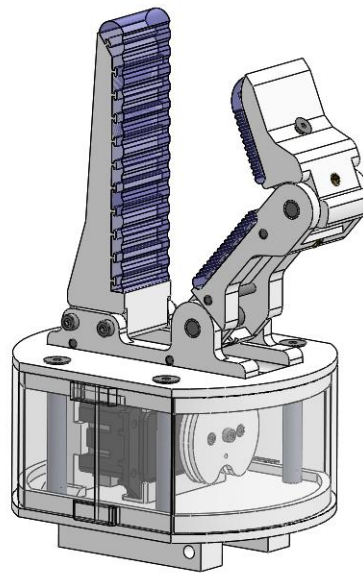
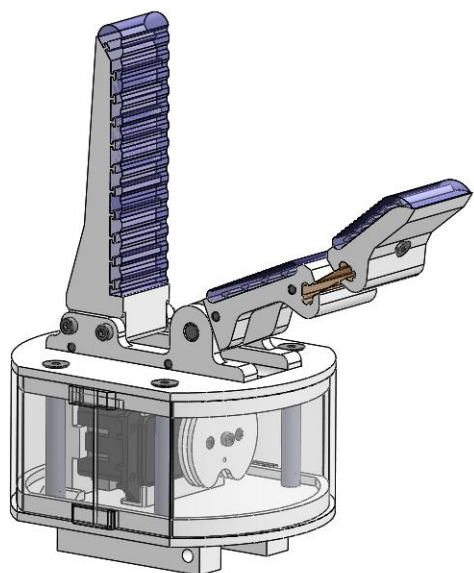
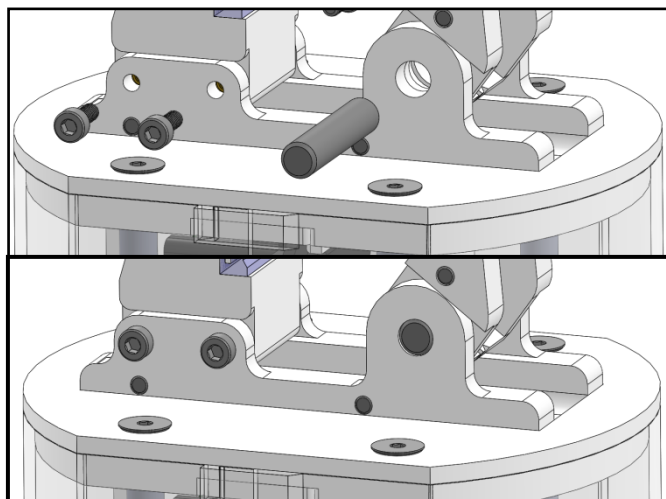
Extension spring

d1\_m.stl (x2, optional)



The final assembly step is nearly identical no matter what your design choices are. The only variation is in whether you chose a torsion spring or extension spring for the base joint of the forefinger. Both will utilize the 1/8" pin below the forefinger base in part *c1\_m.stl*. Consult the *OpenHand Finger Guide* for more details on implementing extension vs torsion springs.

The shell *d1\_m.stl* is optional but should snap together when assembled between the topmost and bottommost plates *a1\_m.stl* and *a4\_coupling\_m.stl*.



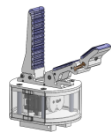


# FINAL ASSEMBLY

## TENDON ROUTING

### Parts

Hand assembly



Spectra tendon line

The tendon is routed from the servo pulley through the tendon clearance in both *a2\_dynamixel\_m.stl* or *a2\_power\_m.stl* and *c1\_m.stl*. The agonist tendon goes across the front of both joints, as shown below.

The tendon can be terminated on the bolt at the back of the distal finger link or with a nut right after the tendon exits the back of the finger.

To zero the tendon line:

1. Anchor the tendon
2. Hook up the actuator and command it to its zero position
3. Unscrew the pulley until it can spin freely
4. Rotate the pulley until the tendon line is taut
5. Re-secure the drive pulley to the actuator

