OpenHand

Model Q

Version 1.0

Assembly Instructions

Last updated: February 22, 2015

OTS Parts List

Part Name	Quantity	Description	Vendor
Power Pro Spectra	1	Tendon	Amazon [link]
PMC-780 Urethane	1	Finger Joint Urethane	Smooth-On [link]
Vytaflex 30 Urethane	1	Finger Pad Urethane	Smooth-On [link]
Ø1/4”, L2”, 8-32 female standoff	4	Support	McMaster [93330A483]
Ø1/4”, L1” steel dowel pin	4	Joint/tendon routing pin	McMaster [98381A542]
Ø1/4”, L5/8” steel dowel pin	2	Tendon routing pin	McMaster [98381A539]
Ø1/8”, L5/8” steel dowel pin	8	Tendon routing pin	McMaster [98381A472]
Ø1/8”, L3/8” steel dowel pin	3	Tendon routing pin	McMaster [97395A435]
8-32, L3/4” countersunk bolt	8	Support bolt	McMaster [92210A197]
6-32, L0.15” heat-set insert	2	Insert for gear (NN)	McMaster [94459A280]
6-32, L3/8” socket bolt	2	Fastener for gear (NN)	McMaster [92196A146]
4-40, L0.135” heat-set insert	4 (anchor) + 4 (PP)	Insert for bolt anchors (AO anchor: any small nut)	McMaster [93365A120]
4-40, L1/4” countersunk screw	4 (anchor) + 4 (PP)	Tendon/spring anchors (AO anchor: any small nut)	McMaster [91253A106]
Any small nut	4	Tendon terminator (AO anchor: 4-40 screws and inserts)	
M2, L5mm socket bolt	1	Horn fastener	McMaster [91290a012]
Torsion spring, 0.340” OD, 0.028” wire diameter	2	Return spring (AO: extension springs)	McMaster [9271k605]
Extension spring, 0.188” OD, L3/4”, 0.016” wire diameter	2 + 2 (PP)	Return spring (AO: torsion spring at proximal). 2 required for PP.	McMaster [9654k955]
Ø3/8”, nylon pulley	1	Tendon-routing pulley	McMaster [3434t31]
Dynamixel XM430-W350-R	4	Actuator	Various [Link]

NN – Not Necessary for a well-functioning hand
AO – There exists an Alternative Option for the piece
PP – Required for pivot-pivot precision grasp fingers
PF – Required for pivot-flexure precision grasp fingers

Printed Parts List

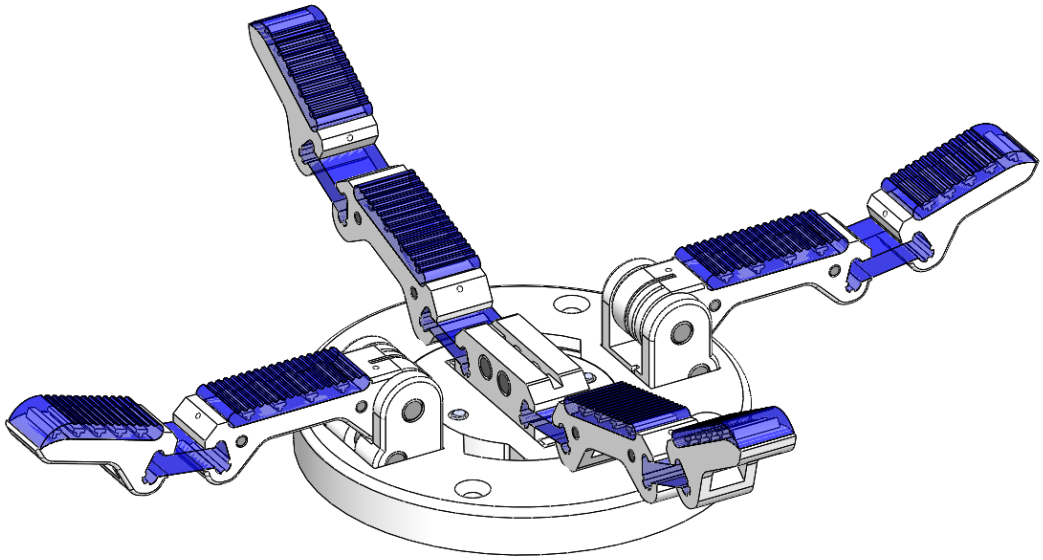
Part Name	Quantity	Description
finger_ffff_q.stl	1	Power grasp fingers cutaway mold
See page 5 for PF finger options - OR - See page 7 for FF finger options	2	
top_outer.stl	1	Structure piece
pivot_base.stl	2	Base for precision fingers
finger_ffff_q.stl	1	Power finger mold
top_inner.stl	1	Base for power fingers
gear_main.stl	1	Main gear for power finger rotation
pulley_block_half.stl	2	Component of pulley block
mid_clamp.stl	1	Structure piece
gear_motor.stl	1	Gear to be attached to motor
horn.stl - OR - horn2.stl	3	Pulley horn
bottom_with_bridge.stl - OR - bottom_no_bridge.stl	1	Structure piece
bottom_reroute.stl	1	Tendon rerouting piece
bottom_brace_insert.stl - OR - bottom_brace_insertv2.stl - OR - bottom_brace_insertv3.stl	1	Arm mounting piece

All files are located in the [OpenHand hardware GitHub page] under model q/stl.

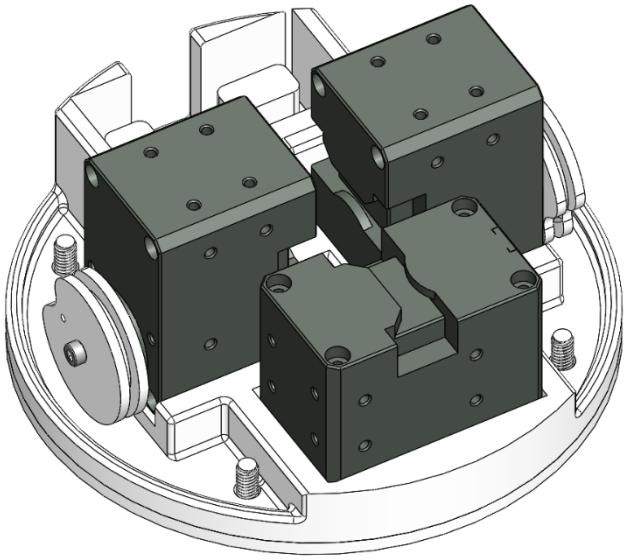
NN – Not Necessary for a well-functioning hand
AO – There exists an Alternative Option for the piece
PP – Required for pivot-pivot precision grasp fingers
PF – Required for pivot-flexure precision grasp fingers

