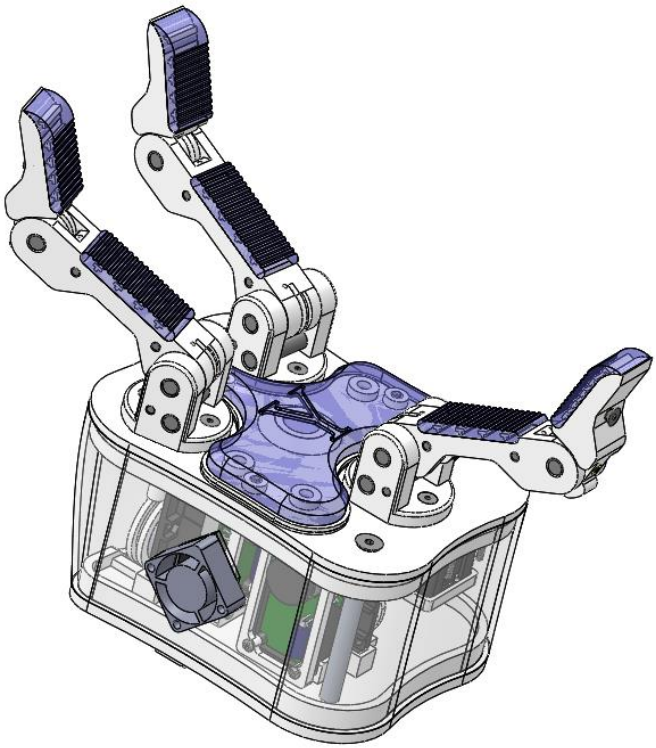
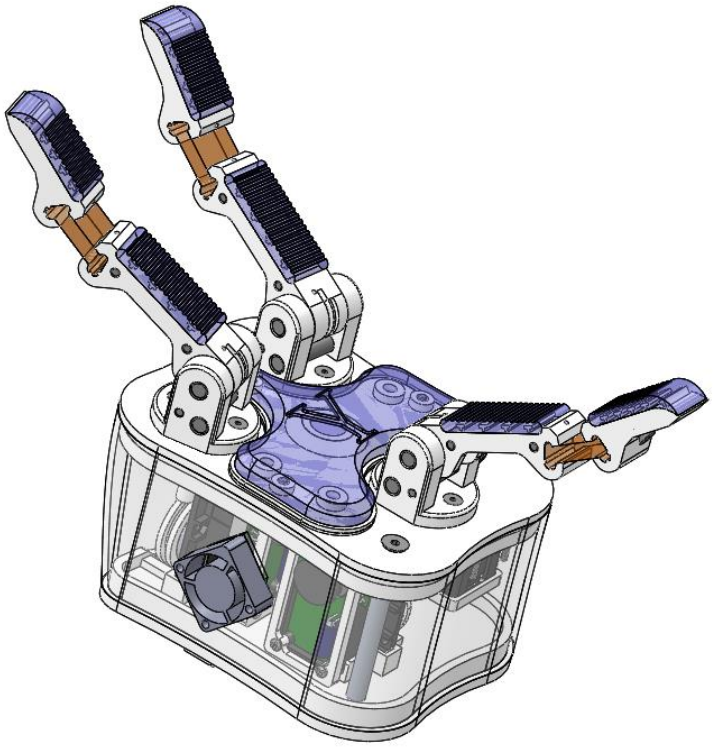
OpenHand

Model O

Version 1.0





Assembly Instructions

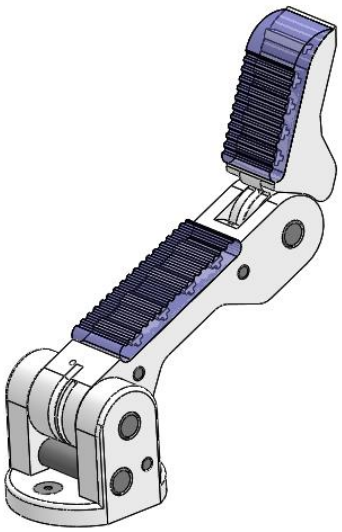
Last updated: February 22, 2015

OTS Parts List

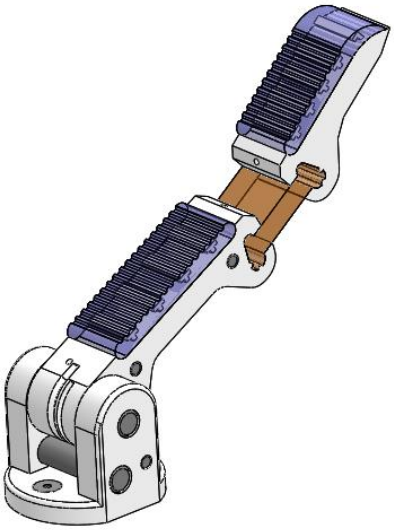
Part Name	Quantity	Description	Vendor
Power Pro Spectra	1	Tendon	Amazon [link]
PMC-780 Urethane	1	Finger Joint Urethane	Smooth-On [link]
Vytaflex 30 Urethane	1	Finger Pad Urethane	Smooth-On [link]
Ø1/4”, L2”, 8-32 zinc-plated female standoff	4	Support	McMaster [93330A483]
Ø1/4”, L1-1/4” steel dowel pin	6	Joint pin	McMaster [98381a544]
Ø1/4”, L5/8” steel dowel pin	3	Joint pin for Pivot-Pivot	McMaster [98381A539]
Ø1/8”, L1-1/4” steel dowel pin	3	Routing pin	McMaster [98381A477]
Ø1/8”, L5/8” steel dowel pin	6	Tendon routing pin	McMaster [98381A472]
8-32, L3/4” countersunk bolt	8	Support bolt	McMaster [92210A197]
M2.5, L8mm bolt	3	Center bolt for Dynamixel (included w/ Dynamixel)	McMaster [91292A012]
M2, L5mm bolt	6	Mounting bolts for Dynamixel	McMaster [91290A012]
M2, L3mm bolt	2	Mounting bolts Dynamixel	McMaster [91292A003]
4-40, L0.135” heat-set insert	17	Insert for bolt anchors	McMaster [93365A120]
4-40, L1/4” countersunk screw	4	Tendon/spring anchors	McMaster [91253A106]
4-40, L1/2” countersunk screw	8	Fastener for palm	McMaster [91253A110]
2-56, L3/4” socket bolt	6	Fastener	McMaster [92196A084]
2-56 nut	6	Fastener	McMaster [90480A003]
Torsion spring, 0.340” OD, 0.028” wire diameter	3	Return spring, alternative to extension springs	McMaster [9271k605]
Extension spring, 0.188” OD, L3/4”, 0.016” wire diameter	6	Return spring, alternative to torsion spring at proximal	McMaster [9654k955]
Dynamixel RX/MX-28, or RX24-F	4	Actuator	Various [Link]
Sunon DC 25x25x10mm Fan 12V	1	Cooling fan for Dynamixel	Various [259-1570-ND]

