



OPENHAND  
**MODEL T**  
VERSION 1.0



# ASSEMBLY INSTRUCTIONS

LAST UPDATED: FEBRUARY 22, 2015



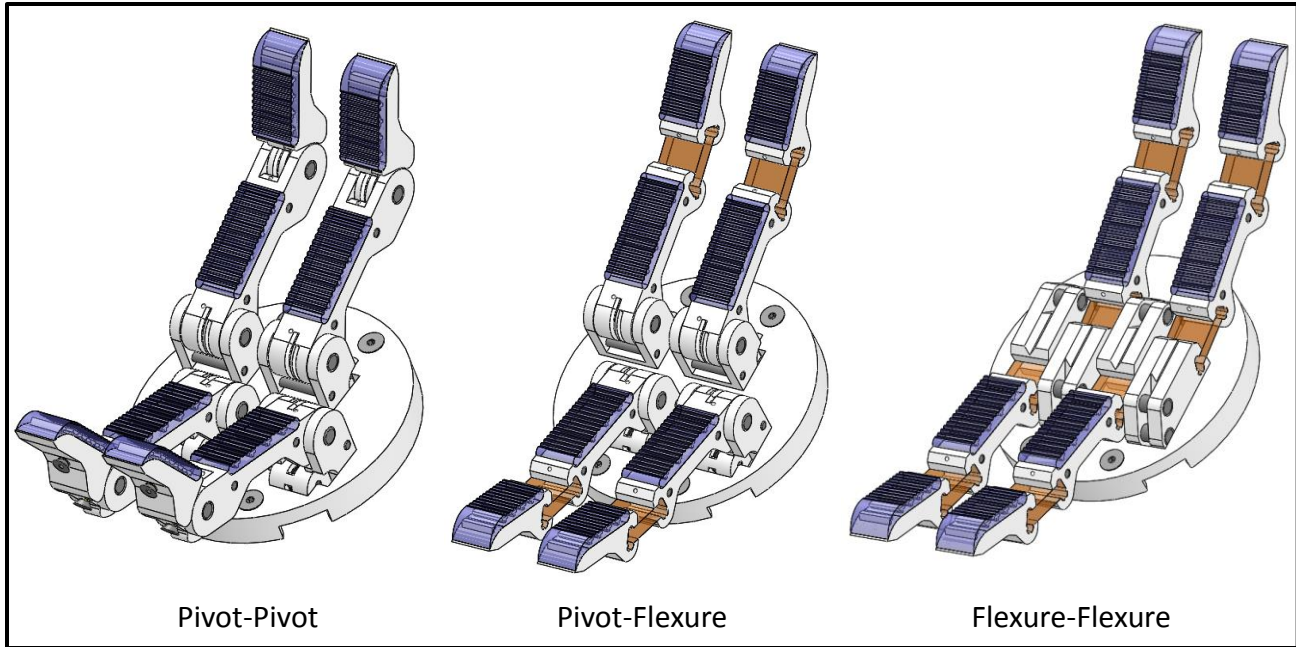
# OTS PARTS LIST

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", L2-1/2", 8-32 zinc-plated female standoff	4	Support	McMaster [ <a href="#">92474A029</a> ]
Ø1/4", L1" steel dowel pin	4	Joint pin	McMaster [ <a href="#">98381A542</a> ]
Ø1/4", L5/8" steel dowel pin	8	Joint pin for Pivot-Pivot	McMaster [ <a href="#">98381A539</a> ]
Ø1/8", L1" steel dowel pin	4	Routing pin	McMaster [ <a href="#">98381A475</a> ]
Ø1/8", L5/8" steel dowel pin	12	Tendon routing pin	McMaster [ <a href="#">98381A472</a> ]
Ø1/8", L3/8" steel dowel pin	13	Tendon routing pin	McMaster [ <a href="#">98381A470</a> ]
8-32, L3/4" countersunk bolt	8	Support bolt	McMaster [ <a href="#">92210A197</a> ]
M3, L8mm bolt	1	Center bolt for Dynamixel (included w/ Dynamixel)	McMaster [ <a href="#">91292A112</a> ]
4-40, L0.135" heat-set insert	12	Insert for bolt anchors	McMaster [ <a href="#">93365A120</a> ]
4-40, L1/4" countersunk screw	12	Tendon/spring anchors	McMaster [ <a href="#">91253A106</a> ]
2-56, L3/4" socket bolt	2	Fastener	McMaster [ <a href="#">92196A084</a> ]
2-56 nut	2	Fastener	McMaster [ <a href="#">90480A003</a> ]
Torsion spring, 0.340" OD, 0.028" wire diameter	4	Return spring, alternative to extension springs	McMaster [ <a href="#">9271k605</a> ]
Extension spring, 0.188" OD, L3/4", 0.016" wire diameter	8	Return spring, alternative to torsion spring at proximal	McMaster [ <a href="#">9654k955</a> ]
Ø3/8", nylon pulley	12	Tendon-routing pulley	McMaster [ <a href="#">3434t31</a> ]
Dynamixel MX-64	1	Actuator	Various [ <a href="#">Link</a> ]
Sunon DC 25x25x10mm Fan 12V	1	Cooling fan for Dynamixel	Various [ <a href="#">259-1570-ND</a> ]

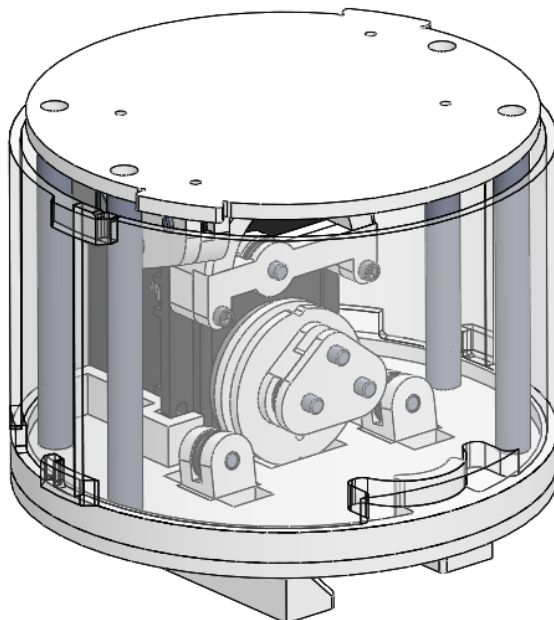


# OVERVIEW

## Finger Options



## Actuator Base





# FINGER SUB-ASSEMBLY

## PIVOT-FLEXURE

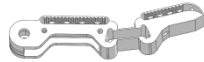
### Parts

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

(x4)

PMC-780 (2:1)

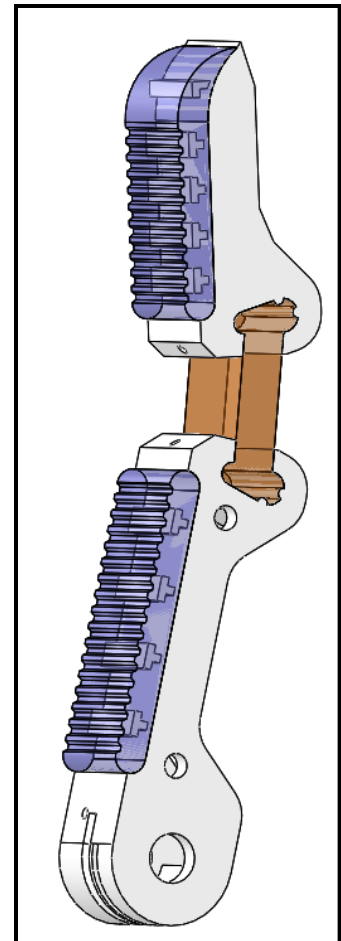
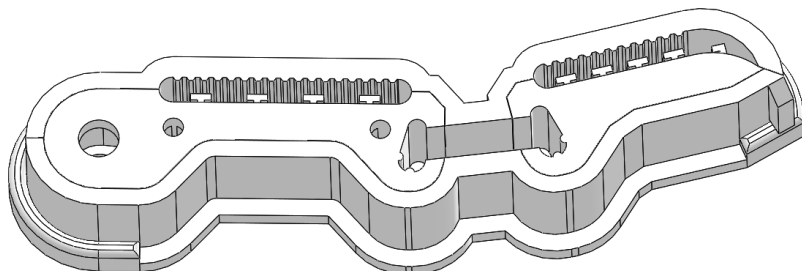
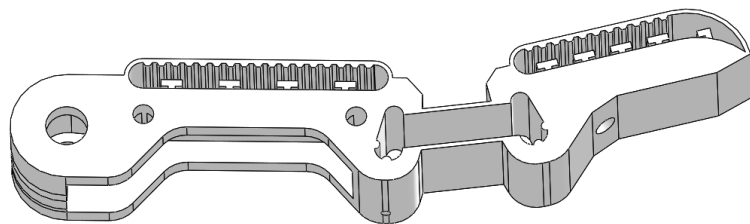
Vytaflex 30 (1:1)



Go to page 5 for Pivot-Pivot finger sub-assembly

Go to page 9 for Flexure-Flexure finger 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





# FINGER SUB-ASSEMBLY

## PIVOT-FLEXURE

### Parts

Pivot-Flexure Forefinger (x4)