Overview

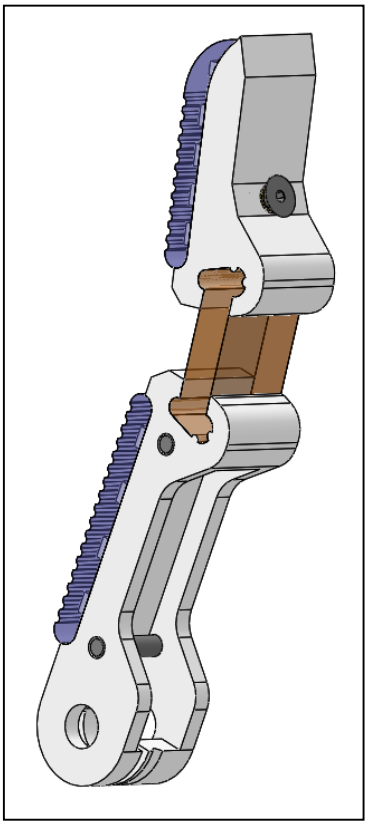
Palm



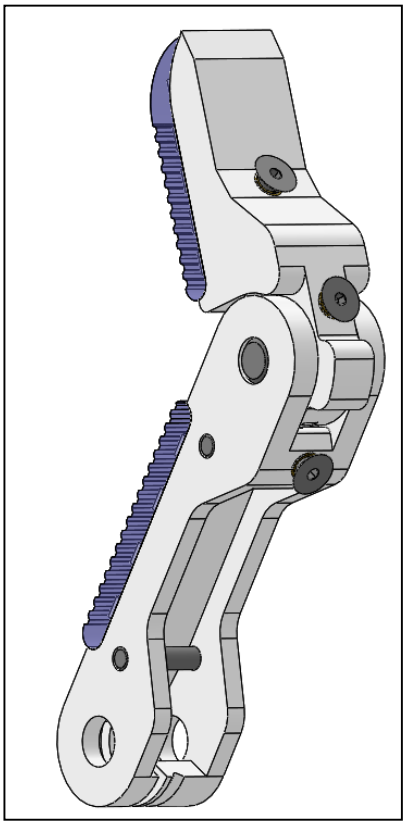
Actuator Base



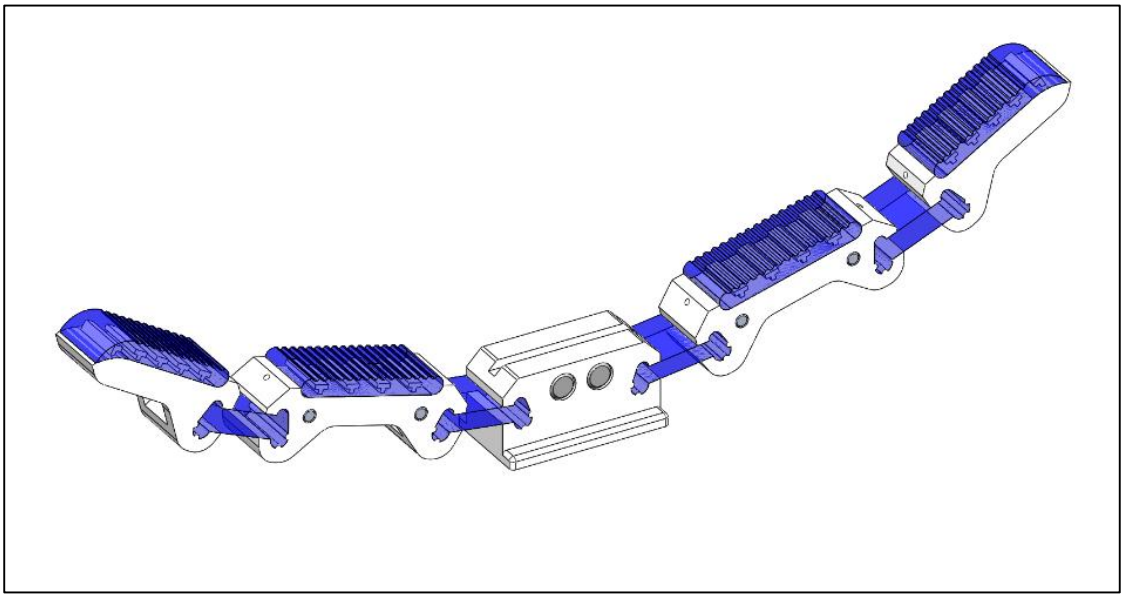
Finger Overview



Precision Pivot-Flexure



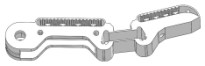
Precision Pivot-Pivot



Power Flexure-Flexure-Flexure-Flexure
(Two fingers combined to make four flexures in series)

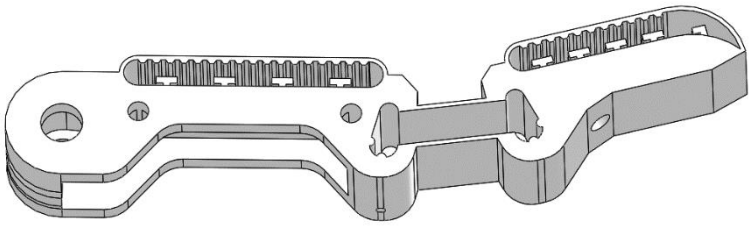
Precision Finger Sub-Assembly

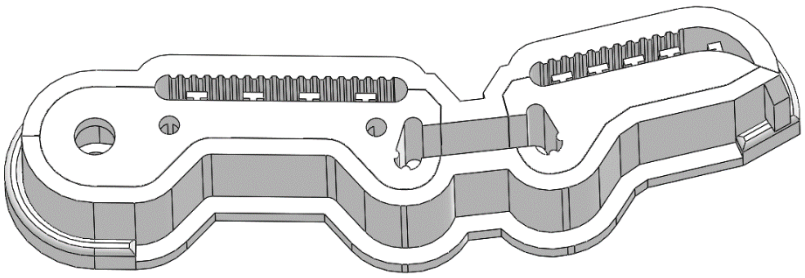
Pivot-Flexure

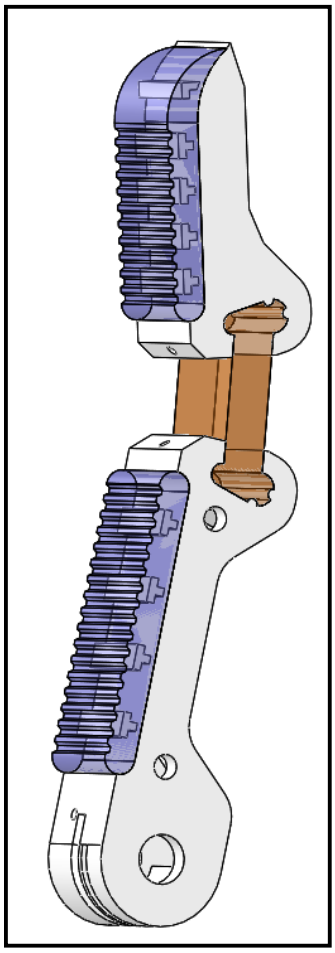
Parts	
finger_pf_torsion_q.stl - or - finger_pf_ext_q.stl - or - finger_pf_mold1_torsion_A_q.stl finger_pf_mold1_B_q.stl finger_pf_mold[2-4]_q.stl - or - finger_pf_mold1_ext_A_q.stl finger_pf_mold1_B_q.stl finger_pf_mold[2-4]_q.stl (x2)	 
PMC-780 (2:1)	
Vytaflex 30 (1:1)	

Go to page 7 for Pivot-Pivot 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.

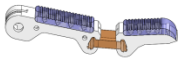




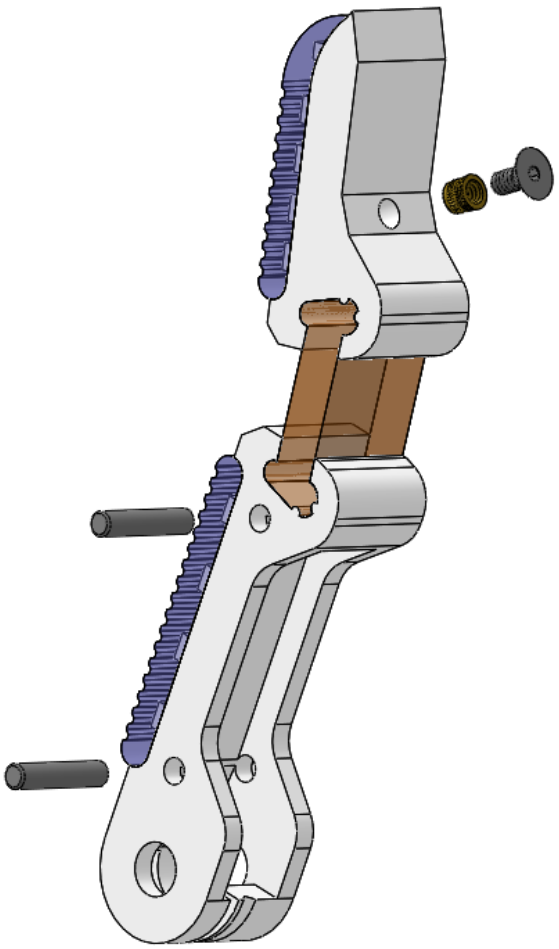


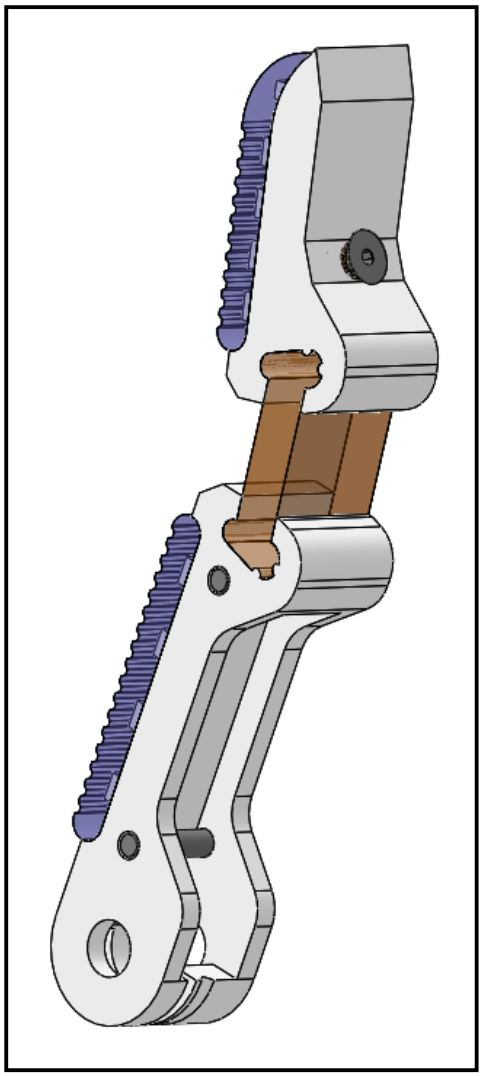
Precision Finger Sub-Assembly

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.