Overview

Finger Options

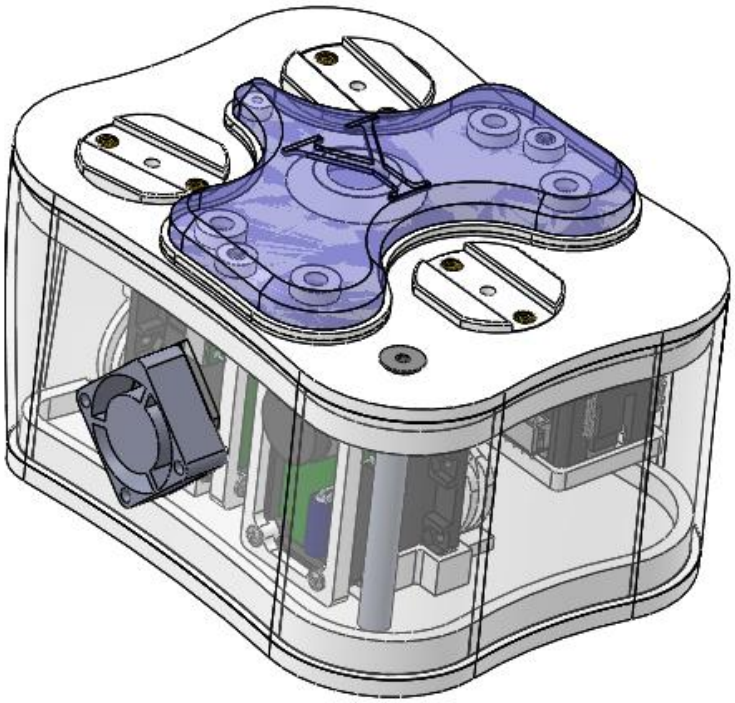


Pivot-Pivot



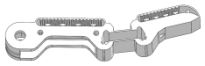
Pivot-Flexure

Actuator Base



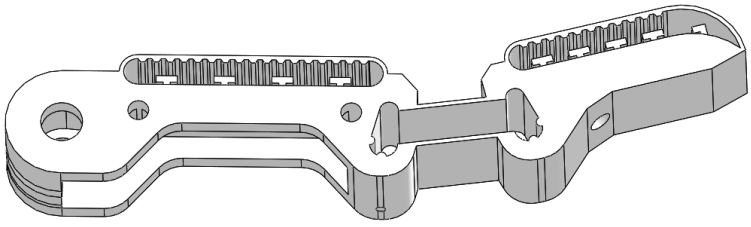
Finger Sub-Assembly

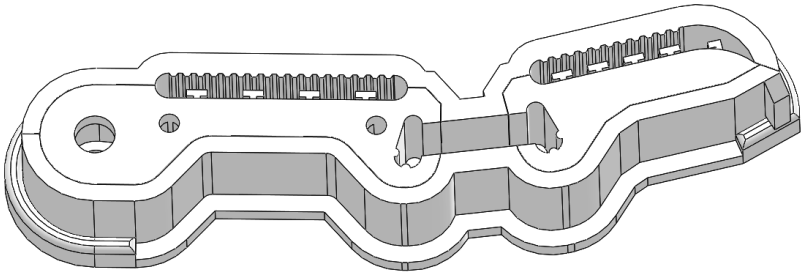
PIVOT-FLEXURE

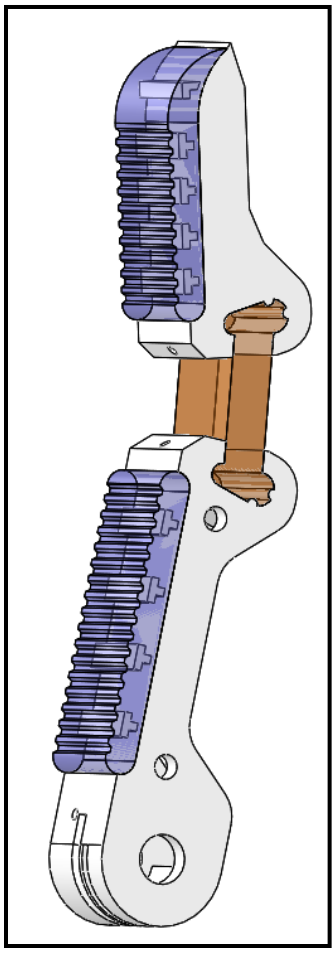
Parts	
finger_pf_torsion_o.stl - or - finger_pf_ext_o.stl - or - finger_pf_mold1_torsion_A_o.stl finger_pf_mold1_B_o.stl finger_pf_mold[2-4]_o.stl - or - finger_pf_mold1_ext_A_o.stl finger_pf_mold1_B_o.stl finger_pf_mold[2-4]_o.stl (x3)	 
PMC-780 (2:1)	
Vytaflex 30 (1:1)	

Go to page 5 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

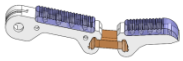




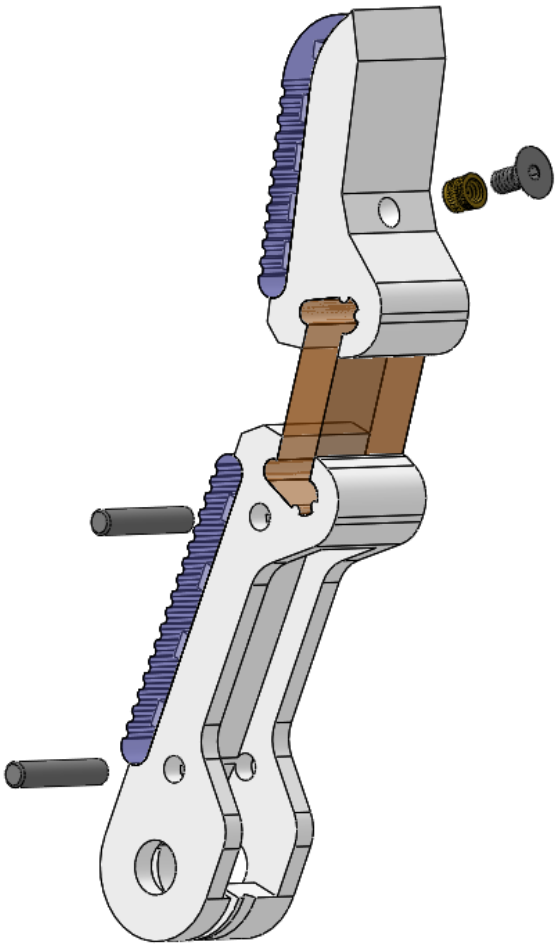


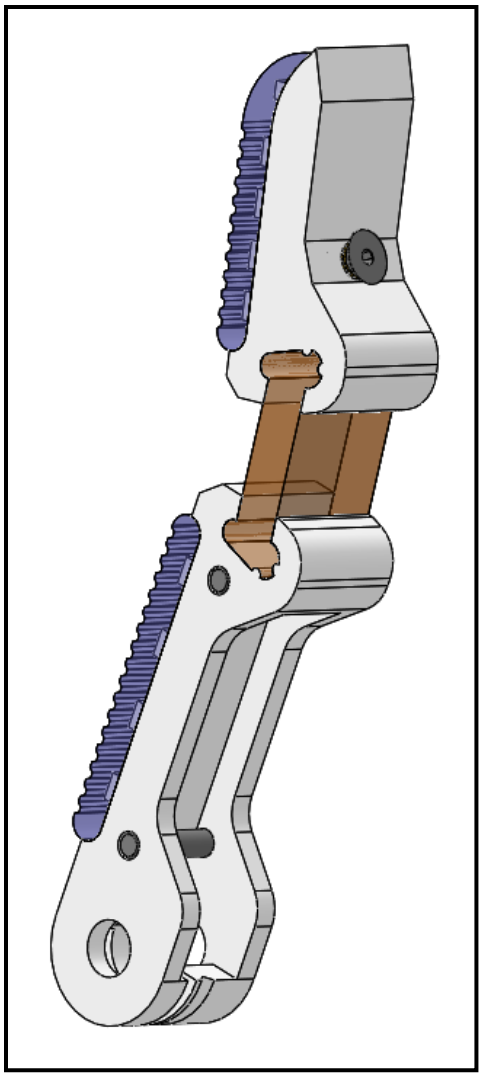
Finger Sub-Assembly

PIVOT-FLEXURE

Parts	
Pivot-Flexure Forefinger (x3)	
4-40, L0.135” heat-set insert (x3)	
4-40, L1/4” countersunk screw (x3)	
Ø1/8”, L5/8” steel dowel pin (x6)	

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.



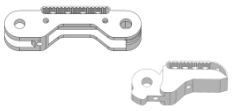


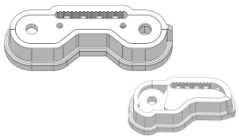
Skip to page 7

FINGER SUB-ASSEMBLY

PIVOT-PIVOT

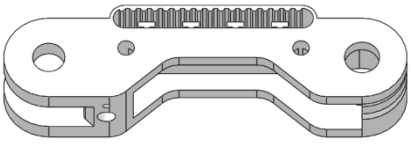
Parts
finger_pp_torsion_A_o.stl finger_pp_B_o.stl - or - finger_pp_ext__A_o.stl finger_pp_B_o.stl - or - finger_pp_torsion_mold1_A_o.stl finger_pp_mold[2-4]_A_o.stl finger_pp_mold1_B_o.stl finger_pp_mold[2-4]_B_o.stl - or - finger_pp_ext_mold1_A_o.stl finger_pp_mold[2-4]_A_o.stl finger_pp_mold1_B_o.stl finger_pp_mold[2-4]_B_o.stl (x3)
Vytaflex 30 (1:1)

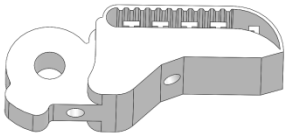


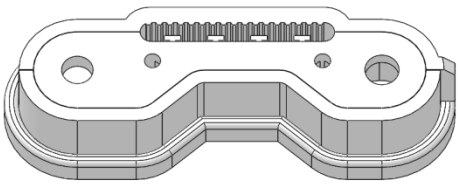


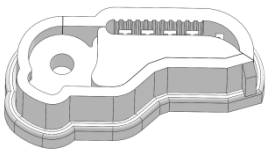
Go back to page 3 for Pivot-Flexure Forefinger sub-assembly