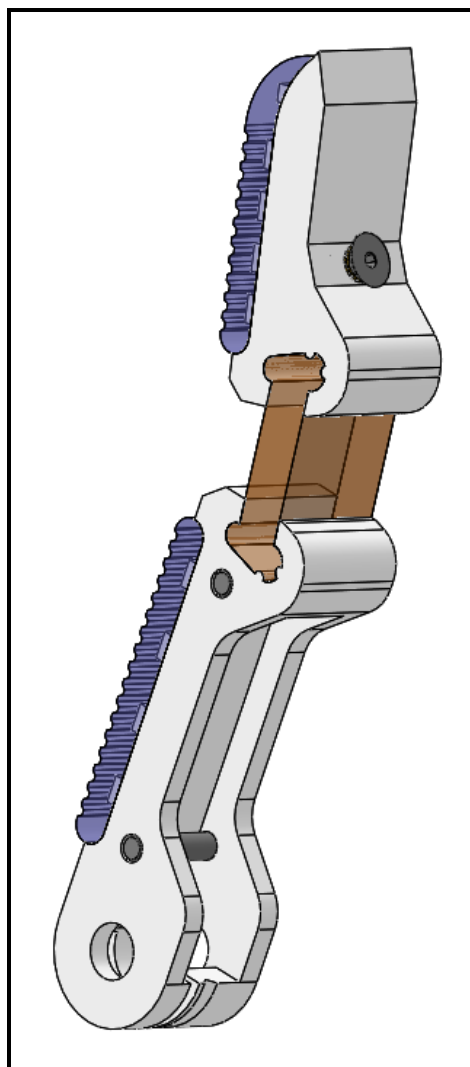
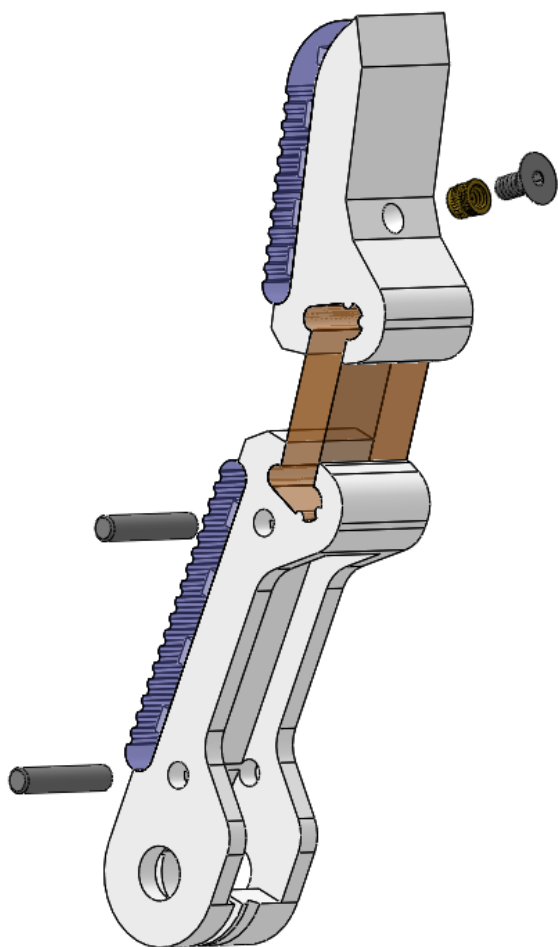
4-40, L0.135" heat-set insert (x4)

4-40, L1/4" countersunk screw (x4)

Ø1/8", L5/8" steel dowel pin (x8)



Press fit the 1/8" dowel pins for tendon-rerouting into the proximal link and back of the fingers. 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.



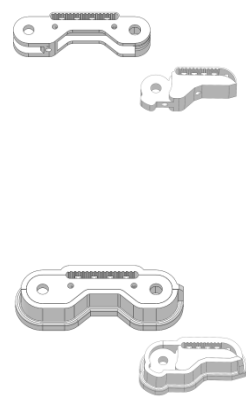


# FINGER SUB-ASSEMBLY

## PIVOT-PIVOT

### Parts

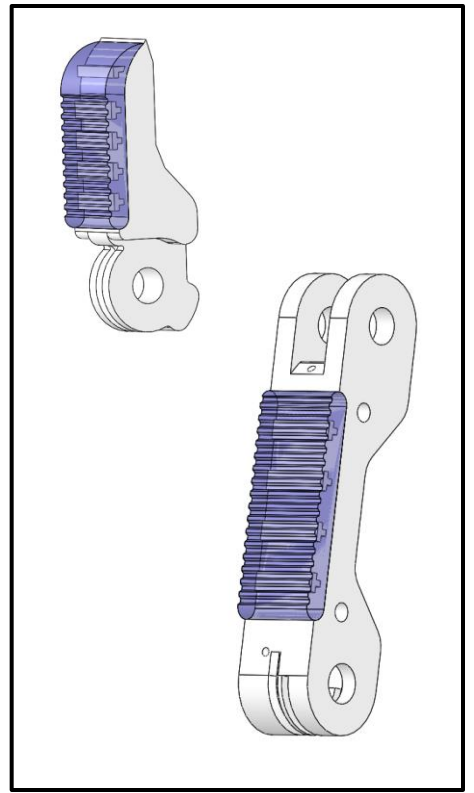
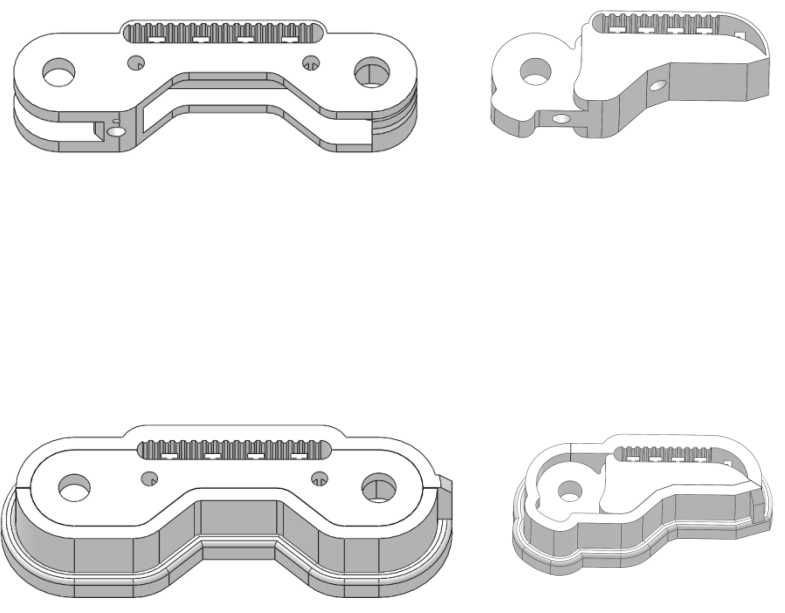
- finger\_pp\_torsion\_A\_t.stl
  - finger\_pp\_B\_t.stl
  - or -
  - finger\_pp\_ext\_A\_t.stl
  - finger\_pp\_B\_t.stl
  - or -
  - finger\_pp\_torsion\_mold1\_A\_t.stl
  - finger\_pp\_mold[2-4]\_A\_t.stl
  - finger\_pp\_mold1\_B\_t.stl
  - finger\_pp\_mold[2-4]\_B\_t.stl
  - or -
  - finger\_pp\_ext\_mold1\_A\_t.stl
  - finger\_pp\_mold[2-4]\_A\_t.stl
  - finger\_pp\_mold1\_B\_t.stl
  - finger\_pp\_mold[2-4]\_B\_t.stl
- (x4)



Go back to page 3 for Pivot-Flexure finger sub-assembly

Go to page 9 for Flexure-Flexure finger 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





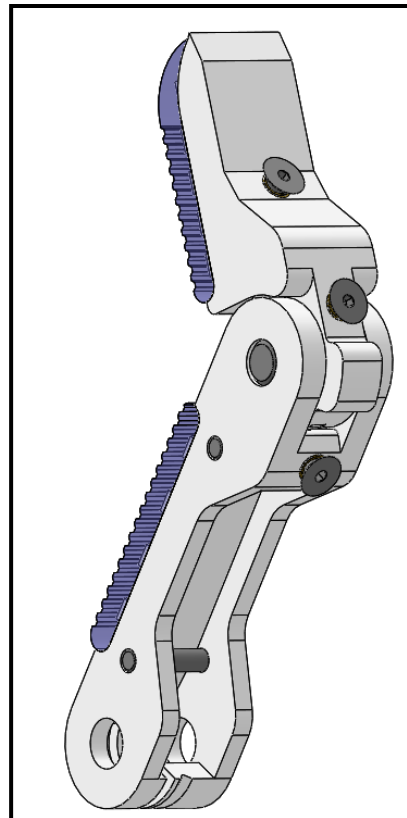
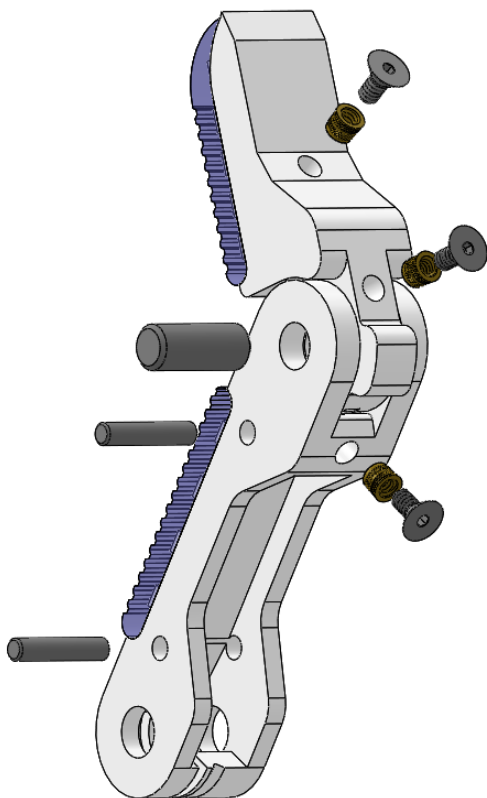
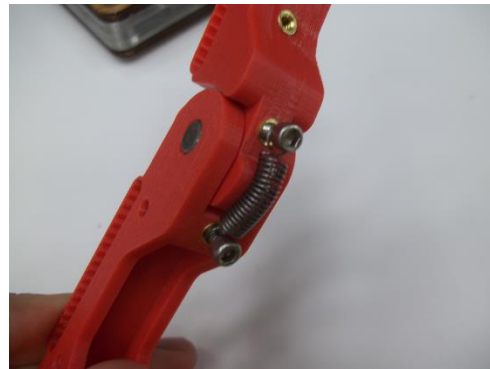
# FINGER SUB-ASSEMBLY

## PIVOT-PIVOT

Parts	
Pivot-Pivot finger distal link (x4)	
Pivot-Pivot finger proximal link (x4)	
4-40, L0.135" heat-set insert (x12)	
4-40, L1/4" countersunk screw (x12)	
Ø1/8", L5/8" steel dowel pin (x8)	
Ø1/4", L5/8" steel dowel pin (x4)	
Extension spring (x4)	

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.