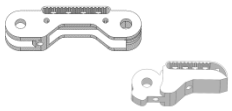


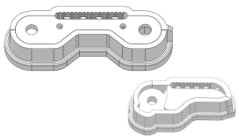


Precision Finger Sub-Assembly

Pivot-Pivot

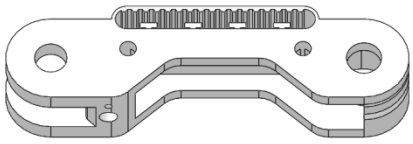
Parts
finger_pp_torsion_A_q.stl finger_pp_B_q.stl - or - finger_pp_ext_A_q.stl finger_pp_B_q.stl - or - finger_pp_torsion_mold1_A_q.stl finger_pp_mold[2-4]_A_q.stl finger_pp_mold1_B_q.stl finger_pp_mold[2-4]_B_q.stl - or - finger_pp_ext_mold1_A_q.stl finger_pp_mold[2-4]_A_q.stl finger_pp_mold1_B_q.stl finger_pp_mold[2-4]_B_q.stl (x4)
Vytaflex 30 (1:1)

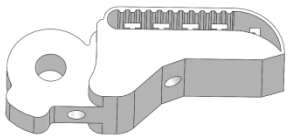


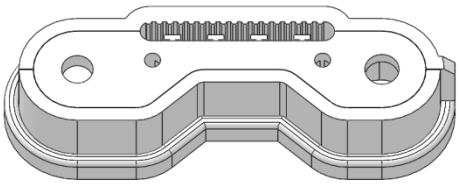


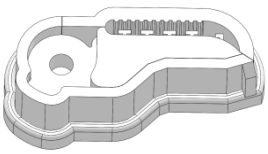
Go back to page 5 for Pivot-Flexure finger sub-assembly

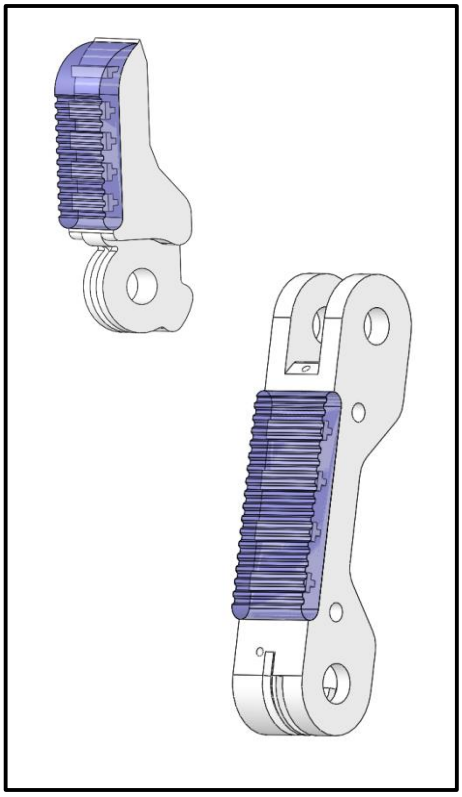
You have a choice of pivot or torsion spring base, and the option of using whether a thin-wall mold or multi-part mold. Refer to the *OpenHand Finger Guide* for more detail on casting these pads. There are no flexures needed for Pivot-Pivot finger design.





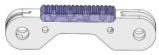
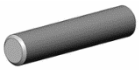






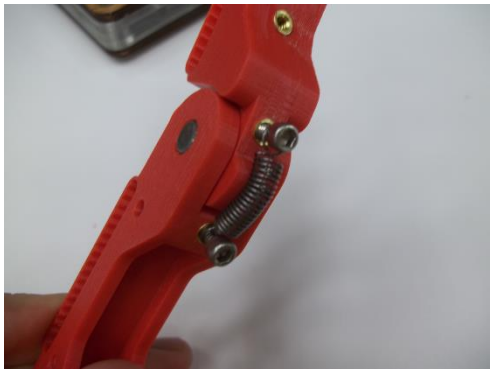
Precision Finger Sub-Assembly

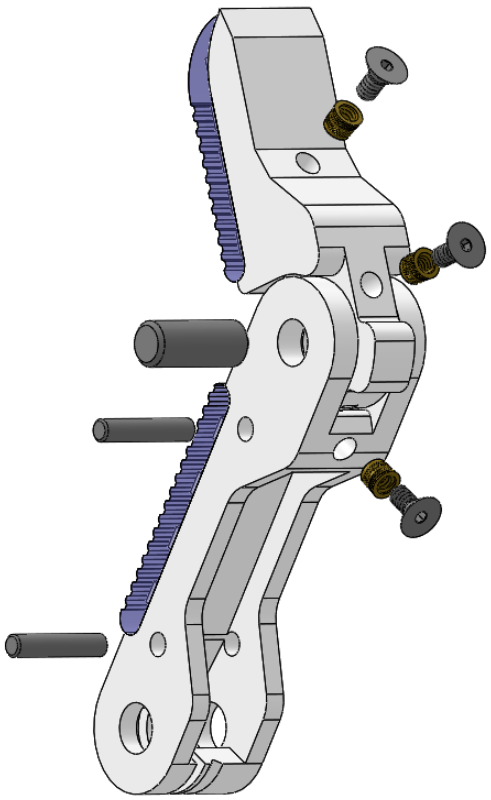
Pivot-Pivot

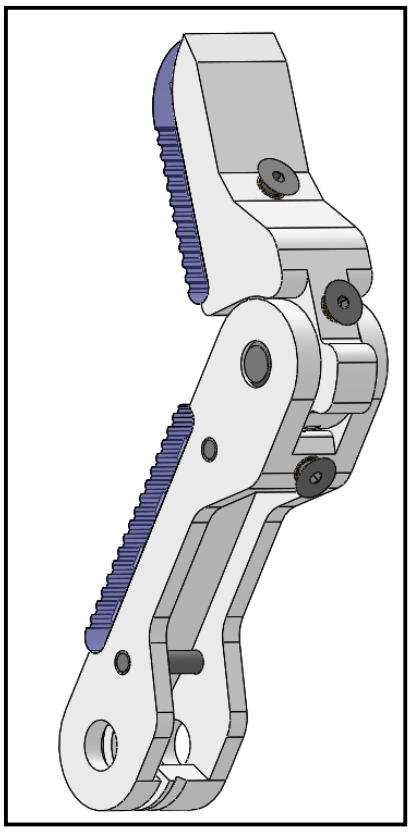
Parts	
Pivot-Pivot finger distal link (x4)	
Pivot-Pivot finger proximal link (x4)	
4-40, L0.135” heat-set insert (x12)	
4-40, L1/4” countersunk screw (x12)	
Ø1/8”, L5/8” steel dowel pin (x8)	
Ø1/4”, L5/8” steel dowel pin (x4)	
Extension spring (x4)	

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.



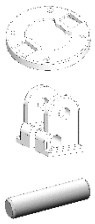




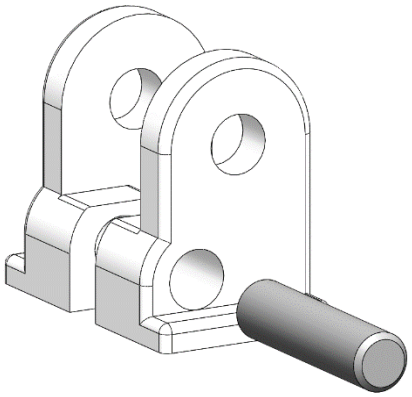
Precision Finger Sub-Assembly

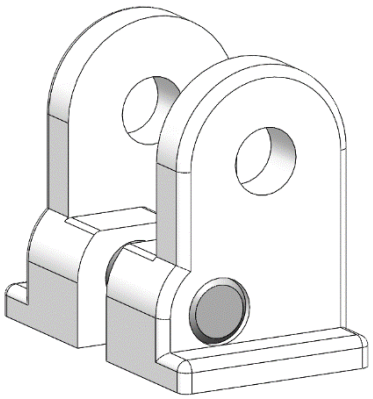
Pivot-Flexure or Pivot-Pivot

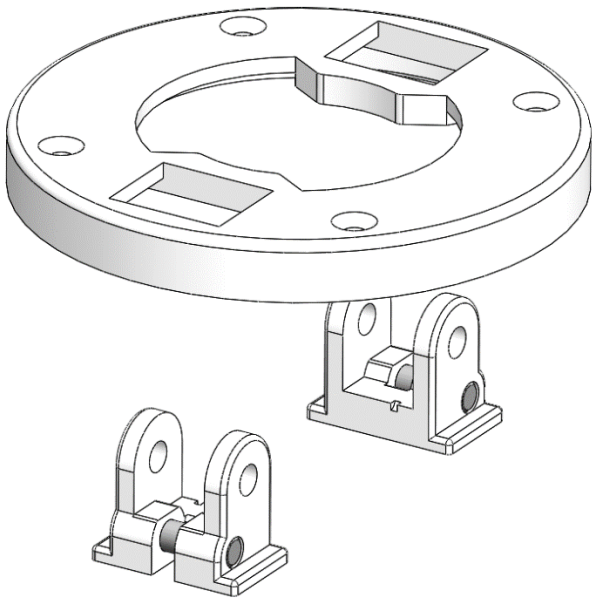
Parts	
top_outer.stl	(x1)
pivot_base.stl	(x2)
Ø1/4”, L1” steel dowel pin	(x2)

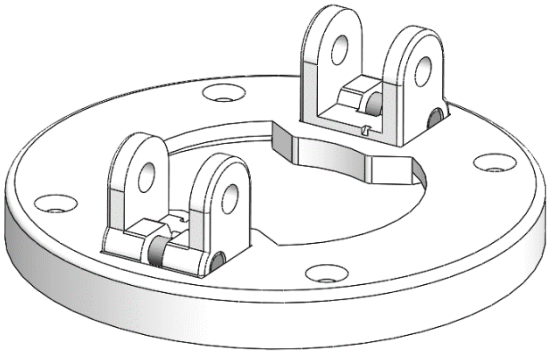


For either the Pivot-Flexure or Pivot-Pivot fingers, the support sub-assembly is the same. Ensure that each pivot base is placed in the correct direction (lower dowel on outer side).