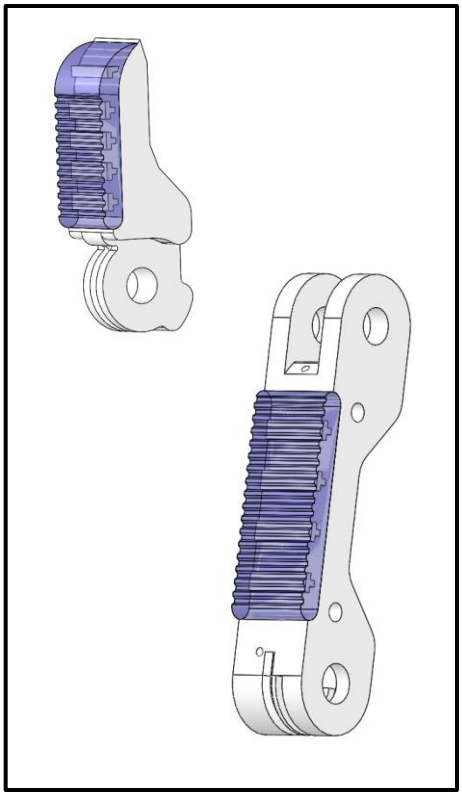
You have a choice of pivot or torsion spring base, and the option of using whether a thin-wall mold or multi-part mold. Refer to the *OpenHand Finger Guide* for more detail on casting these pads. There are no flexures needed for Pivot-Pivot finger design





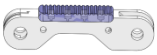
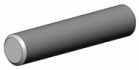






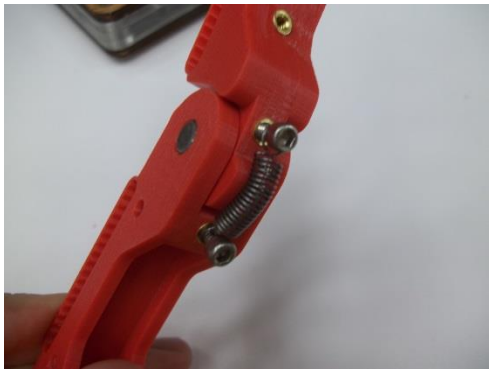
Finger Sub-Assembly

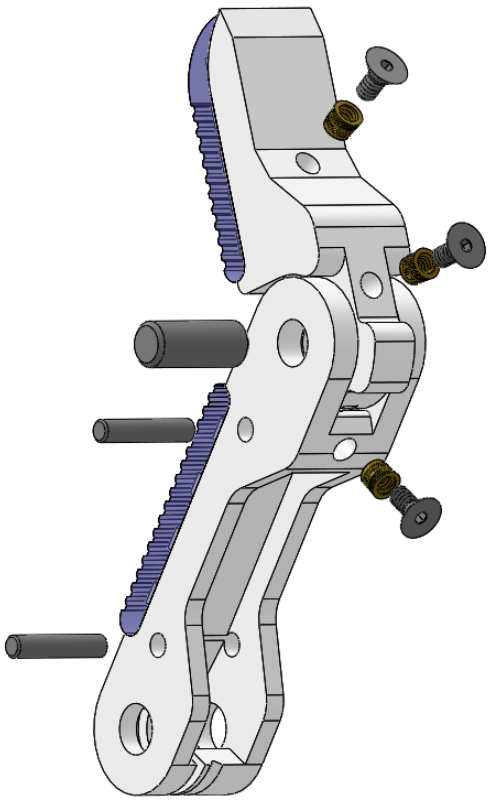
PIVOT-PIVOT

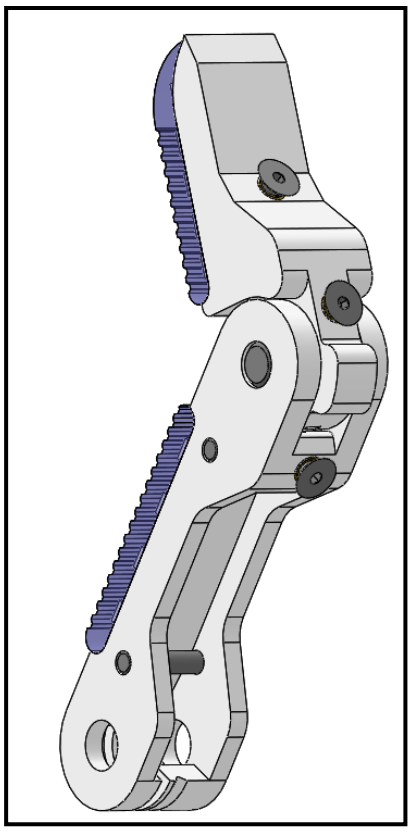
Parts	
Pivot-Pivot finger distal link (x3)	
Pivot-Pivot finger proximal link (x3)	
4-40, L0.135” heat-set insert (x9)	
4-40, L1/4” countersunk screw (x9)	
Ø1/8”, L5/8” steel dowel pin (x6)	
Ø1/4”, L5/8” steel dowel pin (x3)	
Extension spring (x3)	

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.



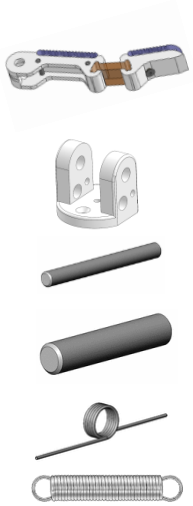




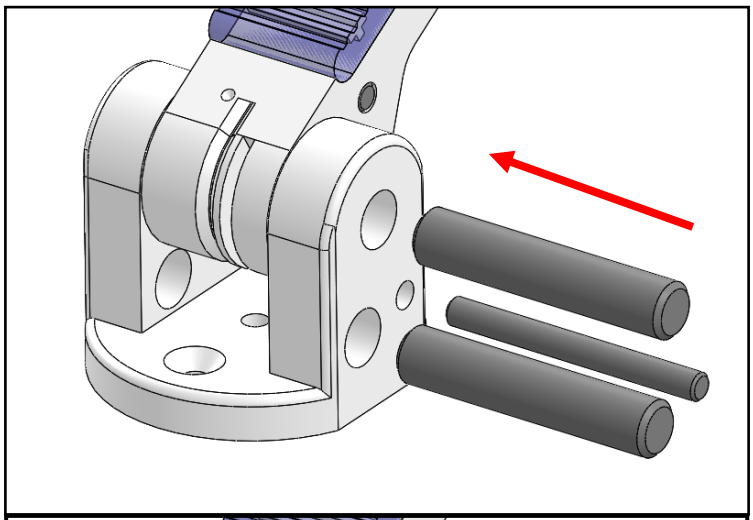
FINGER SUB-ASSEMBLY

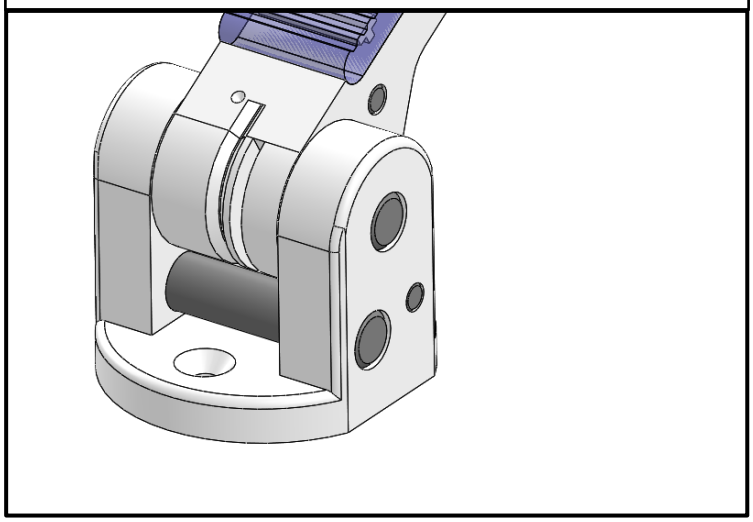
PIVOT-FLEXURE OF PIVOT-PIVOT

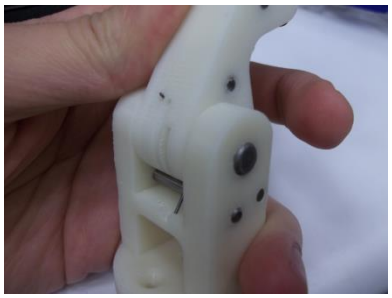
Parts
Pivot-Flexure finger sub-assembly - or - Pivot-Pivot finger sub-assembly (x3)
c1_o.stl (x3)
Ø1/8”, L1-1/4” steel dowel pin (x3)
Ø1/4”, L1-1/4” steel dowel pin (x6)
Torsion spring - or - Extension spring (x3)

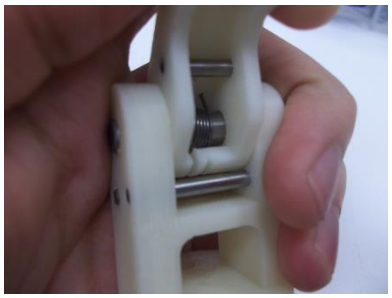


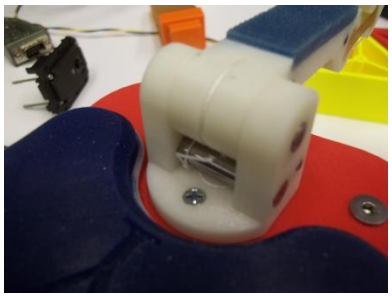
For either the Pivot-Flexure or Pivot-Pivot fingers, the installation onto the base part *c1_o.stl* is the same. The finger is held in place by a press-fit 1/4” steel dowel pin.