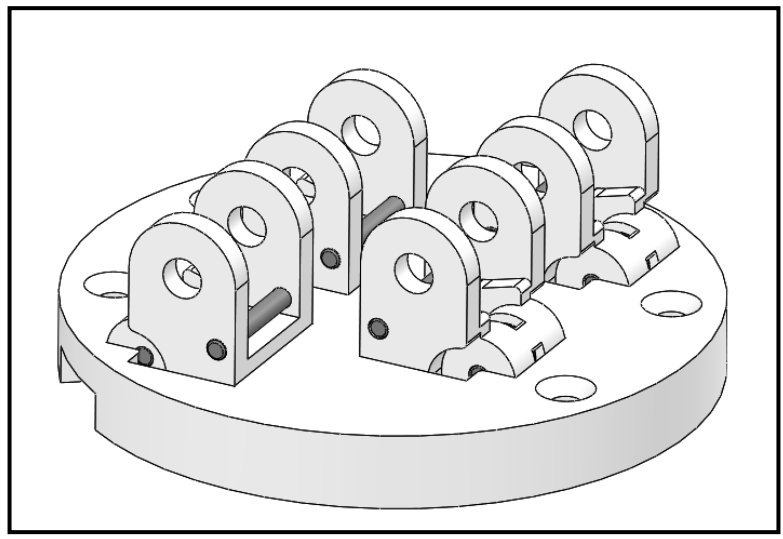
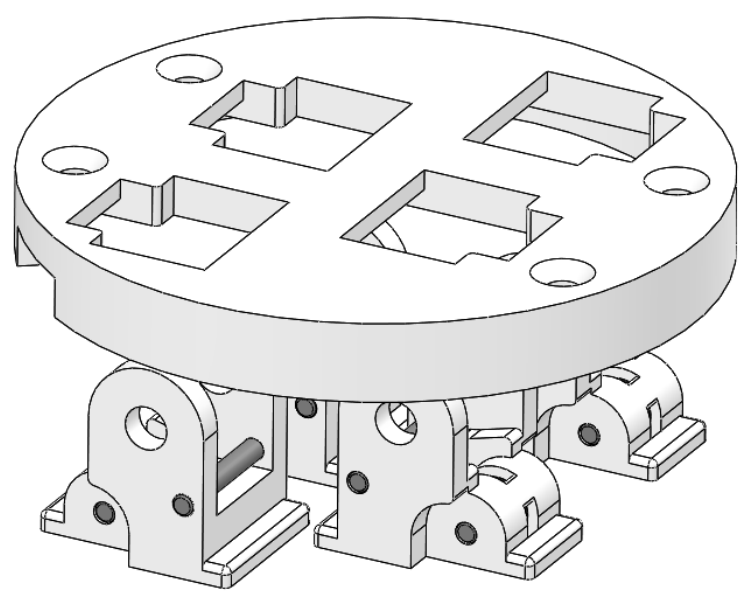
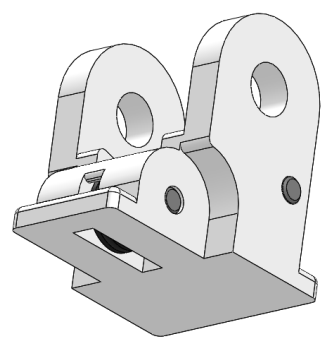
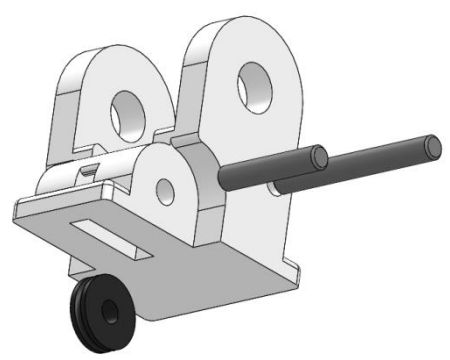


# FINGER SUB-ASSEMBLY

## PIVOT-FLEXURE OF PIVOT-PIVOT

Parts	
a1_p_t.stl	
c1_t.stl (x4)	
Ø1/8", L1" steel dowel pin (x4)	
Ø1/8", L5/8" steel dowel pin (x4)	
Ø3/8" nylon pulley (x4)	

For either the Pivot-Flexure or Pivot-Pivot fingers, the support sub-assembly is the same. Ensure that the nylon pulley is spinning freely after assembly.







# FINGER SUB-ASSEMBLY

## PIVOT-FLEXURE OF PIVOT-PIVOT

### Parts

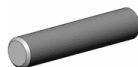
Pivot-Flexure finger sub-assembly  
- or -  
Pivot-Pivot finger sub-assembly  
(x4)



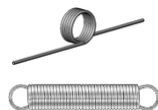
top sub-assembly from previous page



Ø1/4", L1" steel dowel pin  
(x4)

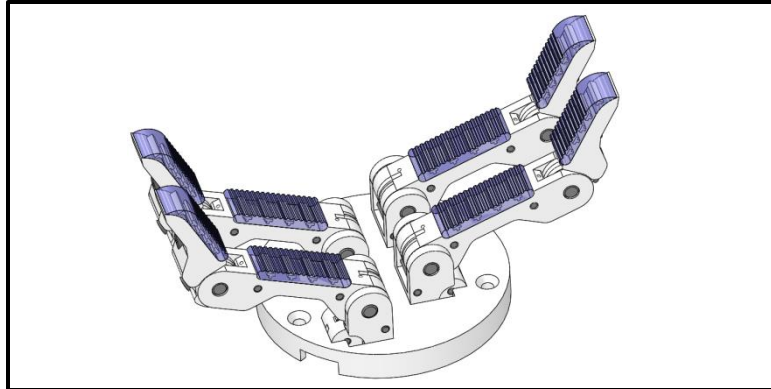
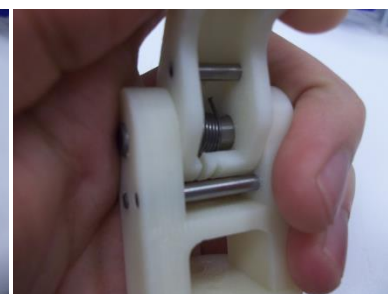
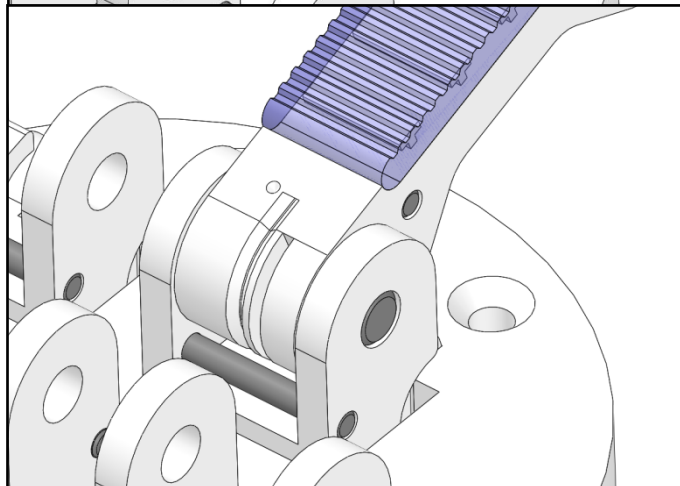
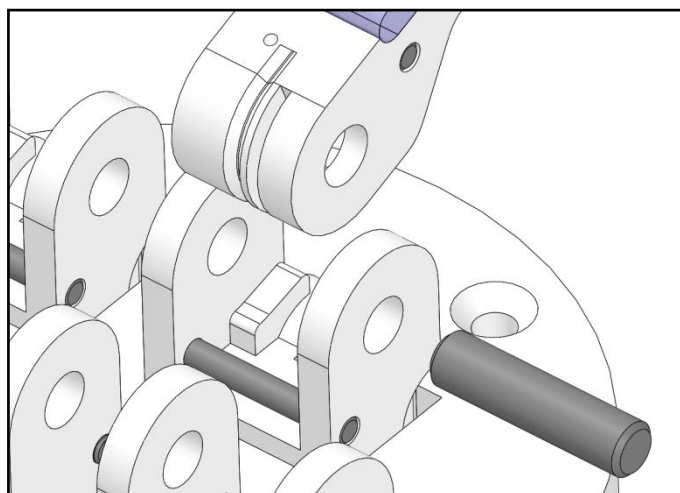


Torsion spring  
- or -  
Extension spring  
(x4)



For either the Pivot-Flexure or Pivot-Pivot fingers, the installation onto the base part *c1\_t.stl* is the same. The finger is held in place by a press-fit 1/4" steel dowel pin. Refer to the *OpenHand Finger Guide* for how to install the torsion spring or extension spring at the base joint.

Example shown below is from the Model O, but the spring implementation is nearly identical.