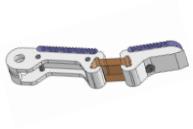
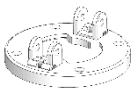
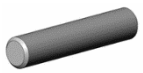
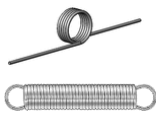






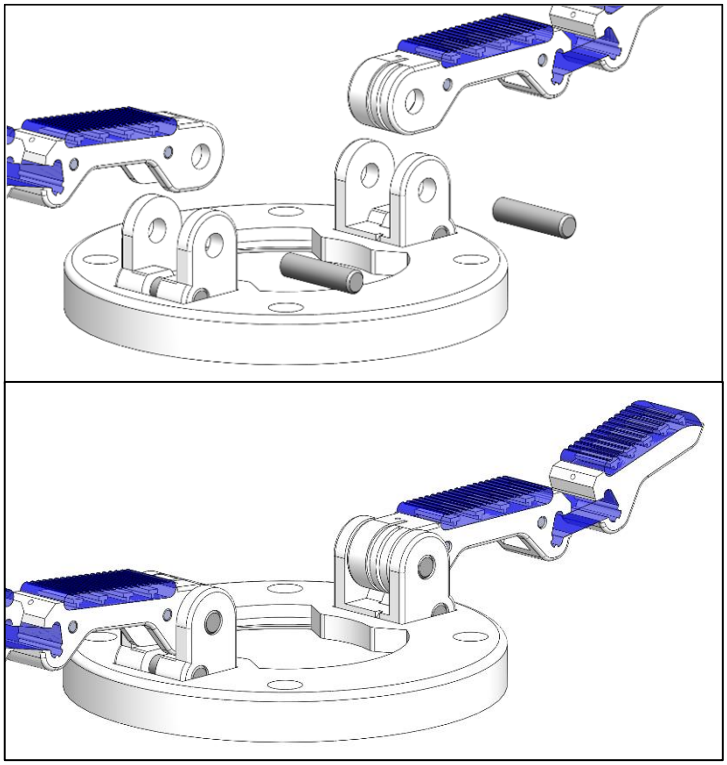
Precision Finger Sub-Assembly

Pivot-Flexure or Pivot-Pivot

Parts	
Pivot-Flexure finger sub-assembly - or - Pivot-Pivot finger sub-assembly (x2)	
top sub-assembly from previous page	
Ø1/4”, L1” steel dowel pin (x2)	
Torsion spring - or - Extension spring (x2)	

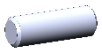
For either the Pivot-Flexure or Pivot-Pivot fingers, the installation into the *pivot_base.stl* is the same. The finger is held in place by a press-fit 1/4” steel dowel pin. Refer to the *OpenHand Finger Guide* for how to install the torsion spring or extension spring at the base joint.

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



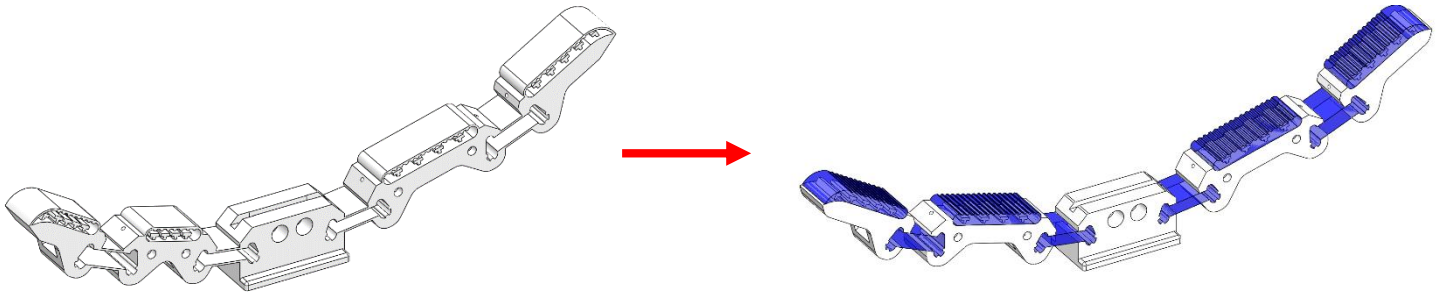
Power Fingers Sub-Assembly

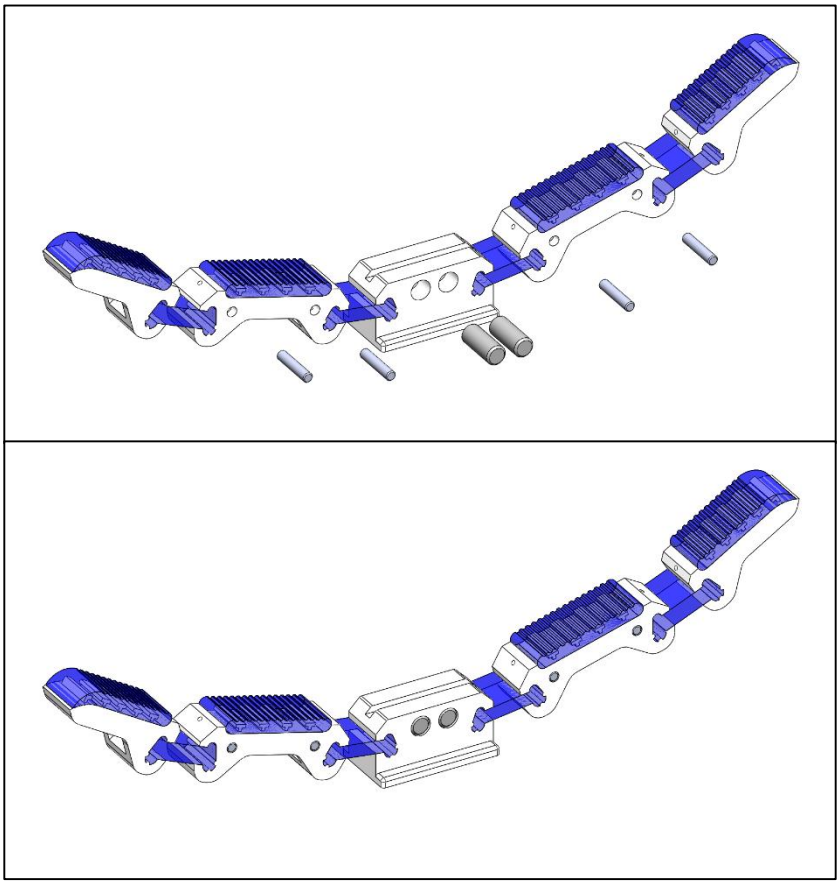
Flexure-Flexure-Flexure-Flexure

Parts	
finger_ffff_q.stl (x1)	
PMC-780 (2:1)	
Vytaflex 30 (1:1)	
Ø1/4”, L5/8” steel dowel pin (x2)	
Ø1/8”, L5/8” steel dowel pin (x4)	

Refer to the *OpenHand Finger Guide* for more detail on casting these pads and flexures. Press-fit 1/4” dowels are used as tendon routing pins.

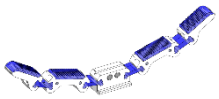
If you choose to use heat-set inserts for tendon termination, refer to page 6.