Actuator Sub-Assembly

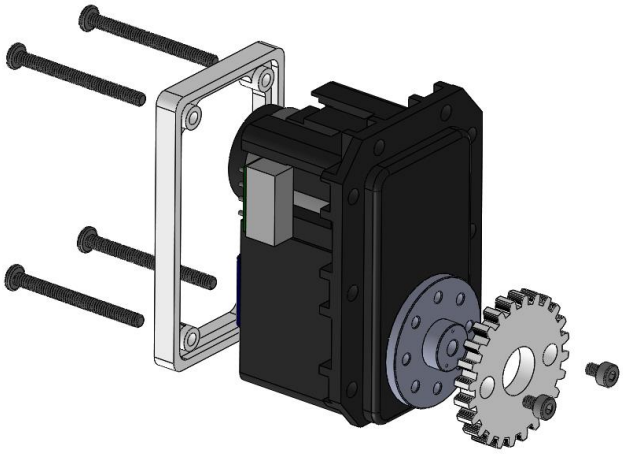
DYNAMIXEL PREPARATION

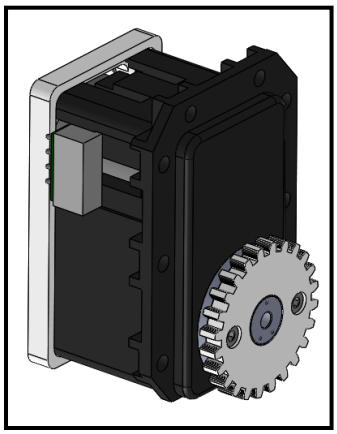
Parts	
Dynamixel RX/MX-28 or RX-24F (x4)	
d2_o.stl (x4)	
b1_o.stl (x3)	
b2_o.stl	
M2.5, L8mm bolt (x3)	
M2, L5mm bolt (x8)	
M2, L3mm bolt (x2)	

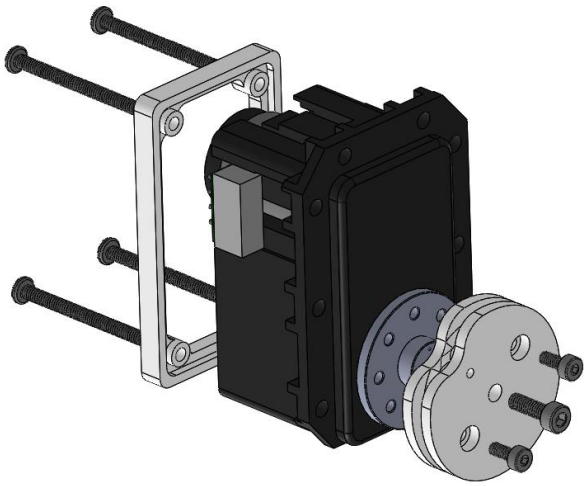
Remove the back plate to all of the Dynamixels and replace it with *d2_o.stl*. These are attached with the same default screws that come with the Dynamixel.

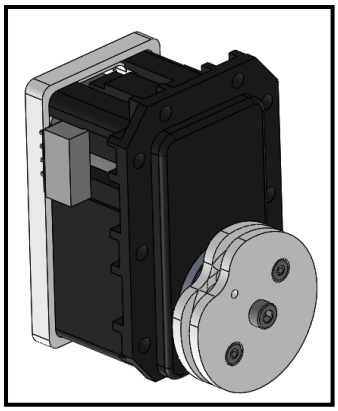
For three of the servos, install the drive pulley part *b1_o.stl*. For the remaining servo, install the gear part *b2_o.stl*.

At this step, you can also tie about a foot (~30cm) of tendon to each of the drive pulleys.



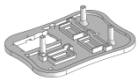




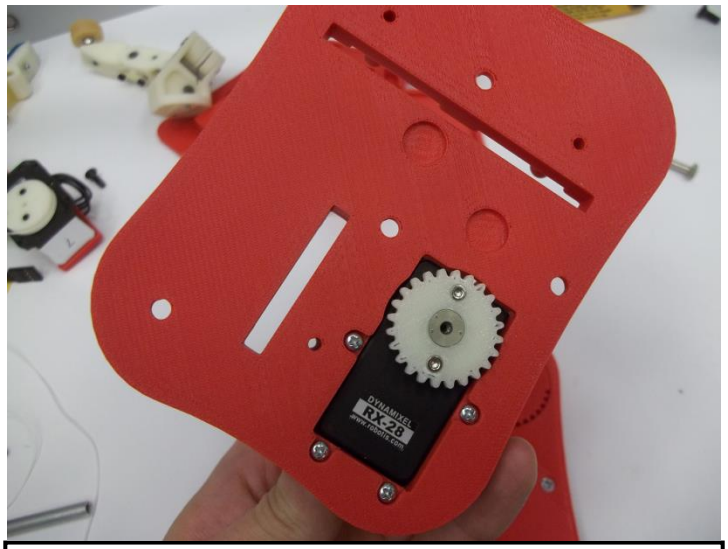


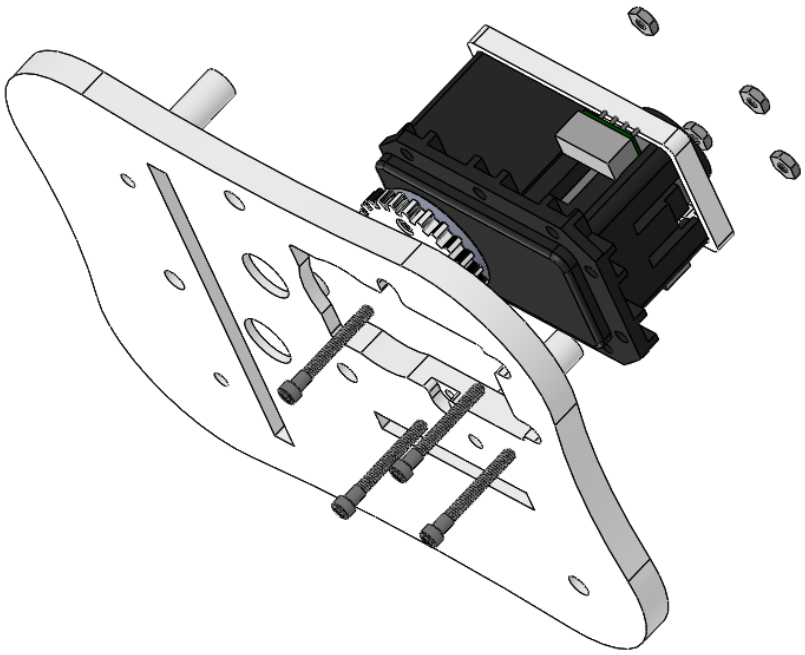
Actuator Sub-Assembly

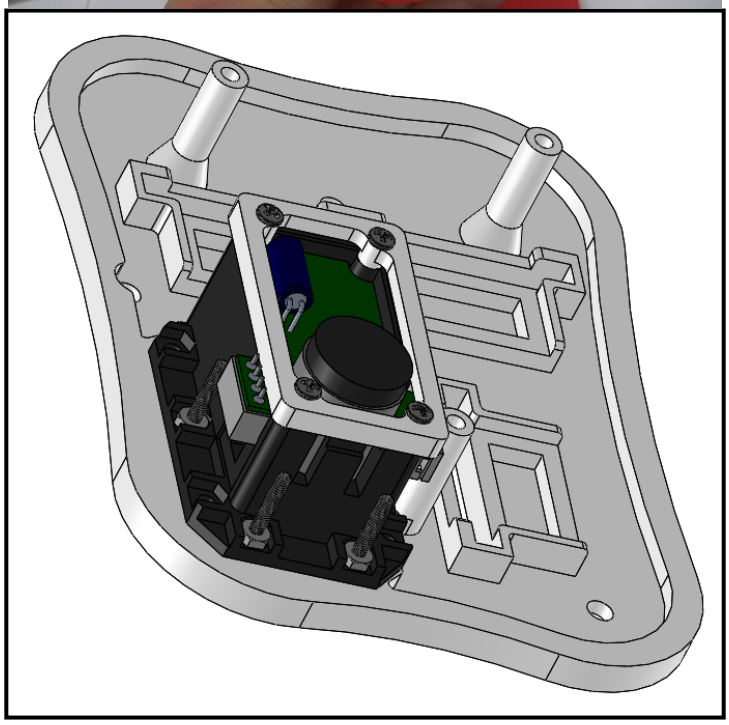
GEARED DYNAMIXEL

Parts	
Dynamixel w/ gear from previous page	
2-56, L3/4" socket bolt (x4)	
2-56 nut (x4)	
a2_o.stl	

The sub-assembly with Dynamixel and gear is attached to the secondary top plate *a2_o.stl* with 2-56 bolts and nuts. The Dynamixel is locked in via the fastener features on its front frame.