Skip to page 12



# FINGER SUB-ASSEMBLY

## FLEXURE-FLEXURE

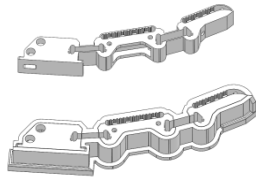
### Parts

finger\_ff\_t.stl  
- or -  
finger\_ff\_mold1\_[A-C]\_t.stl  
finger\_ff\_mold[2-4]\_t.stl

(x4)

PMC-780 urethane (2:1)

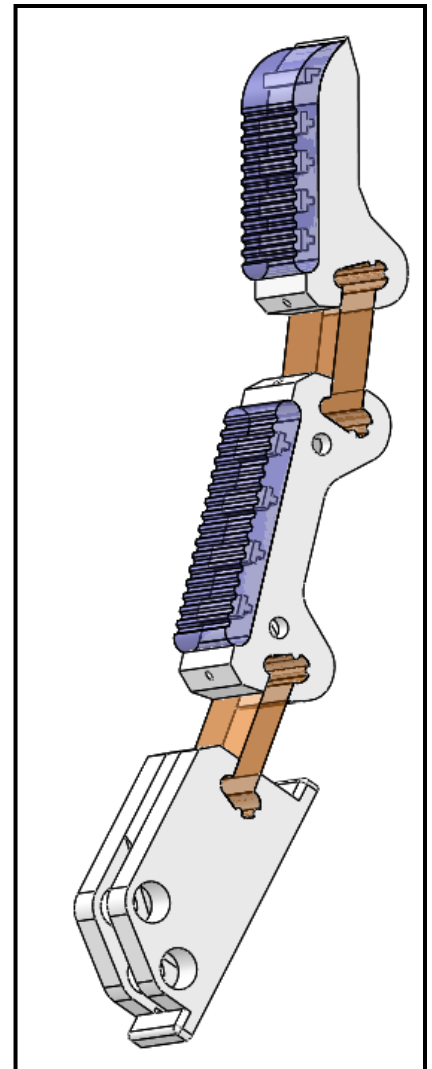
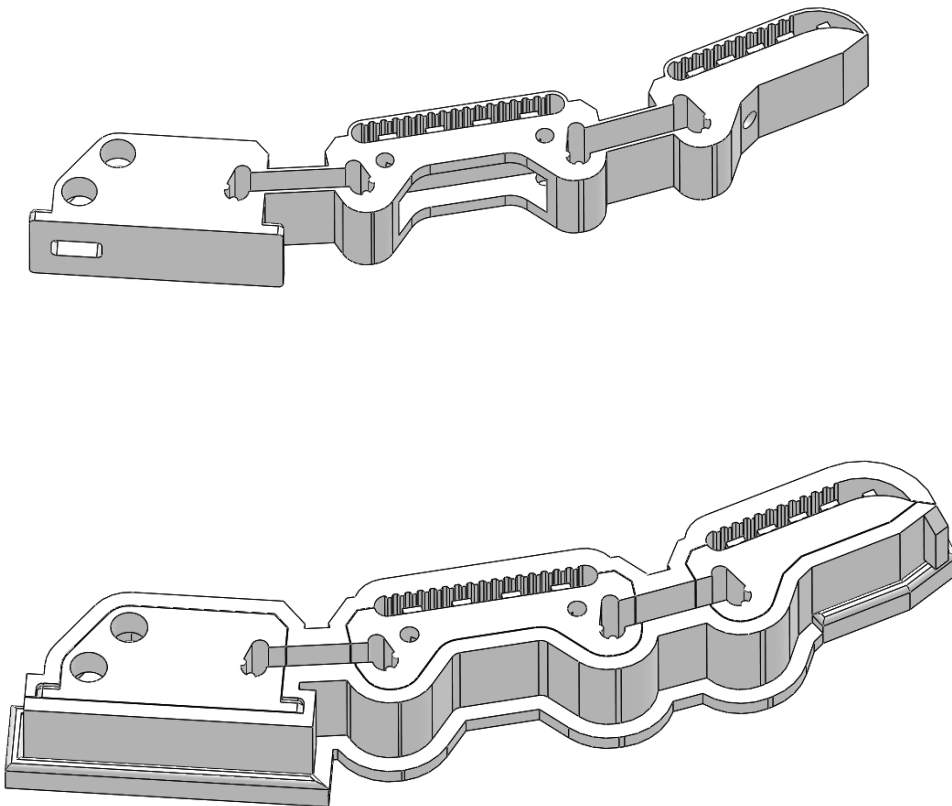
Vytaflex 30 urethane (1:1)



Go to page 3 for Pivot-Flexure finger sub-assembly

Go to page 5 for Pivot-Pivot finger sub-assembly

Refer to the *OpenHand Finger Guide* for more detail on casting these pads and flexures. No pins or additional elastic elements are needed for the joints in the Flexure-Flexure finger design.





# FINGER SUB-ASSEMBLY

## FLEXURE-FLEXURE

### Parts

Flexure-flexure finger from page 9 (x4)

4-40, L0.135" heat-set insert (x4)

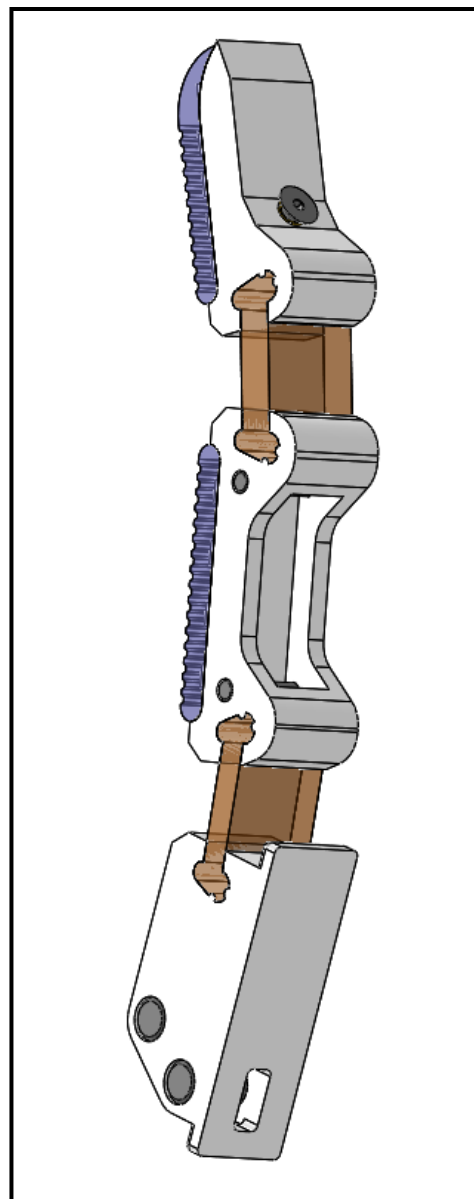
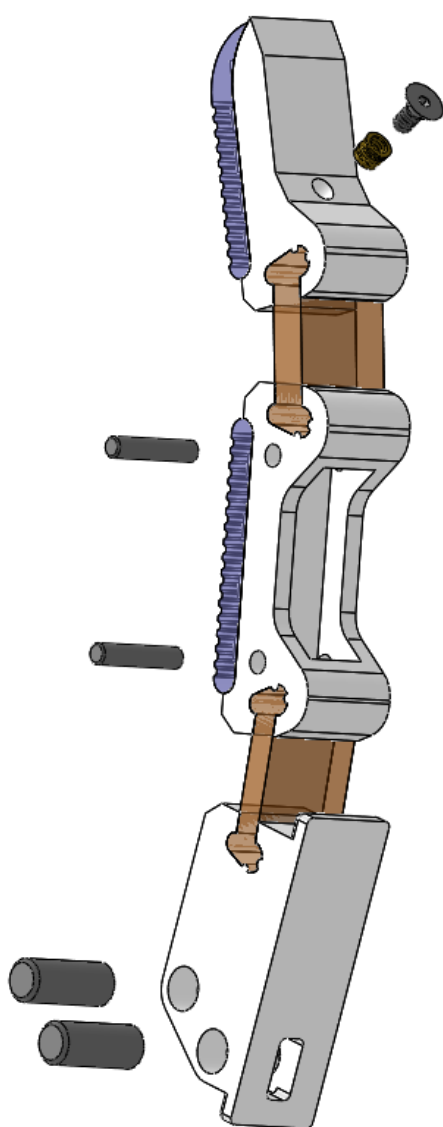
4-40, L1/4" countersunk screw (x4)

Ø1/8", L5/8" steel dowel pin (x8)

Ø1/4", L5/8" steel dowel pin (x8)



Press fit the 1/8" dowel pins for tendon-rerouting into the proximal link. Press fit the 1/4" dowel pins in the base of the fingers. If the pins do not press-fit easily, use a larger reamer to clean out the pin clearances or a vice. 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.