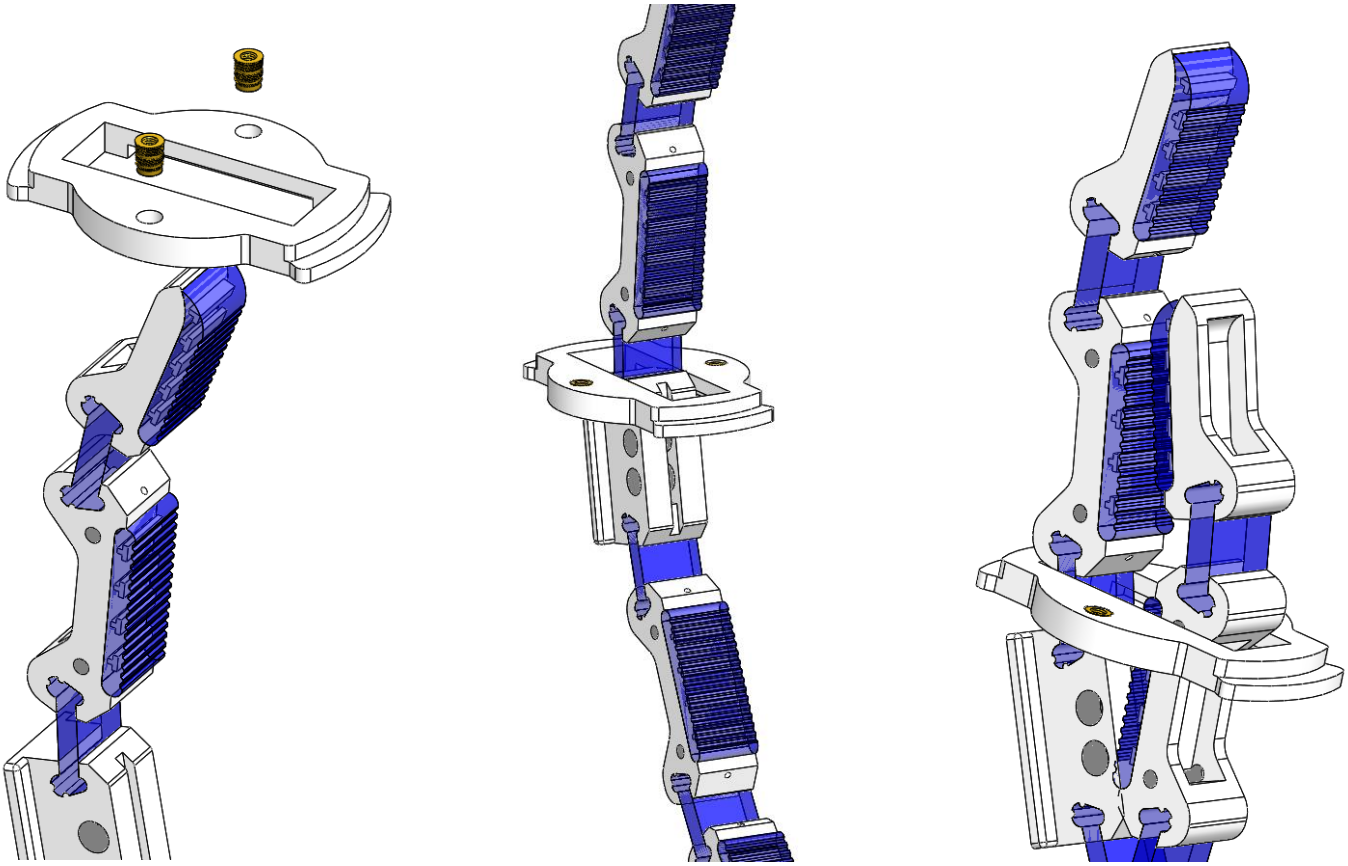
Power Fingers Sub-Assembly

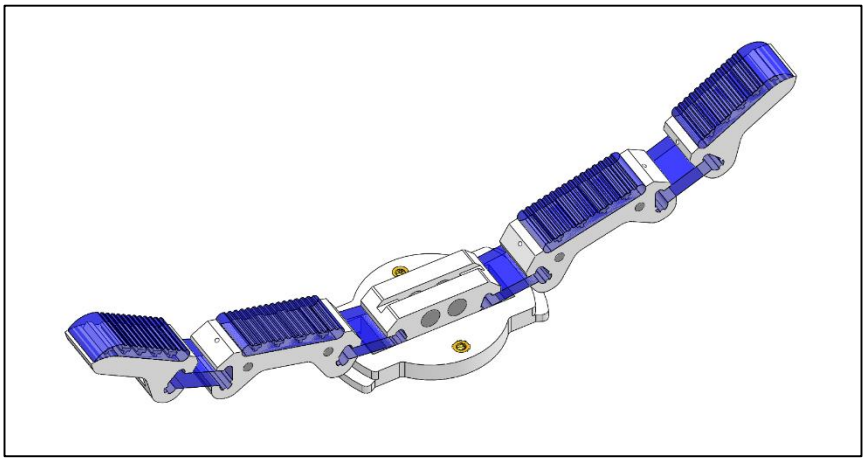
Flexure-Flexure-Flexure-Flexure

Parts	
Power fingers sub-assembly from previous page (x1)	
top_inner.stl (x1)	
6-32 heat-set insert (x2)	

Use a soldering iron to install the heat-set inserts into the *top_inner.stl* piece. You will need to bend some of the flexure joints to force the fingers through the hole.

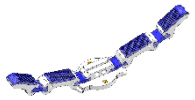
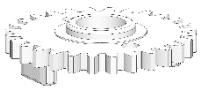
The heat-set inserts are used to hold the rotation gear to *top_inner.stl*, but the hand operates well even without them.

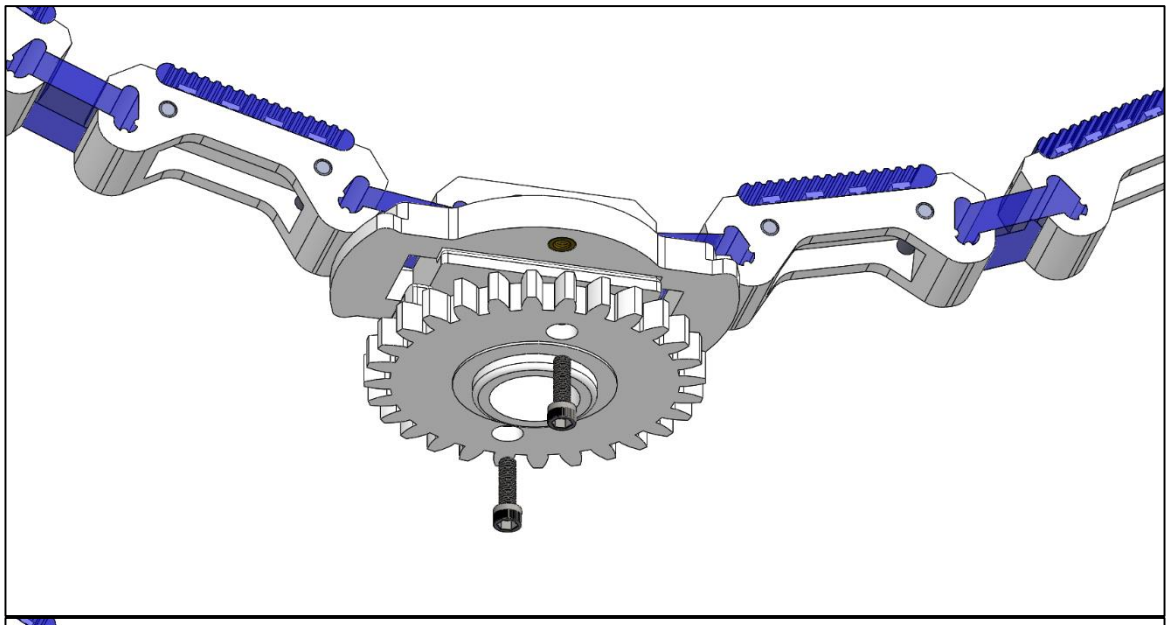


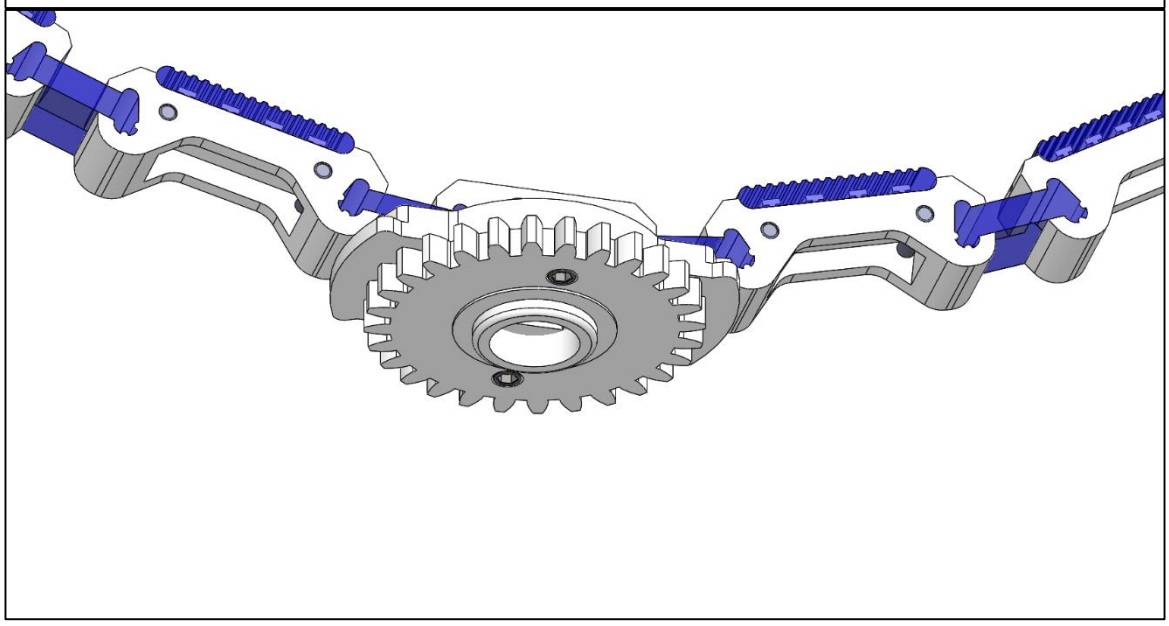


Power Fingers Sub-Assembly

Flexure-Flexure-Flexure-Flexure

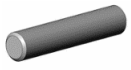
Parts	
Power fingers sub-assembly from previous page (x1)	
gear_main.stl (x1)	
6-32, L3/8” socket head screw (x2)	