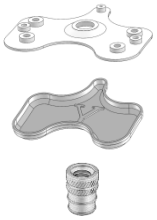




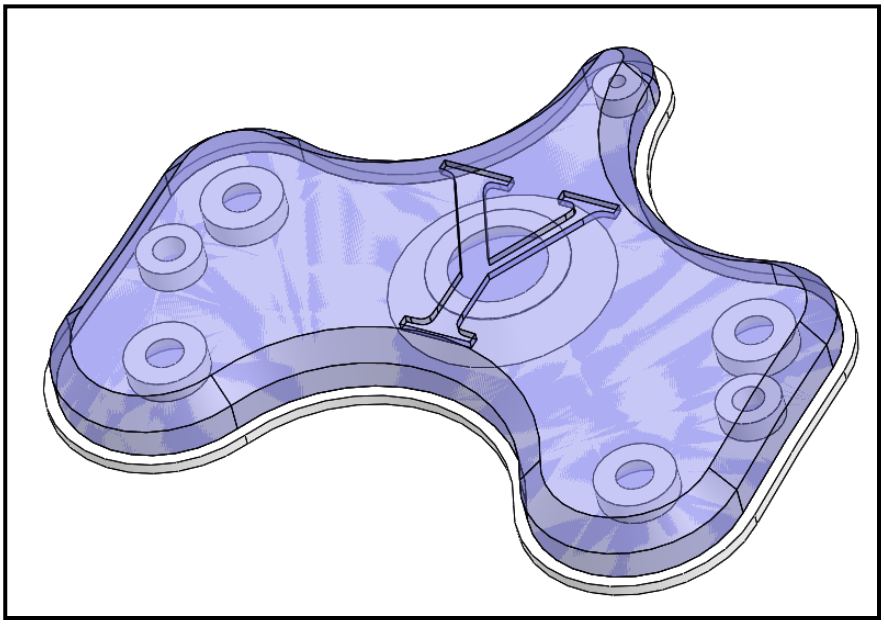
Actuator Sub-Assembly

PALM PAD

Parts
d3_base_o.stl
d3_mold1_o.stl
4-40, L0.135” heat-set insert (x3)
Vytaflex 30 (1:1)

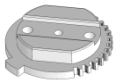


The palm pad is option, but it’s a nice feature to have. Before pouring the mold, install the heated-inserts onto *d3_base_o.stl*. To cast the palm, tape the two mold halves together and place is such that *d3_base_o.stl* is on top. Pour the Vytaflex through the openings, enough so that the urethane is just short of filling up to the top surface.

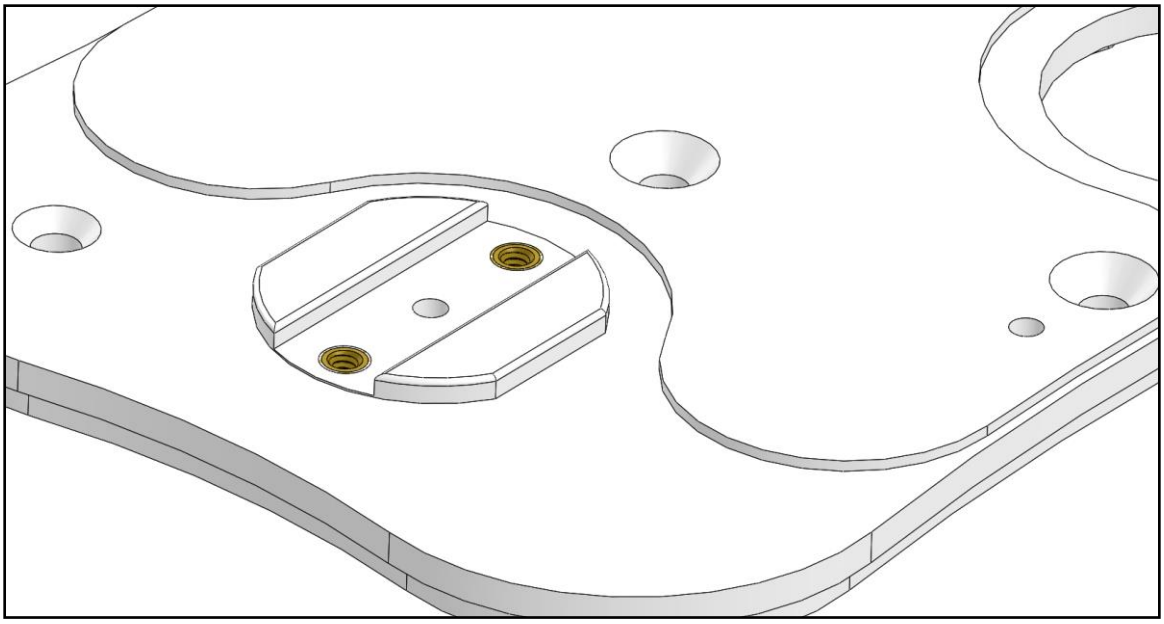


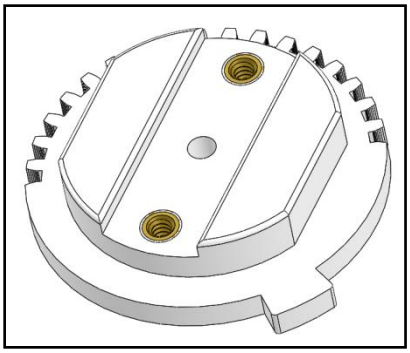
ACTUATOR SUB-ASSEMBLY

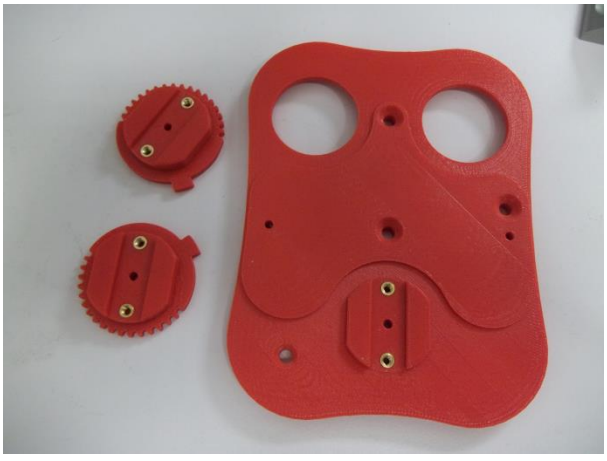
BASE INSERTS

Parts	
a1_o.stl	
c2_left_o.stl and c2_right_o.stl	
4-40, L0.135” heat-set insert (x6)	

Install the remaining heat-set inserts in the finger base parts: *a1_o.stl, c2_left_o.stl, c2_right_o.stl*. Note that *c2_left_o.stl* and *c2_right_o.stl* are mirrors of each other, so they are not interchangeable.