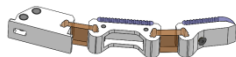
# FINGER SUB-ASSEMBLY

## FLEXURE-FLEXURE

### Parts

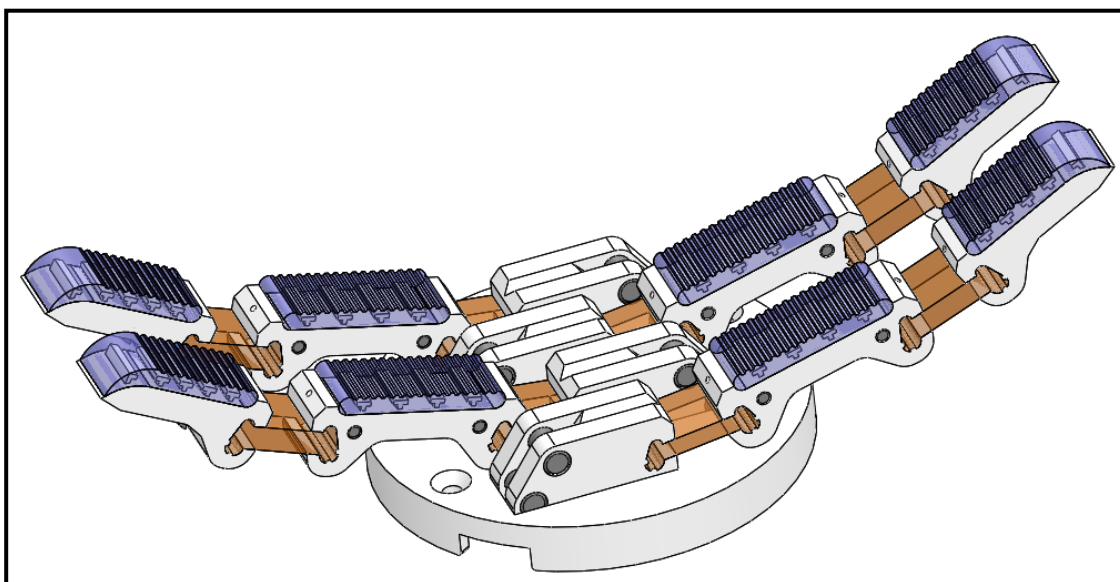
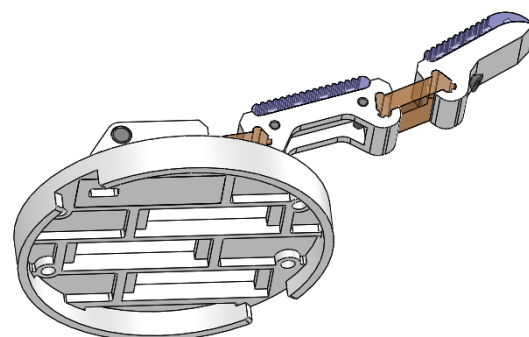
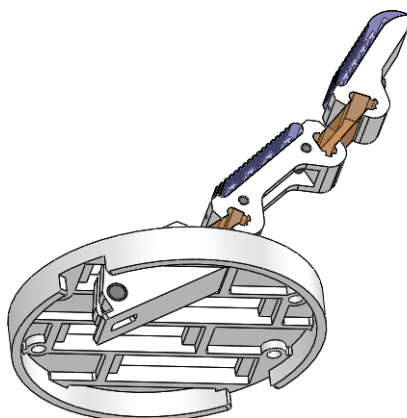
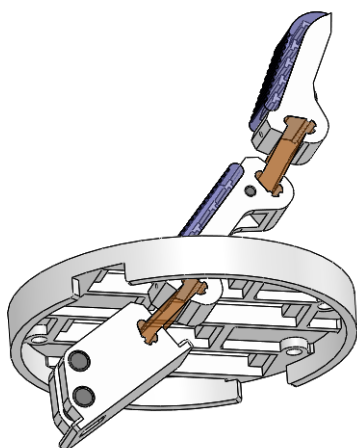
Flexure-flexure finger sub-assembly from previous page (x4)

a1\_f\_t.stl



The Flexure-Flexure fingers are simply inserted up through the top plate *a1\_f\_t.stl* and press-fit into place.



Note the positioning and orientation of the fingers. The Flexure-Flexure design uses a non-intuitive orientation of the fingers that may be confusing to some users.



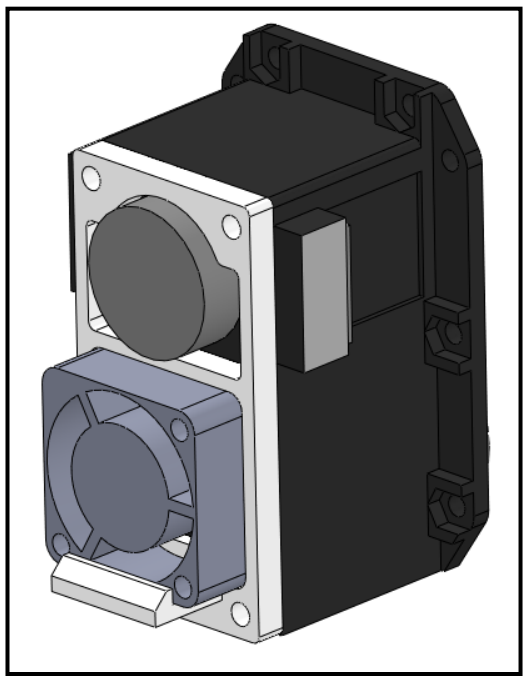
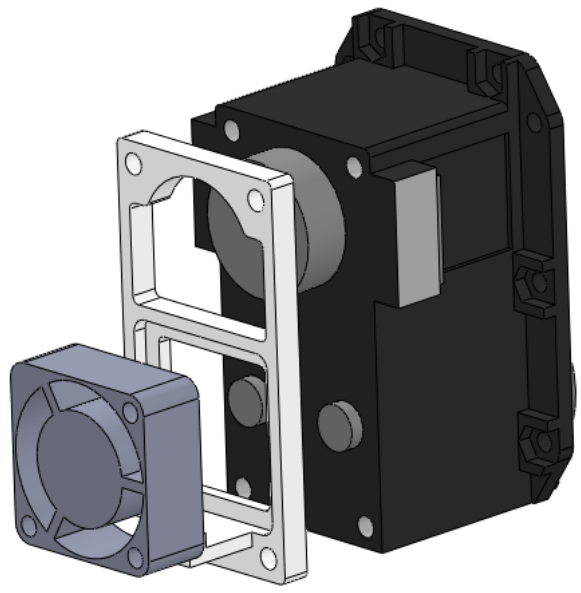
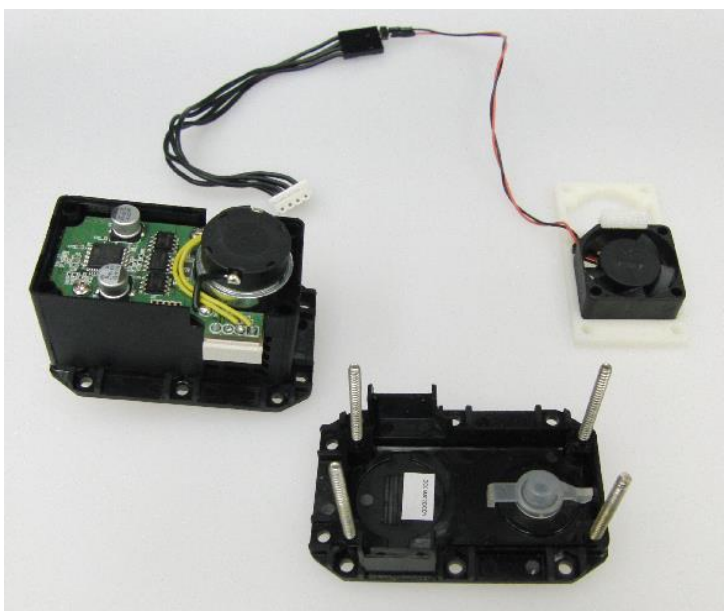


# ACTUATOR SUB-ASSEMBLY

## DYNAMIXEL

Parts	
Dynamixel MX-64	
d2_t.stl	
Sunon 25x25x10mm 12V fan	

Remove the default back of the Dynamixel MX-64 and replace it with part *d2\_t.stl*. The Sunon 12V DC fan will snap into this part. It's highly recommended that this fan be installed, as the Dynamixel is prone to over-heating.