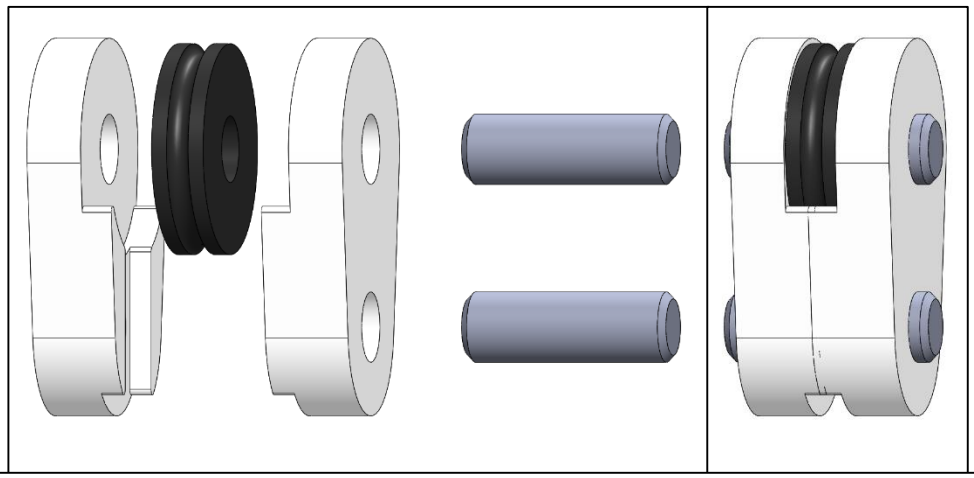


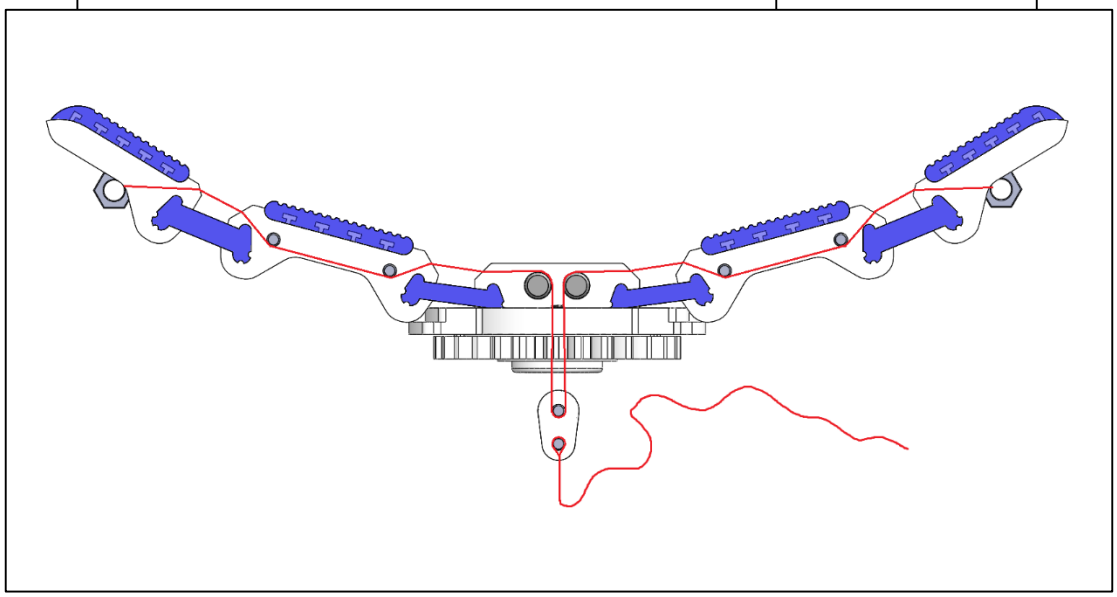
Power Fingers Sub-Assembly

Pulley Block

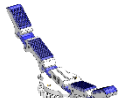
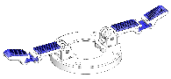
Parts	
pulley_block_half.stl (x2)	
Ø3/8”, nylon pulley (x1)	
Ø1/8”, L3/8” steel dowel pin (x2)	
Power fingers sub-assembly from previous page (x1)	
Spectra tendon line	
Nut (any small size) (x2)	

The terminating nuts can be replaced with heat-set inserts and screws. When stringing, the pulley block can be raised closer to the gear while keeping the string taut for a tighter resting hand position. Leave dangling string (about 8”) on the bottom end of the pulley block for future steps.

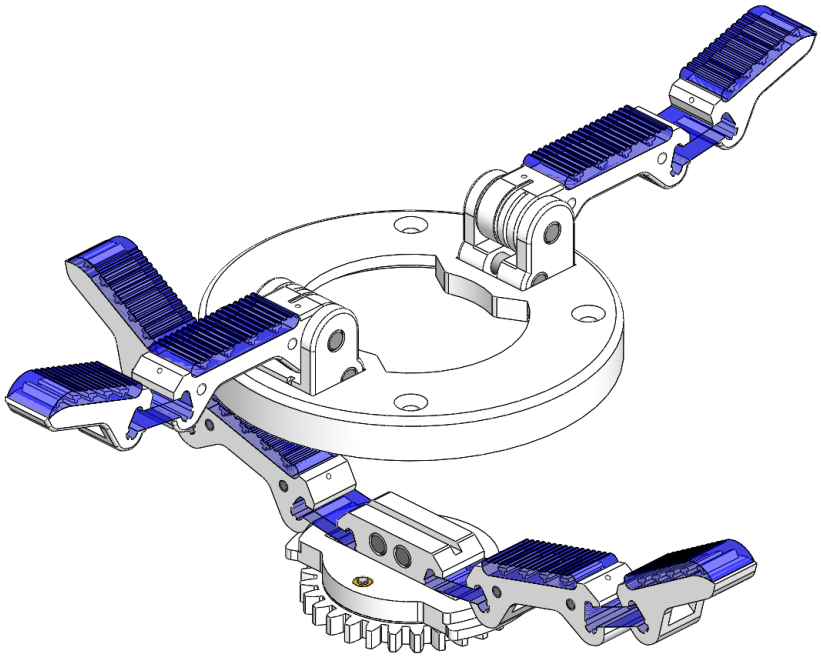


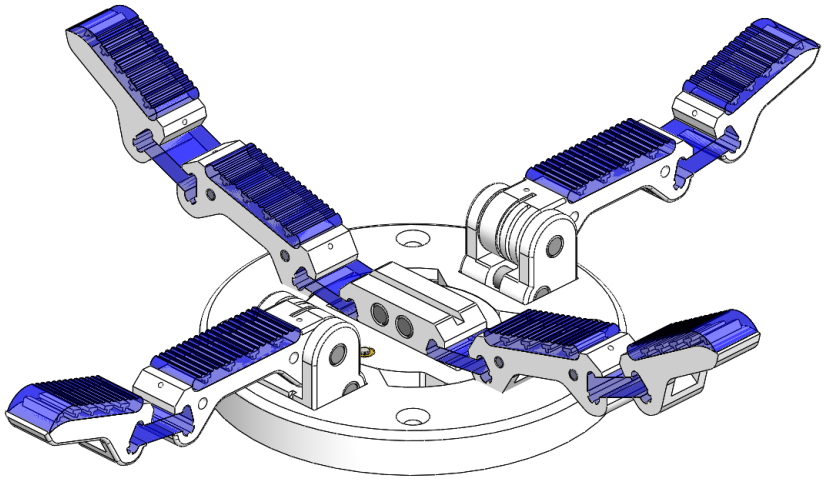


Fingers Sub-Assembly

Parts	
Power fingers sub-assembly from previous page (x1)	
Finger base sub-assembly from page 9 (x1)	

Fit the power fingers sub-assembly through the palm base piece. Again, you will have to bend the flexures to fit through the hole.



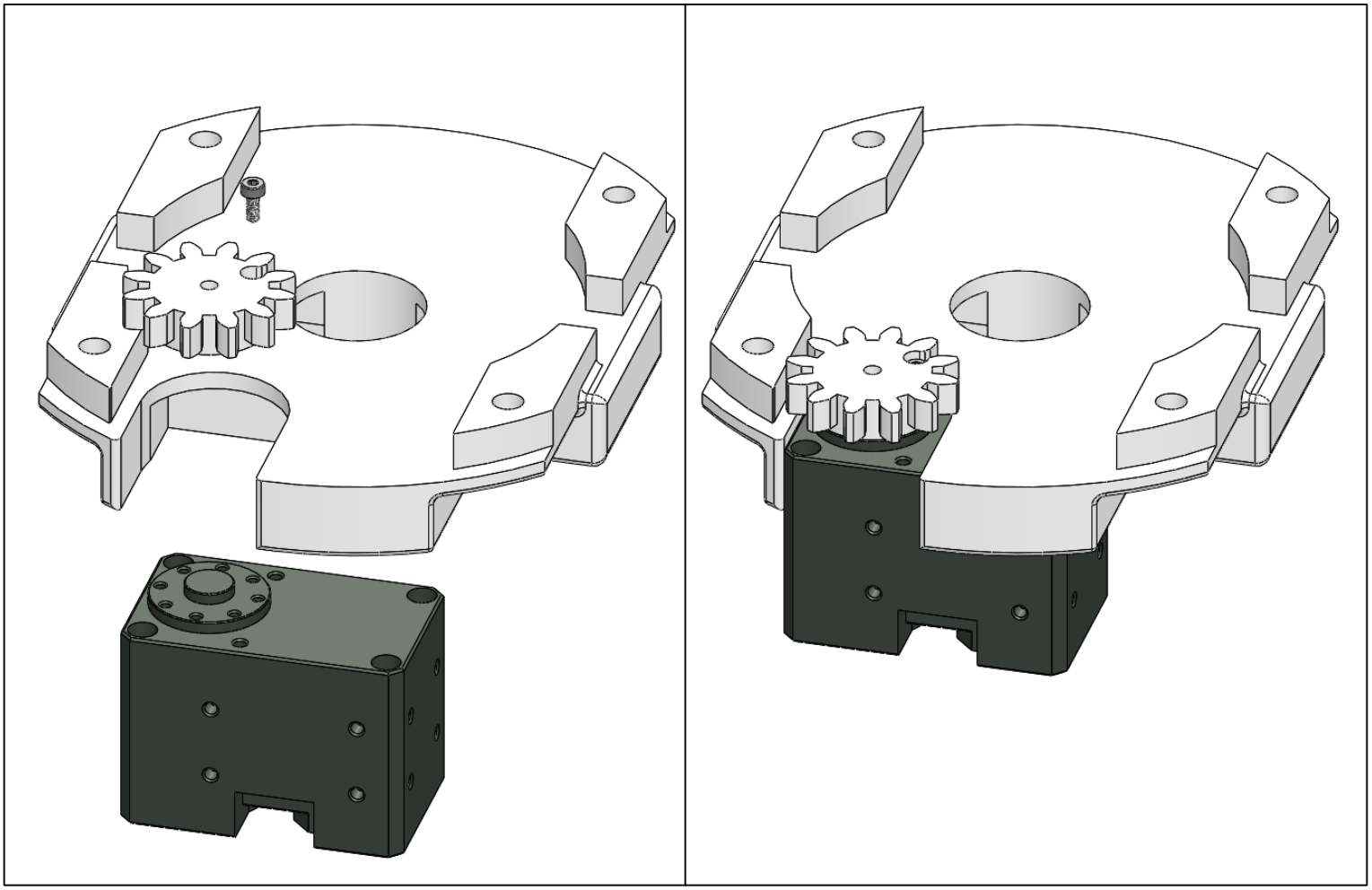


Inner Gearing Sub-Assembly

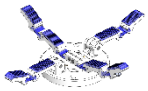
Parts	
mid_clamp.stl (x1)	
gear_drive3_xm430.stl (x1)	
Dynamixel XM430 (x1)	
M2, L5mm socket head screw (x1)	

Be sure to assemble the pieces in the order presented in the diagram.