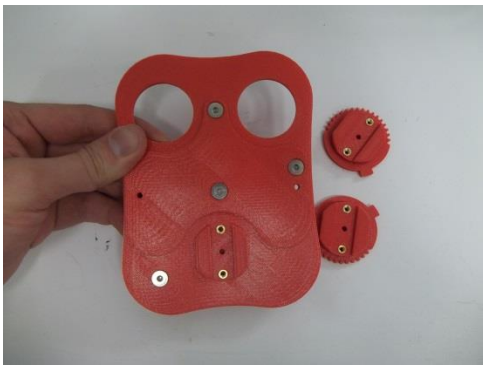


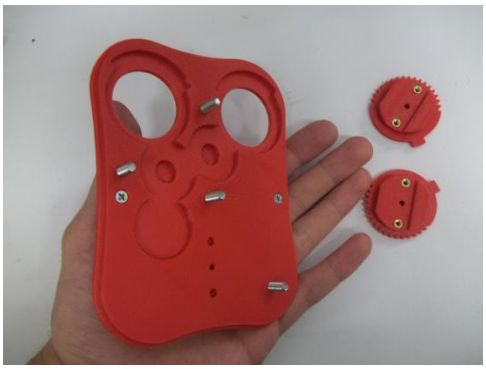
Actuator Sub-Assembly

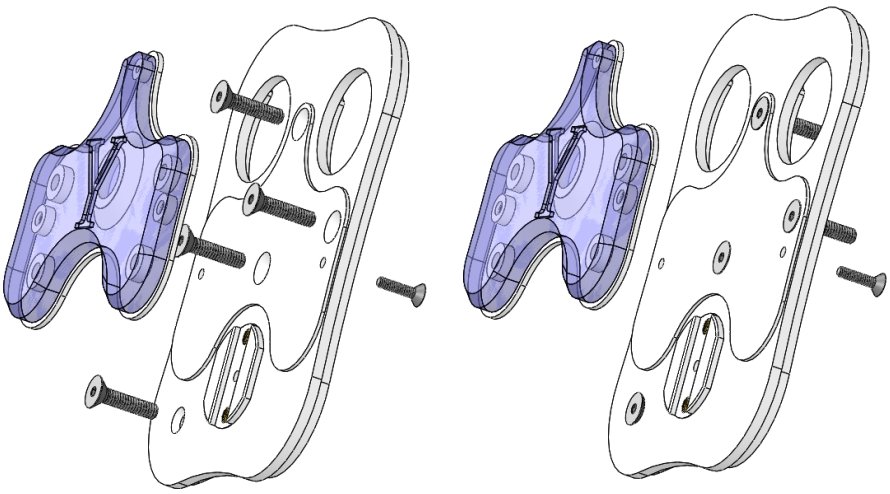
TOP SUB-ASSEMBLY

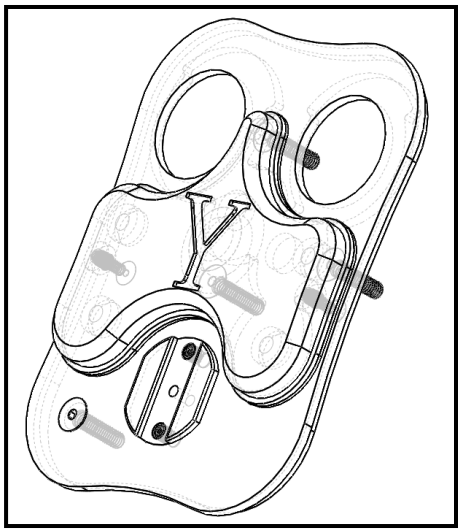
Parts	
a1_o.stl w/ inserts from previous page	
8-32, L3/4" countersunk bolt (x4)	
palm pad	
4-40, L1/2" countersunk screw (x2)	

Place the 8-32 countersunk bolts in their proper positions on *a1_o.stl*. Three of them will be locked in place beneath the palm pad upon assembly of the palm pad to *a1_o.stl*.



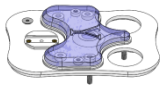




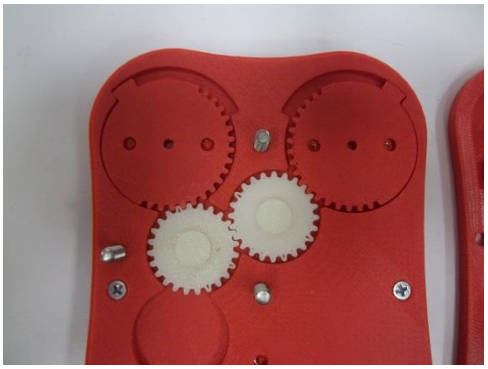


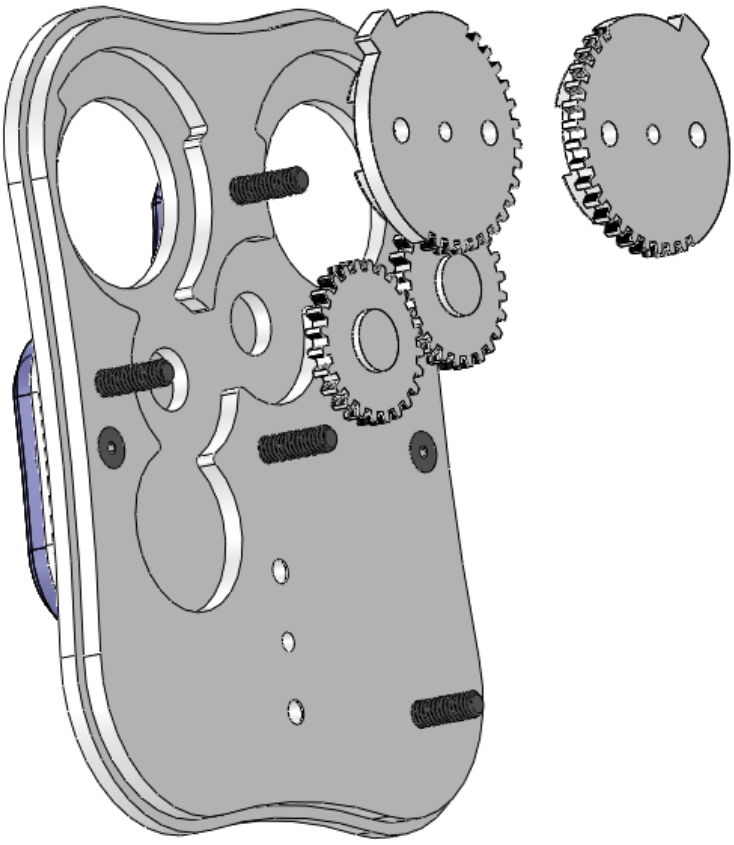
Actuator Sub-Assembly

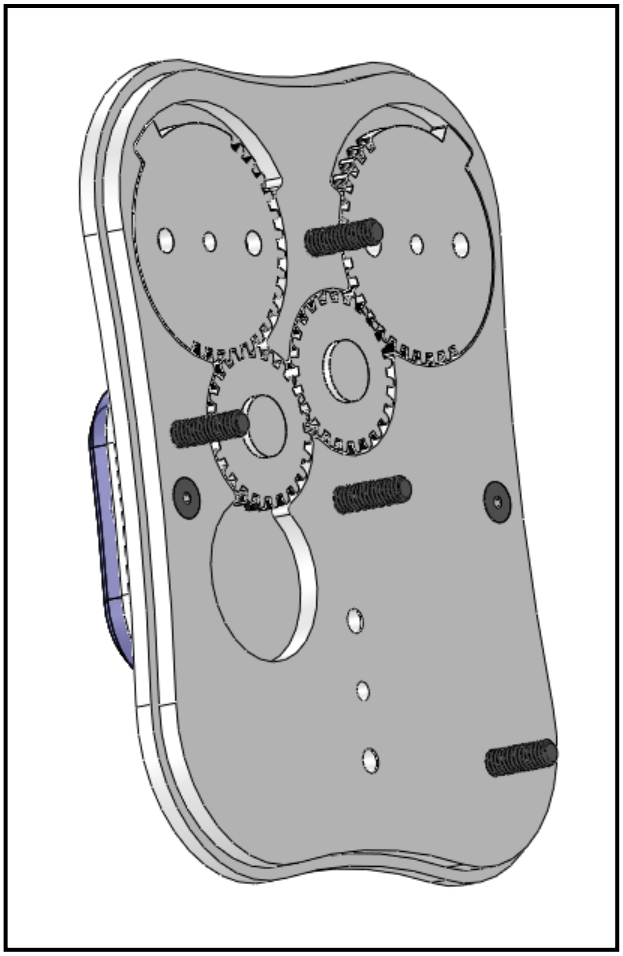
GEAR POSITIONING

Parts	
top assembly from previous page	
c1_left_o.stl and c1_right_o.stl w/ inserts from page 11	
b3_o.stl (x2)	

Flip the top sub-assembly upside down and place the gears as shown below. The gear bases *c1_left_o.stl* and *c1_right_o.stl* should be placed such that their endstops are aligned with the outermost track boundary in *a1_o.stl* and the line formed by their inserts run horizontal (parallel to the minor axis of the top plate)

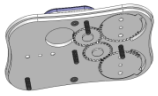
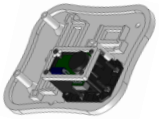
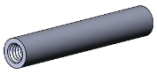