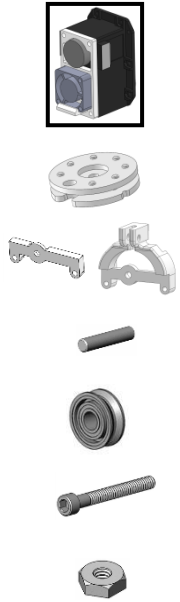


# ACTUATOR SUB-ASSEMBLY

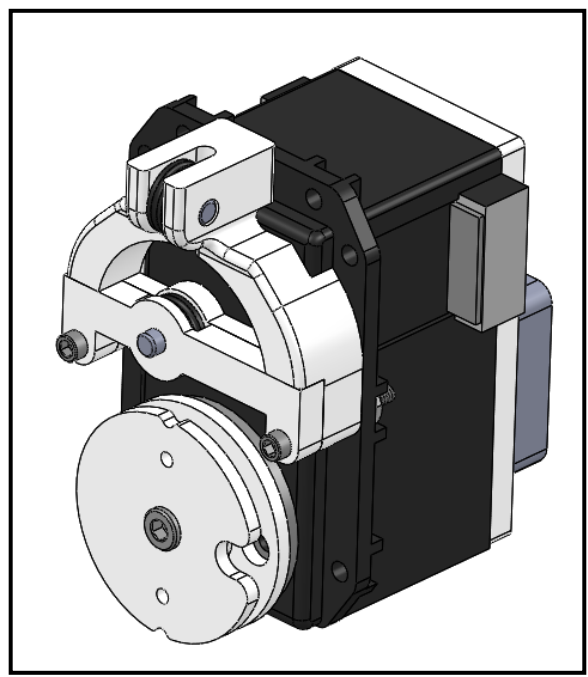
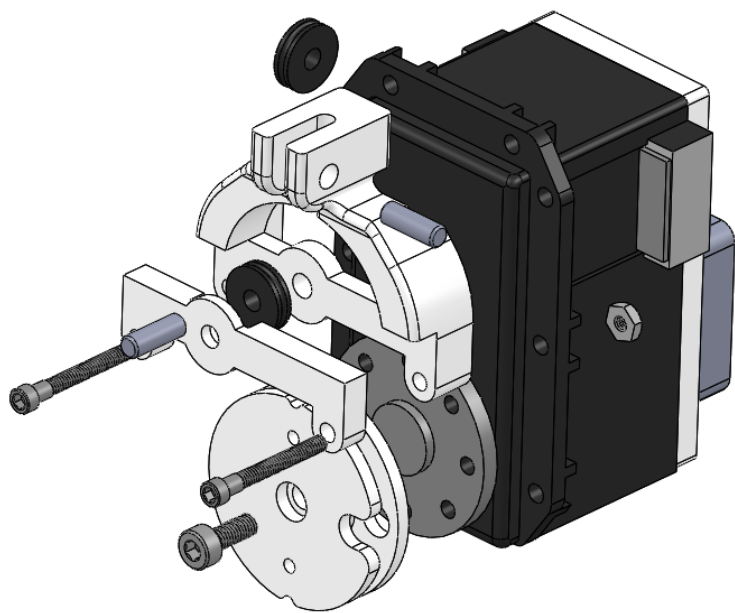
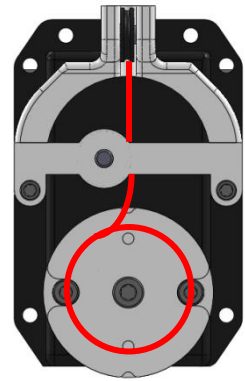
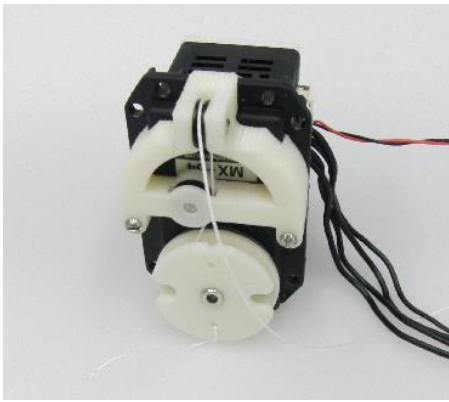
## DYNAMIXEL

### Parts

Dynamixel sub-assembly from previous page
b1_t.stl
b4_a_t.stl, b4_b_t.stl
Ø1/8", L3/8" steel dowel pin (x2)
Ø3/8" nylon pulley (x2)
2-56, L3/4" socket bolt (x2)
2-56 nut



Assemble the actuator block as shown. Ensure that the nylon pulleys are spinning freely after assembly. Now is a good time to tie about a foot (~30cm) of tendon to the main drive pulley.





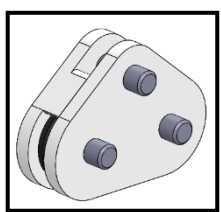
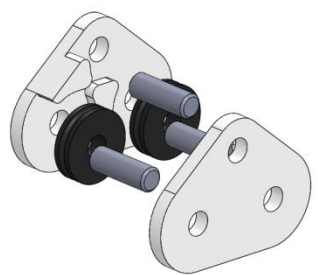
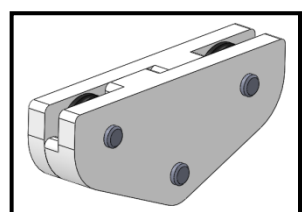
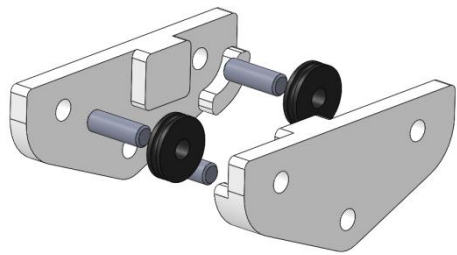
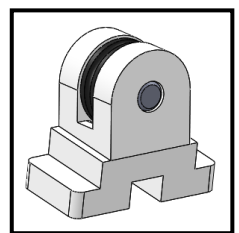
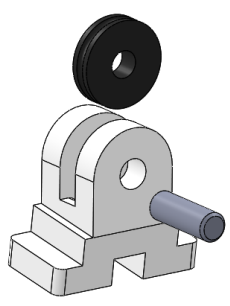
# ACTUATOR SUB-ASSEMBLY

## PULLEY BLOCKS

Parts	
b2_t.stl (x2)	
b3_t.stl (x4)	
b5_t.stl (x2)	
Ø1/8", L3/8" steel dowel pin (x11)	
Ø3/8" nylon pulley (x6)	

Pulley blocks are assembled with press-fit 1/8" pins and nylon pulleys. Ensure that the nylon pulleys are free-spinning after assembly for all blocks.

It may be necessary to use a pair of pliers to press-fit all items together properly.





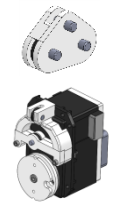
# ACTUATOR SUB-ASSEMBLY

## INITIAL TENDON TYING

### Parts

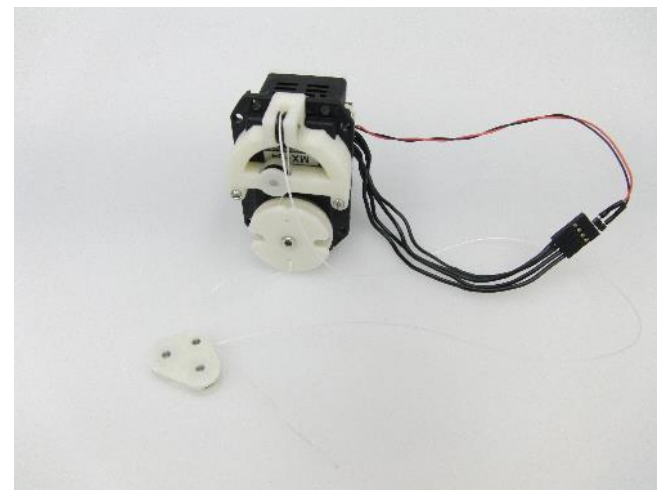
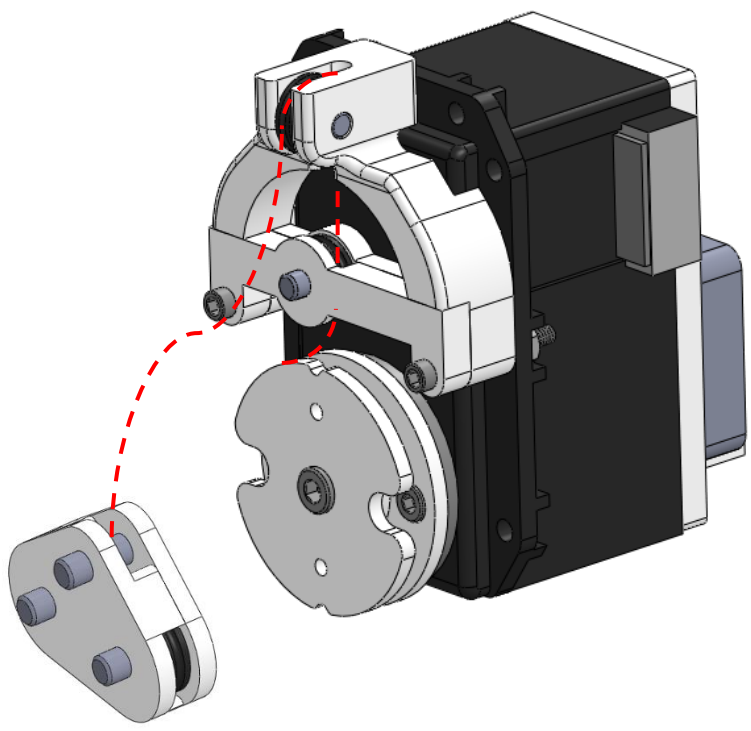
b5 sub-assembly from previous page

actuator block from page 13



Spectra tendon should be tied as shown below between the actuator block and the b5 sub-assembly.

It's not too critical how much slack to leave between the b5 block and the actuator block. The tendon length will be set later during servo initialization.