The screw may have to thread itself into the gear. In this case, firmly hold the gear in place against the actuator horn face while tightening the bolt, preventing a gap from forming between the gear and horn.

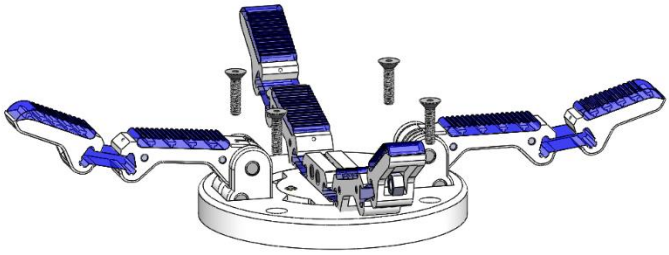


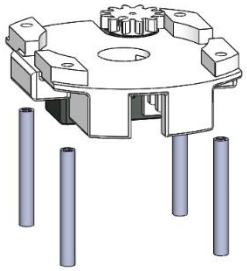
Upper Hand Sub-Assembly

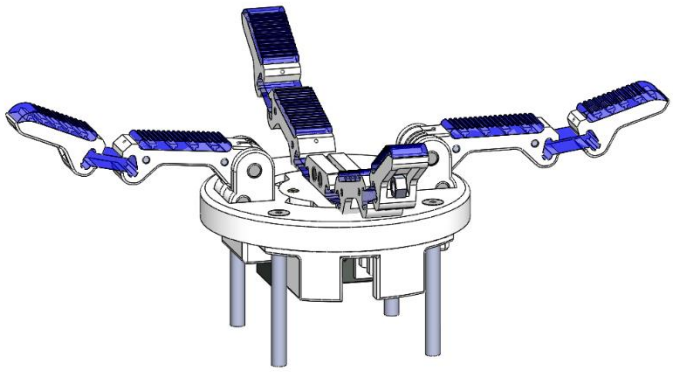
Parts	
Fingers sub-assembly from page 14 (x1)	
Inner gearing sub-assembly from page 15 (x1)	
8-32, L3/4” countersunk bolt (x4)	
Ø1/4”, L2”, 8-32 zinc-plated female standoff (x4)	

The palm and the inner gearing are held together by the countersunk bolts and the standoffs. When aligning the two sub-assemblies together, ensure the actuator is underneath one side of the power-gripping fingers. Doing this aligns each of the precision fingers with a vertical actuator.

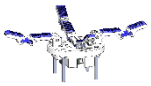
The loose string should go through the center hole in the inner gearing sub-assembly.





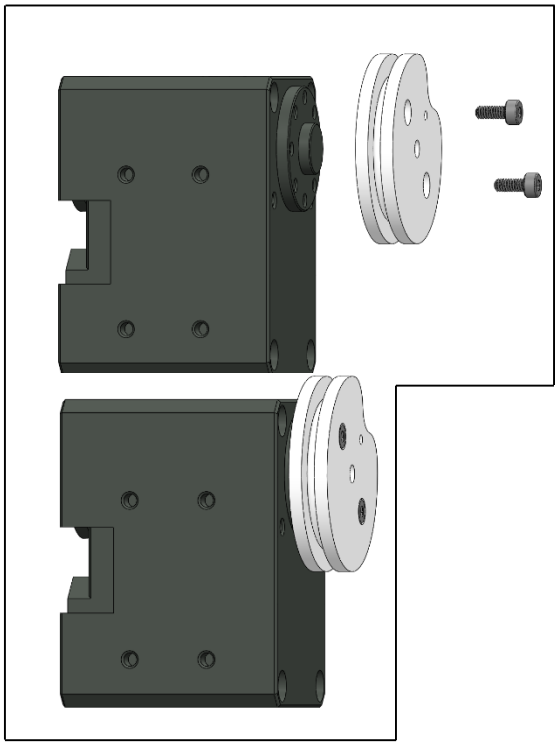


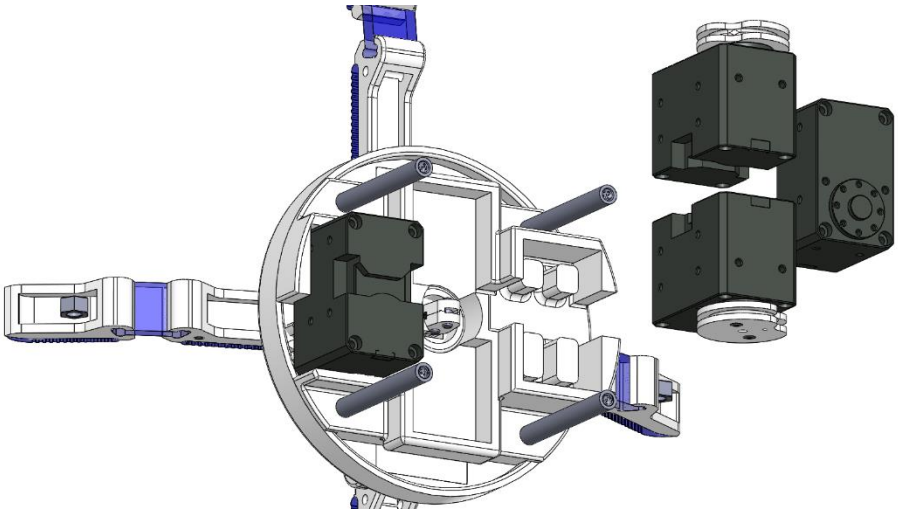
Actuator Sub-Assembly

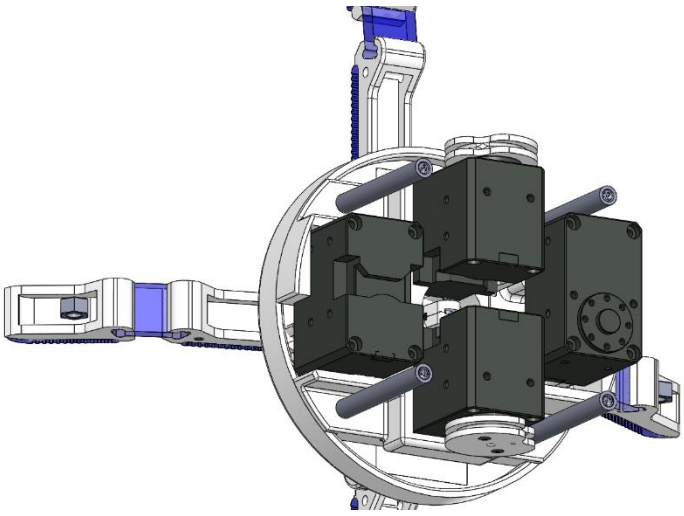
Parts	
Dynamixel XM430 (x3)	
horn2.stl (x2)	
M2, L5mm socket head screw (x4)	
Upper hand sub-assembly from previous page (x1)	

For two of the servos, install the pulley horn *horn2.stl*. The third servo will have the same pulley horn installed in a future step.

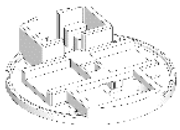
This step is the easiest for installing the wires. You can install the precision finger tendons (page 21) for open access to the horns, but this step can also be done after completion of the hand.