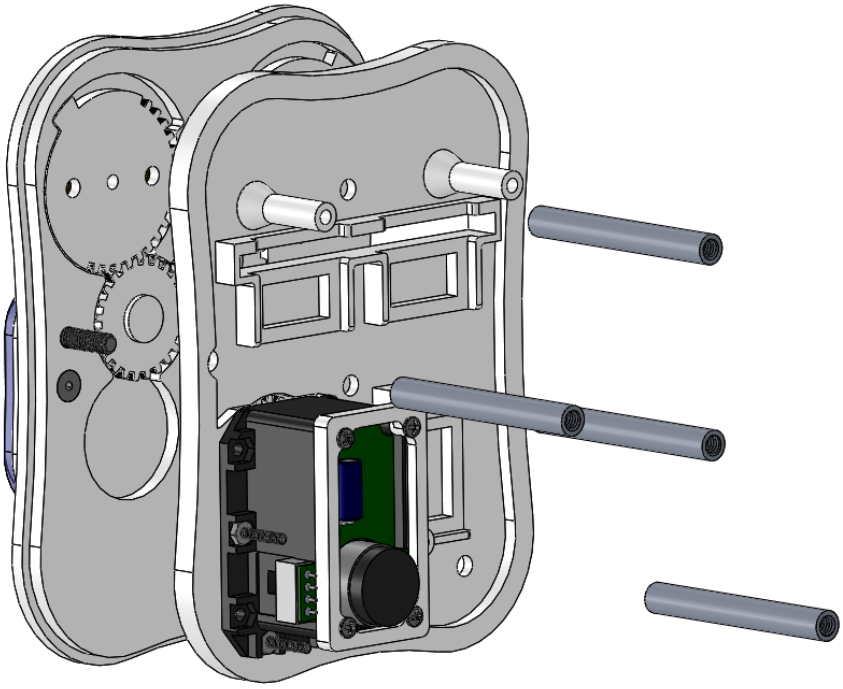
Actuator Sub-Assembly

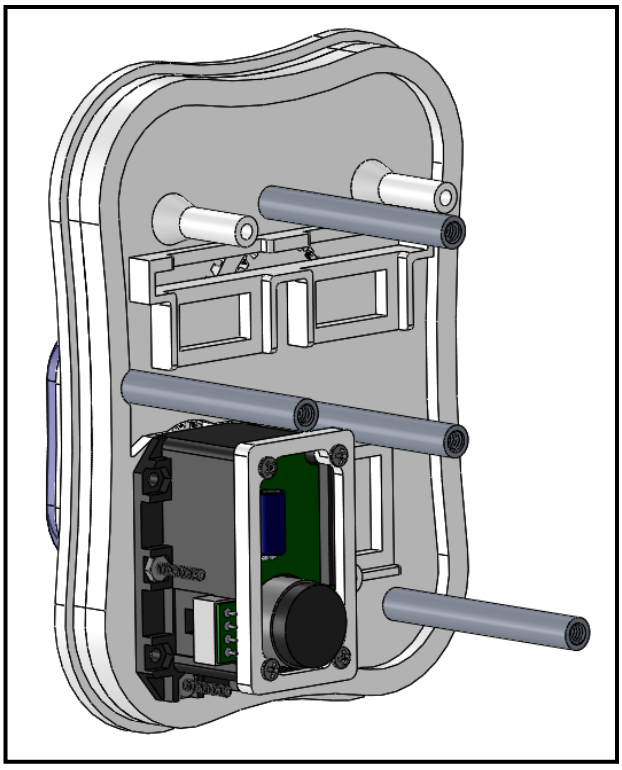
GEAR POSITIONING

Parts	
top sub-assembly w/ gears from previous page	
Dynamixel gear sub-assembly from page 9	
Ø1/4”, L2”, 8-32 zinc-plated female standoff (x4)	

IMPORTANT: You should power up the Dynamixel with gear and drive it to its zero position. The arrangement of gears described in the previous page corresponds to the zero position of the geared Dynamixel. You can do this later during the final assembly steps, but it’s easiest if you do it here.

Align the two sub-assemblies shown below according to the 8-32 bolts in the top sub-assembly and the corresponding hole clearances in the sub-assembly with the Dynamixel. You may need to wiggle it slightly for the gears to settle in place. The plates *a1_o.stl* and *a2_o.stl* should be flush with each other. The threaded standoffs are used to hold these two sub-assemblies together.





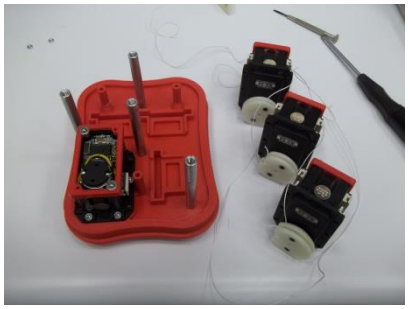
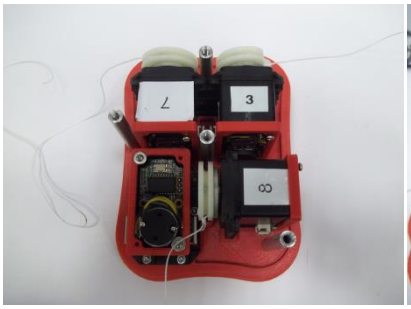
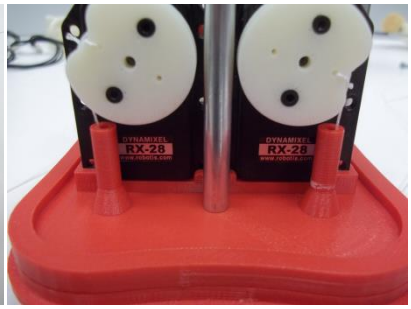
Actuator Sub-Assembly

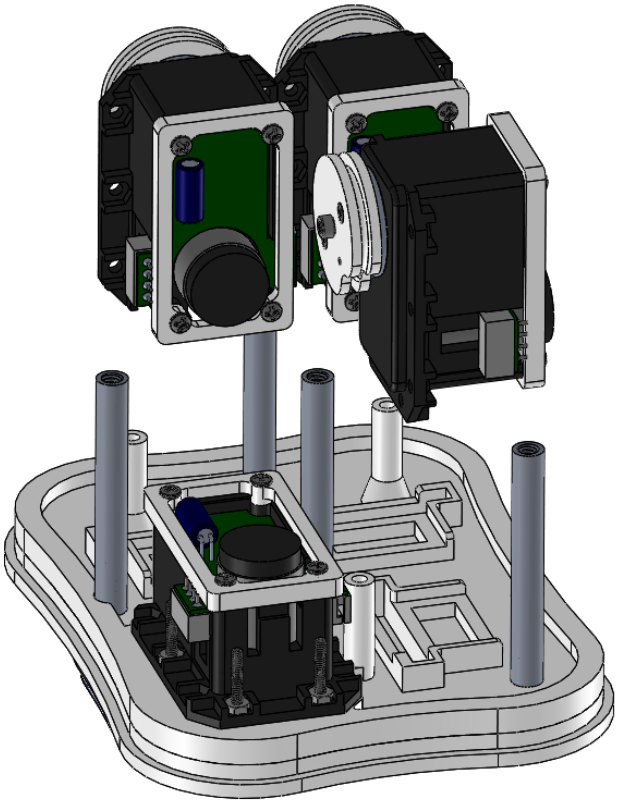
FULL ACTUATOR SET

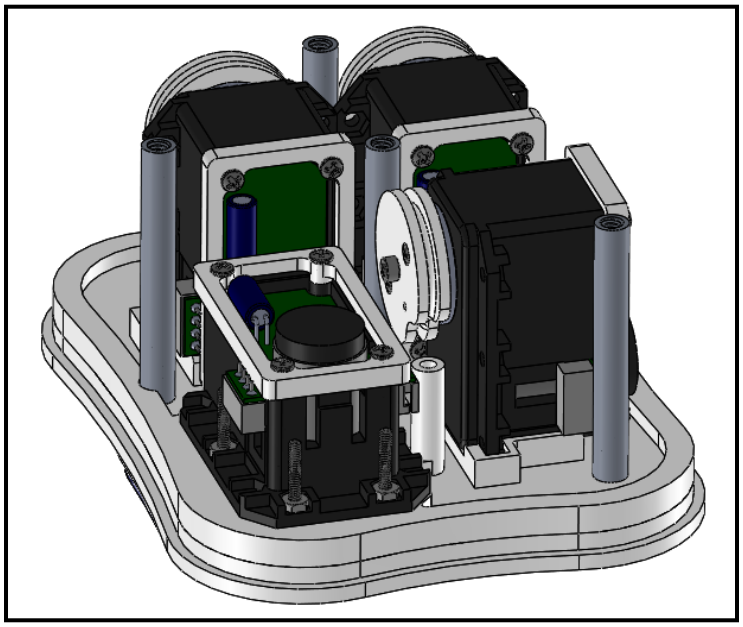
Parts	
sub-assembly from previous page	
Dynamixel pulley sub-assemblies from page 8 (x3)	

The remaining 3 Dynamixels w/ attached pulleys should be placed in the slots of *a2_o.stl* as shown below. The Dynamixels are positioned such that the pulleys are farther from *a2_o.stl*. Thread the tendon through the tendon ports (the tubes) in *a2_o.stl*. Note that one of the Dynamixels will be running in reverse in order to actuate the tendons. You'll want to note the servo id of this Dynamixel for future reference.