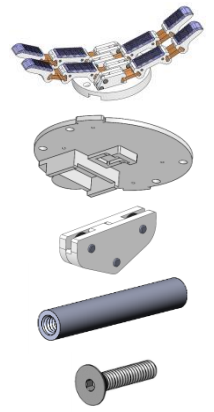


# FINAL ASSEMBLY

## FLEXURE-FLEXURE TOP

### Parts

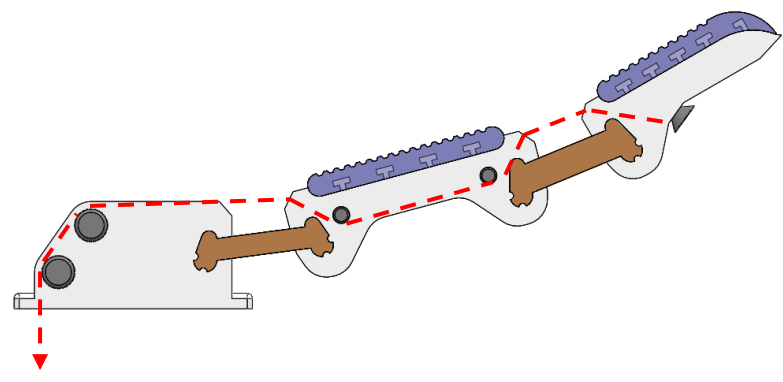
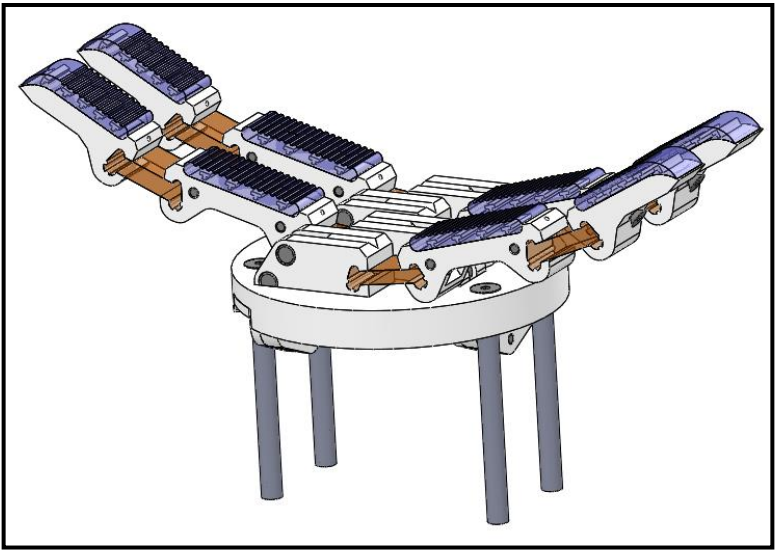
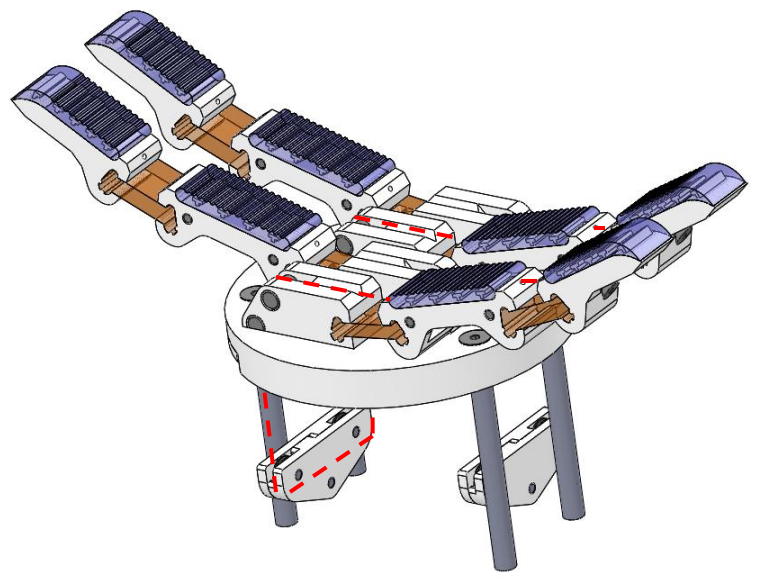
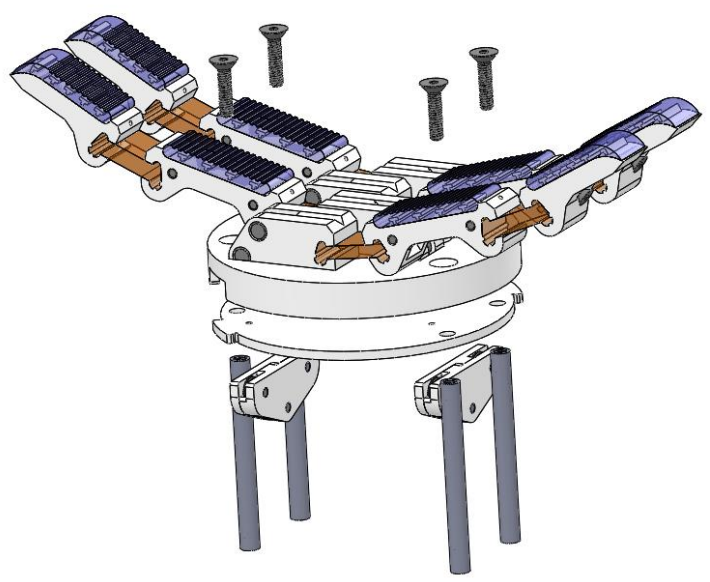
- top finger sub-assembly from page 11
- a2\_t.stl
- b3 sub-assembly from page 14 (x2)
- ∅1/4", L2-1/2", 8-32 zinc-plated female standoff (x4)
- 8-32, L3/4" countersunk bolt (x4)



For Pivot-base tops, go to page 17

Regardless of finger type, the top plate is attached to *a2\_t.stl* and incorporate the b3 floating pulley block in the same way. The top two layers are sandwiched with 8-32 bolts and standoffs, and tendons are tied between the ends of finger pairs as shown such that the b3 pulley block is held taut against the bottom of *a2\_t.stl*.

Note how the tendon should be routed in the diagram below.



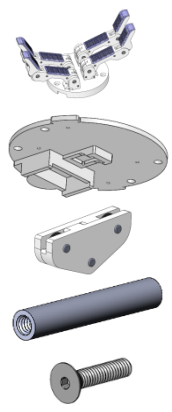


# FINAL ASSEMBLY

## PIVOT-PIVOT OR PIVOT-FLEXURE TOP

### Parts

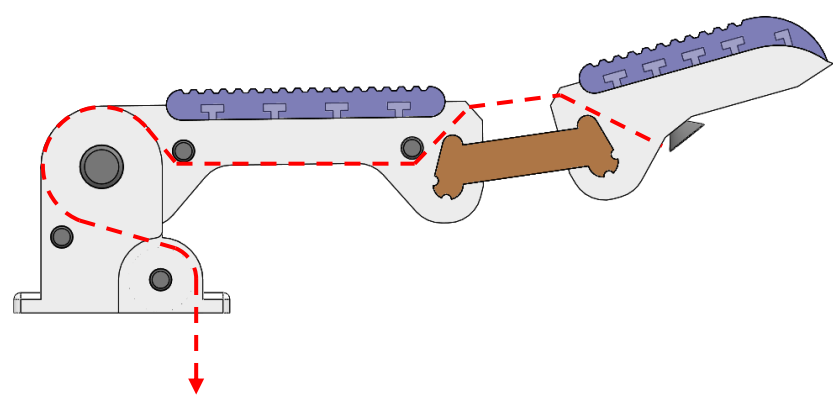
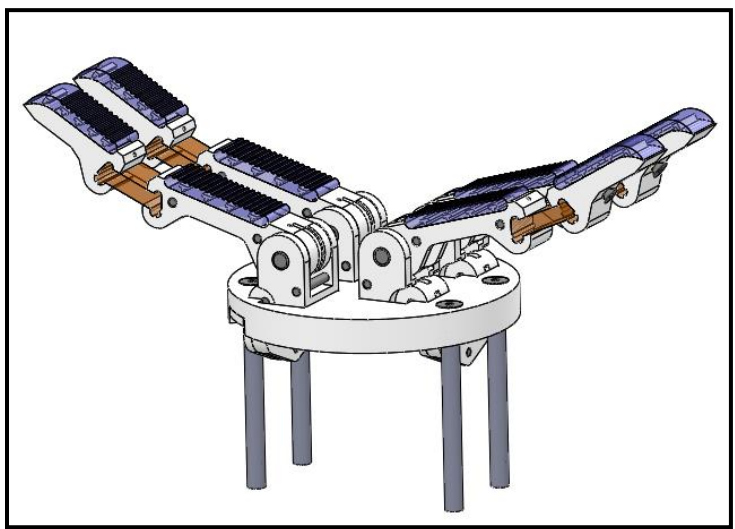
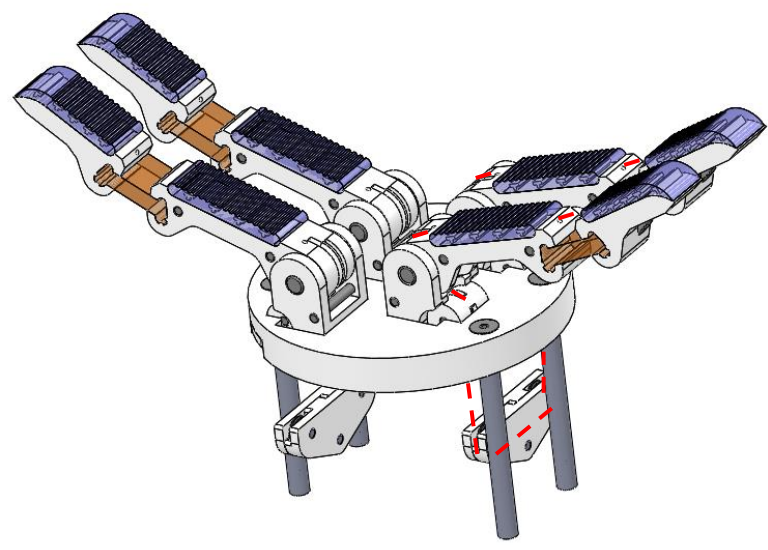
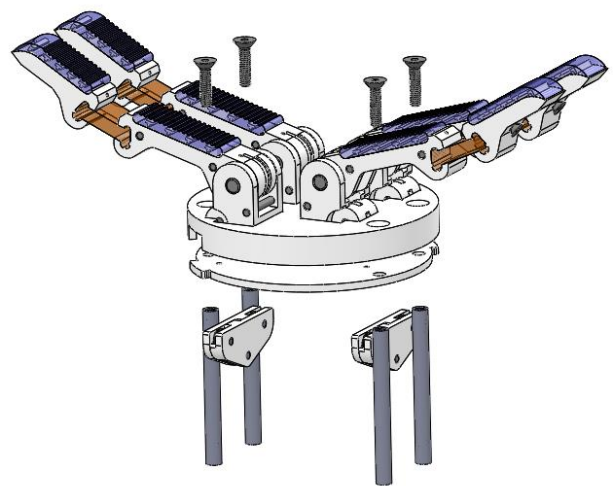
- top finger sub-assembly from page 8
- a2\_t.stl
- b3 sub-assembly from page 14 (x2)
- ∅1/4", L2-1/2", 8-32 zinc-plated female standoff (x4)
- 8-32, L3/4" countersunk bolt (x4)



For Pivot-base tops, go back to page 16

Regardless of finger type, the top plate is attached to *a2\_t.stl* and incorporate the b3 floating pulley block in the same way. The top two layers are sandwiched with 8-32 bolts and standoffs, and tendons are tied between the ends of finger pairs as shown such that the b3 pulley block is held taut against the bottom of *a2\_t.stl*.