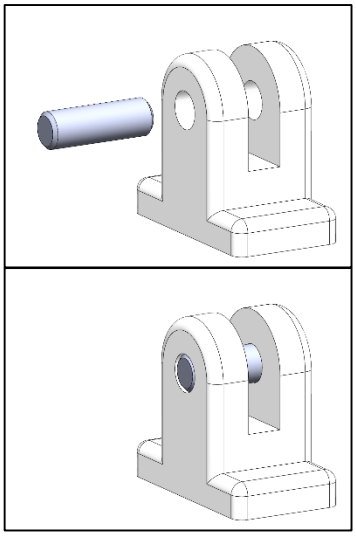


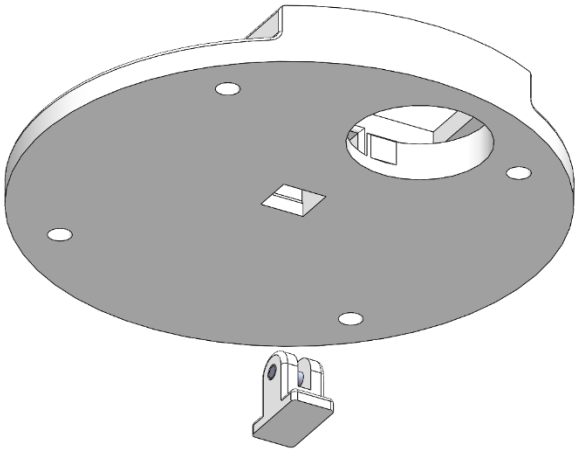


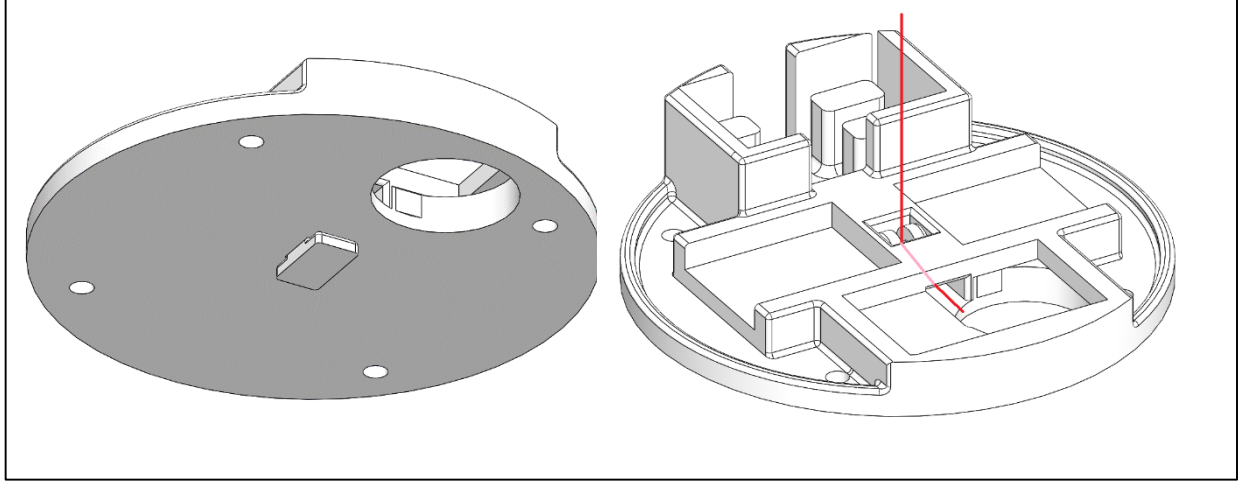
Actuator Sub-Assembly

Parts	
bottom_no_bridge.stl - OR - bottom_with_bridge.stl (x1)	
bottom_reroute.stl (x1)	
Ø1/8”, L3/8” steel dowel pin (x1)	

Ensure that *bottom_reroute.stl* is inserted such that a string from the circular horn hole can run directly to the reroute piece.







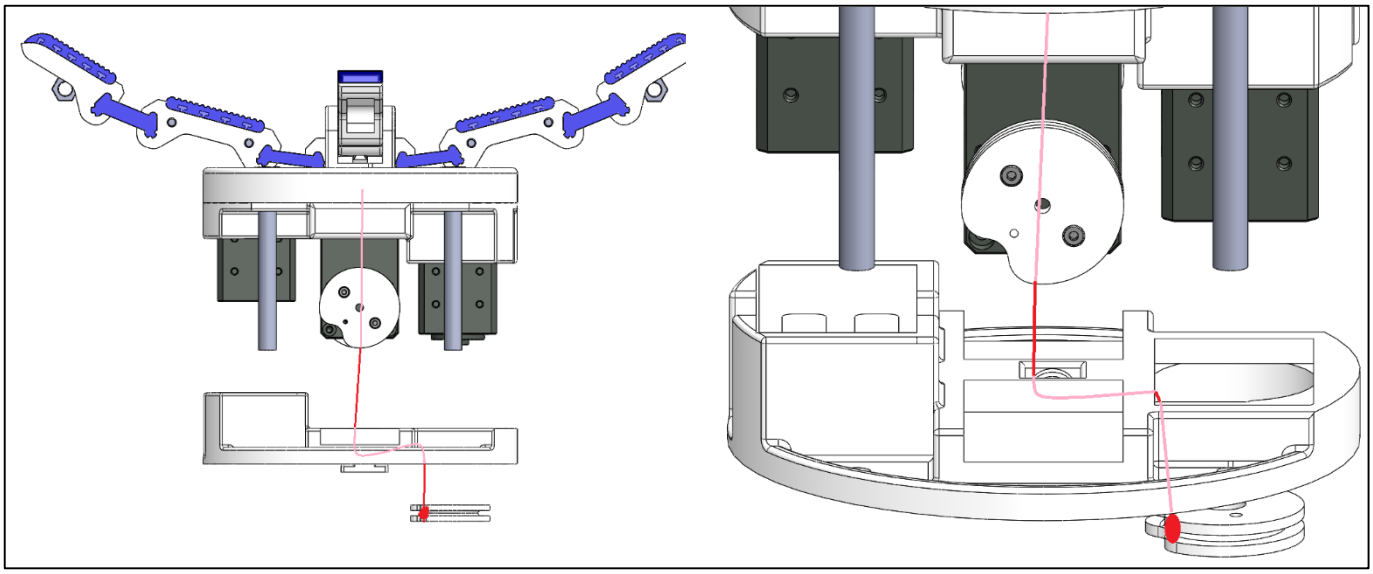
Final Assembly

Parts	
Bottom piece from previous page (x1)	
Upper hand from page 17 (x1)	
horn.stl - OR - horn2.stl (x1)	
M2, L5mm socket head screw (x2)	
Spectra tendon line	

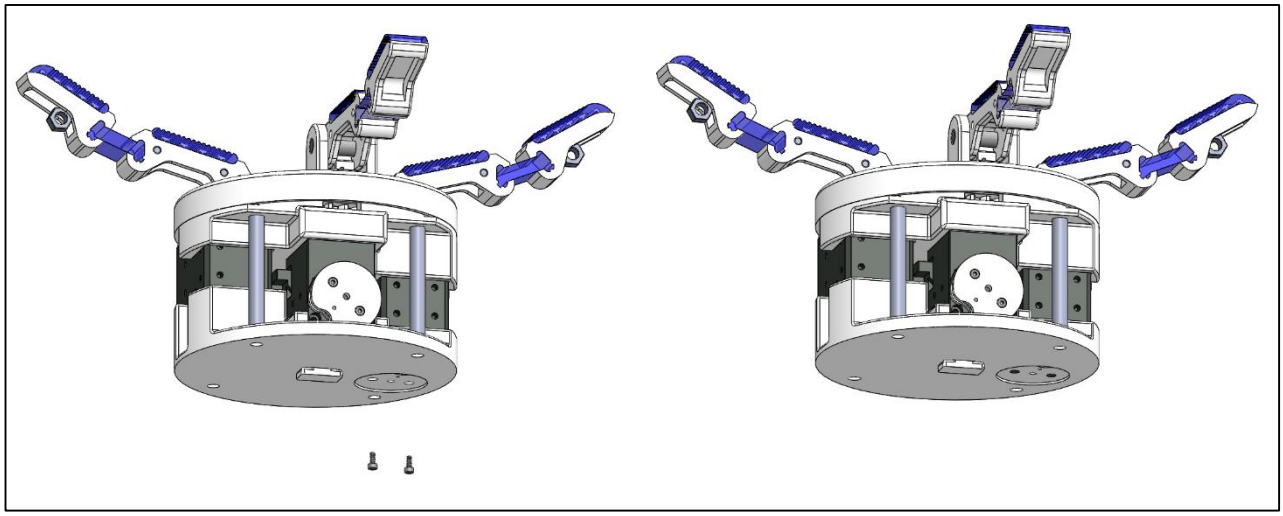
The stringing in this step must be completed while all three components are held separately from each other.

If you're using *bottom_with_bridge.stl*, run the line through the bridge next to the bottom reroute piece.

Any slack in the line can be eliminated by freely spinning the printed horn before attaching it to the motor. Be sure the line is wrapped around the horn in a manner such that it creates a direct line to the rerouting block.

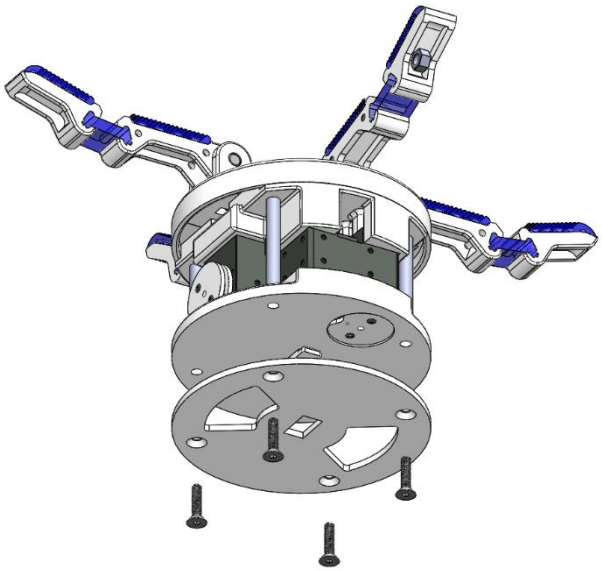


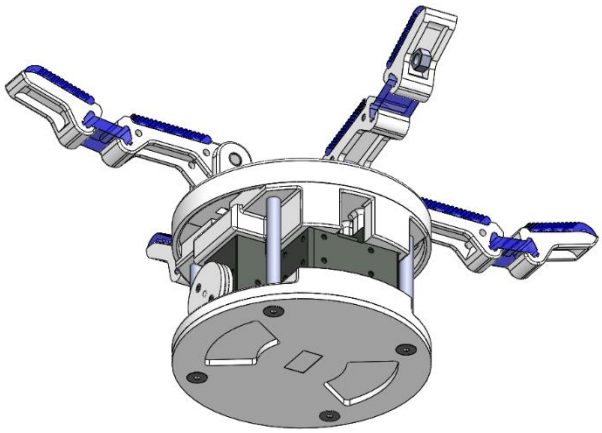
After stringing:



Final Assembly

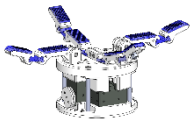
Parts	
Hand from previous page (x1)	
bottom_brace_insert.stl - or - bottom_brace_insertv2.stl - or - bottom_brace_insertv3.stl (x1)	
8-32, L3/4” countersunk bolt (x4)	





Precision Finger Stringing

Pivot-Flexure or Pivot-Pivot

Parts	
Completed hand from previous page - or - Upper hand from page 17 (x1)	
Spectra tendon line	
Nut (any small size) (x2)	

The terminating nuts can be replaced with heat-set inserts and screws.