Note how the tendon should be routed in the diagram below. It is different from the Flexure-





# FINAL ASSEMBLY

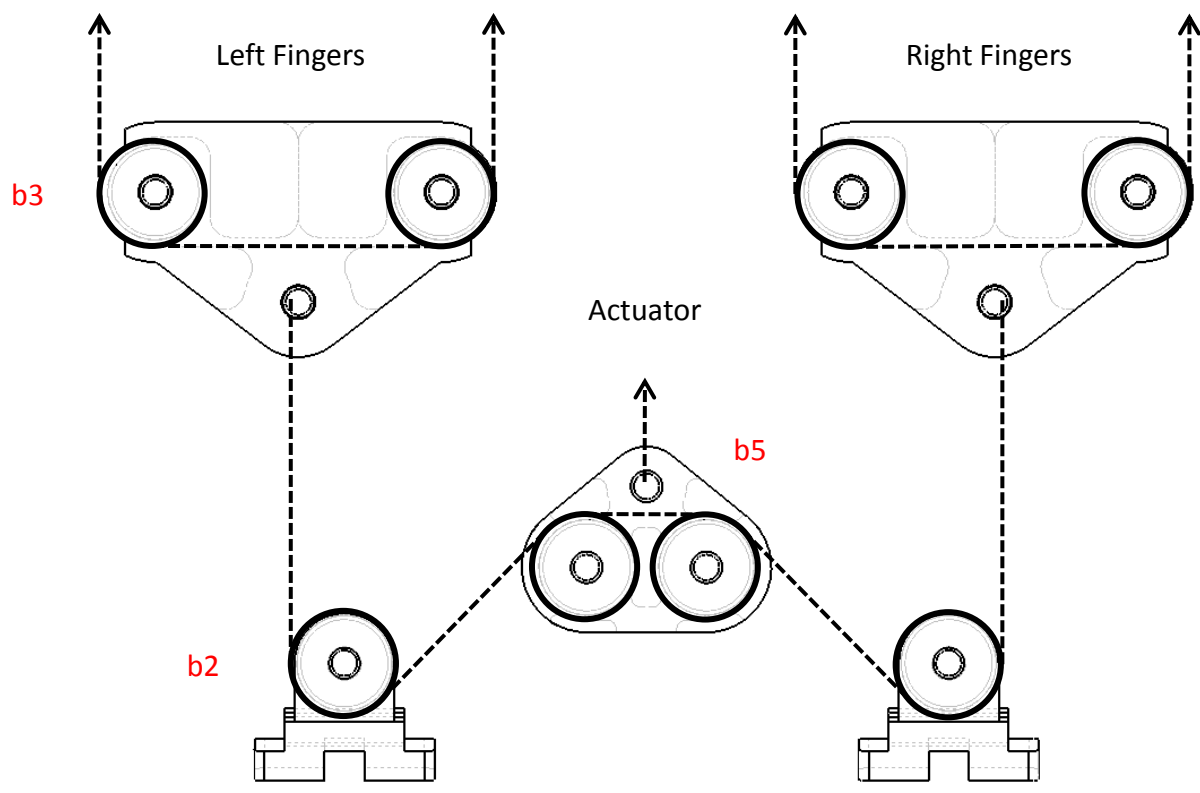
## SECURING MAIN TRANSMISSION (1/2)

Parts	
top finger assembly from page 16 or 17	
b2 block from page 14	
a3_t.stl	
Spectra tendon line	

This is probably the most difficult part of the build. Refer to the transmission diagram below for how the tendon should tie the b3 floating pulley blocks, through the b2 and b5 blocks.



Transmission Diagram

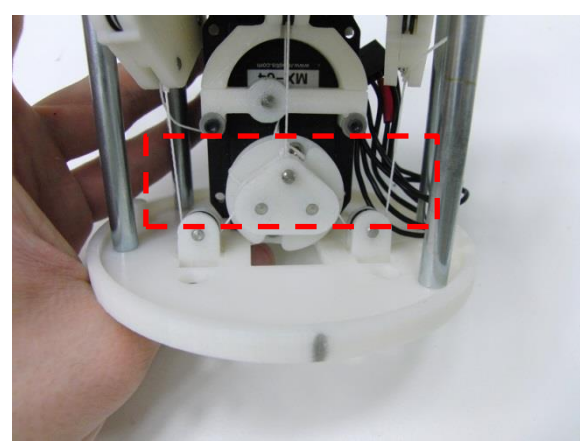
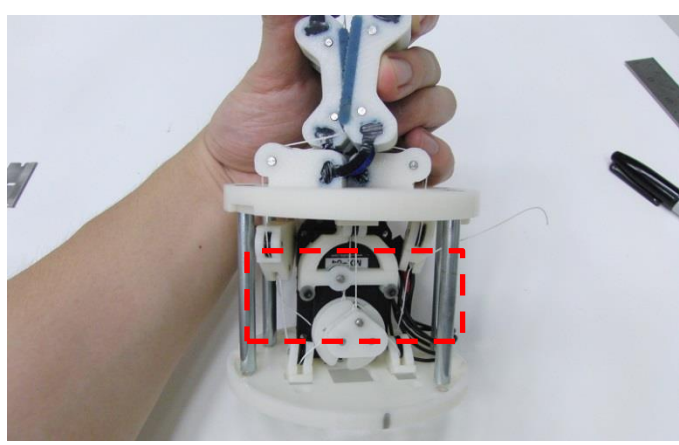
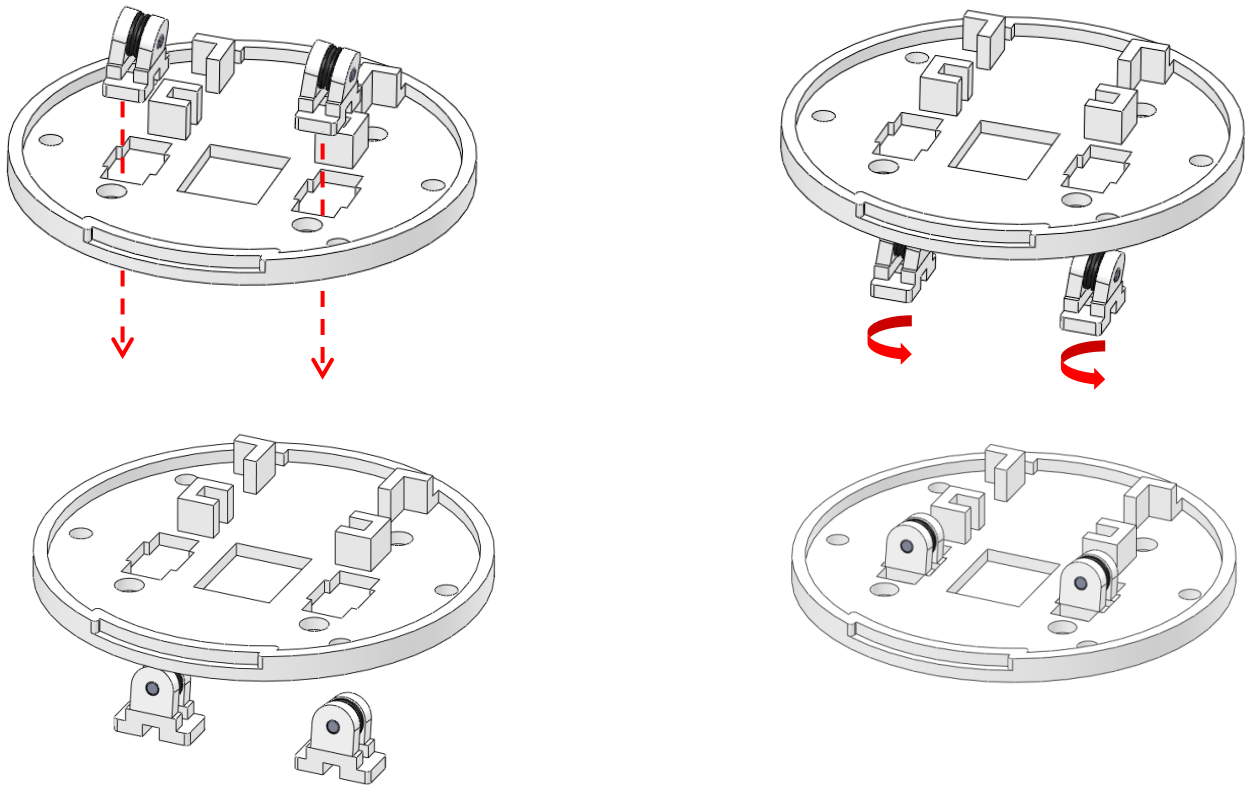




# FINAL ASSEMBLY

## SECURING MAIN TRANSMISSION (2/2)

Note that the slots in *a3\_t.stl* allow for the b2 pulley blocks to be pulled completely through. This can allow you to tie a set length of tendon between the floating b3 blocks before anchoring the b2 blocks to the bottom of the hand. To generate more slack, you can manually close the fingers as shown.





# FINAL ASSEMBLY

## BOTTOM BLOCK

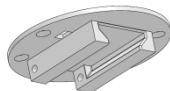
### Parts

completed sub-assembly from previous page

a4\_coupling\_t.stl  
- or -  
a4\_blank\_t.stl

8-32, L3/4" countersunk bolt (x4)

d1\_a\_t.stl, d1\_b\_t.stl (optional)



The final assembly step is the same no matter what style of fingers are used. The shell pieces are optional and can be snapped together at any time.