Now is also a good opportunity to wire up the 4 Dynamixels in a daisy-chain setup. Please double-check that you're daisy-chaining the Dynamixels correctly (and not in reverse)

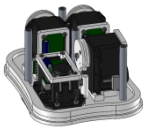
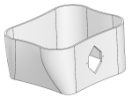






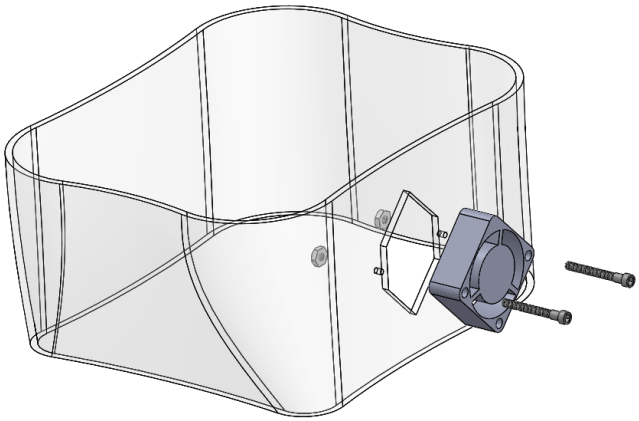


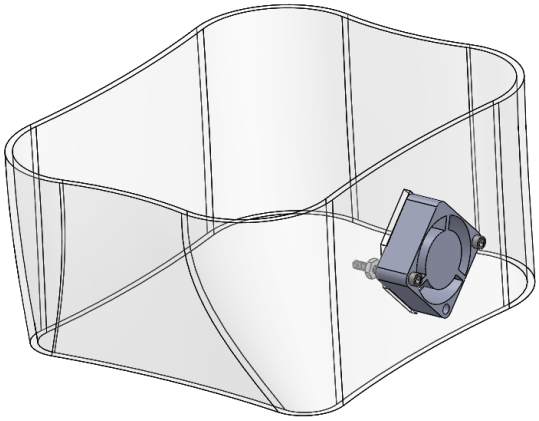
Actuator Sub-Assembly

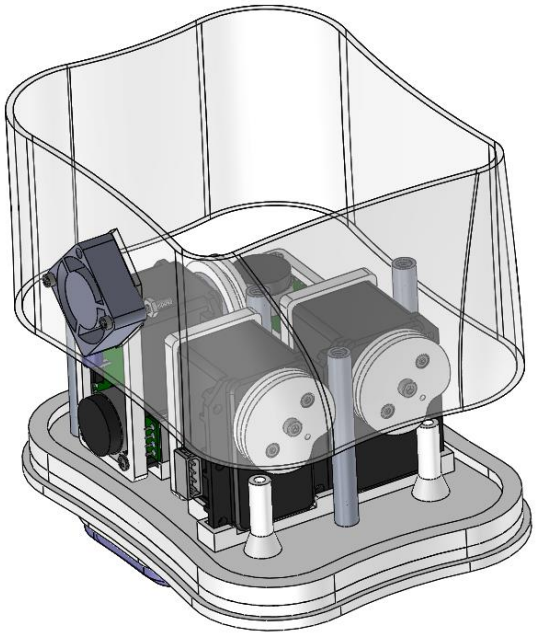
outer shell (optional)

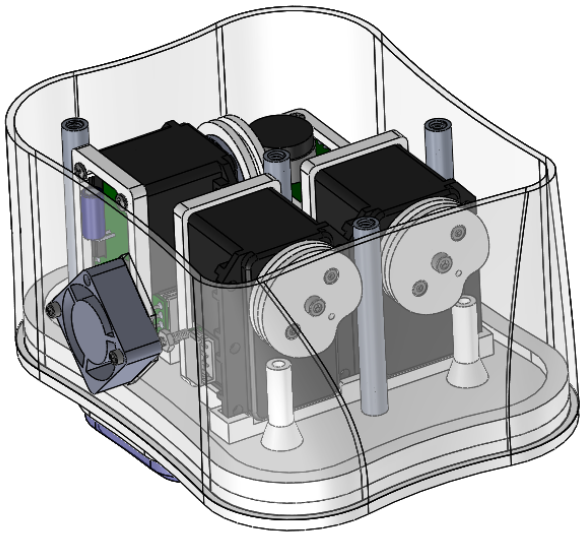
Parts	
sub-assembly from previous page	
d1_o.stl	
2-56, L3/4” socket bolt (x2)	
2-56 nut (x2)	
Sunon 25x25x10mm 12V fan	

You have the option of installing a shell with a fan. The fan can be wired directly to one of the remaining 2 available ports among the Dynamixels for power. If you use the shell, I highly recommend installing the fan as well, since over-heating can be an issue with these Dynamixels.



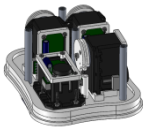
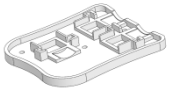




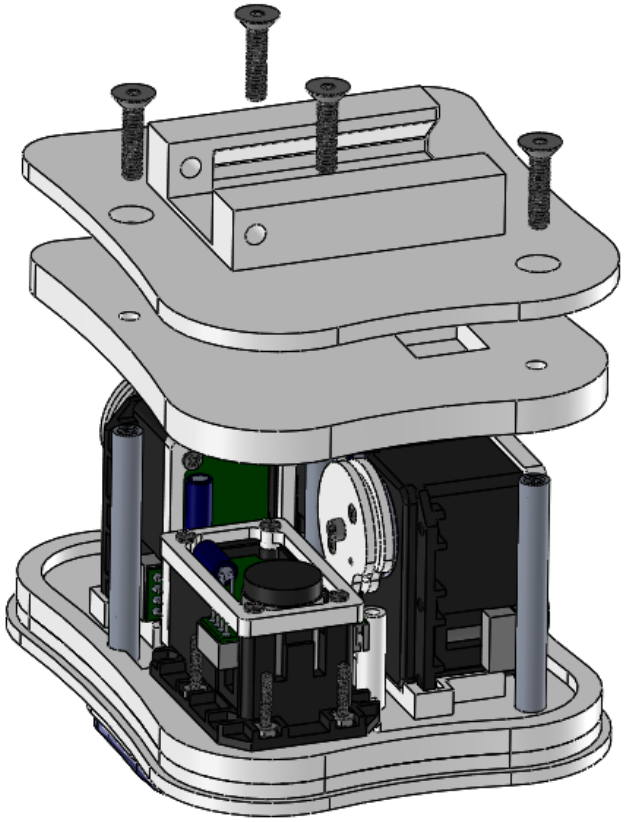


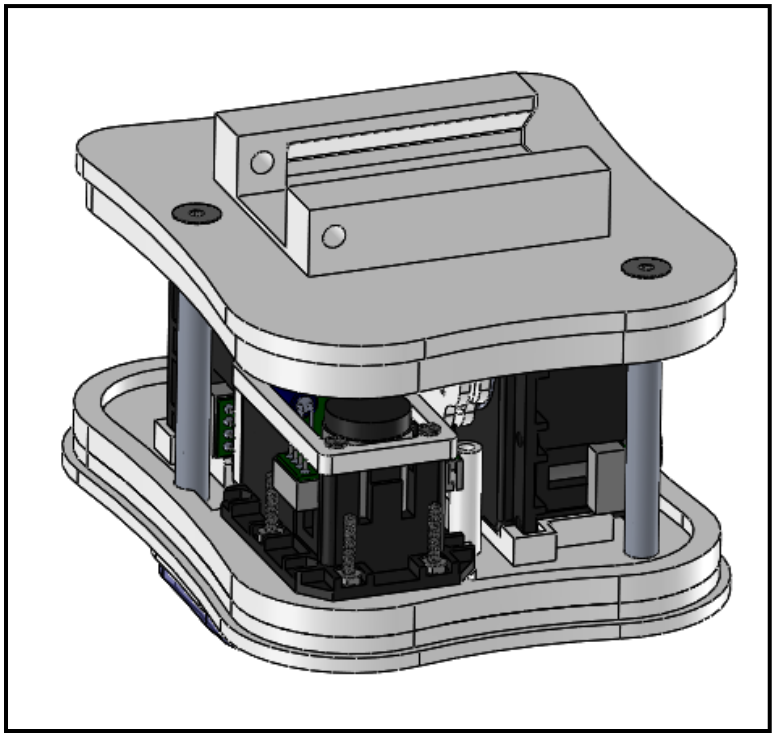
ACTUATOR SUB-ASSEMBLY

FULL ACTUATOR SET

Parts	
sub-assembly from previous page	
a3_o.stl	
a4_coupling_o.stl - or - a4_blank_o.stl	
8-32, L3/4” countersunk bolt (x4)	

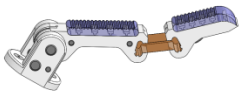
Move the wires out of the way and assemble *a3_o.stl* and *a4_coupling_o.stl* with the 8-32 countersunk bolts. Be careful to not pinch or trap any of the wires when positioning *a3_o.stl*. The features of the Dynamixel servo and the corresponding slots in *a3_o.stl* should help with the positioning.



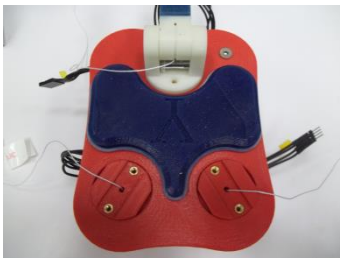


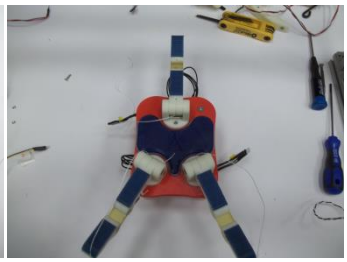
Final Assembly

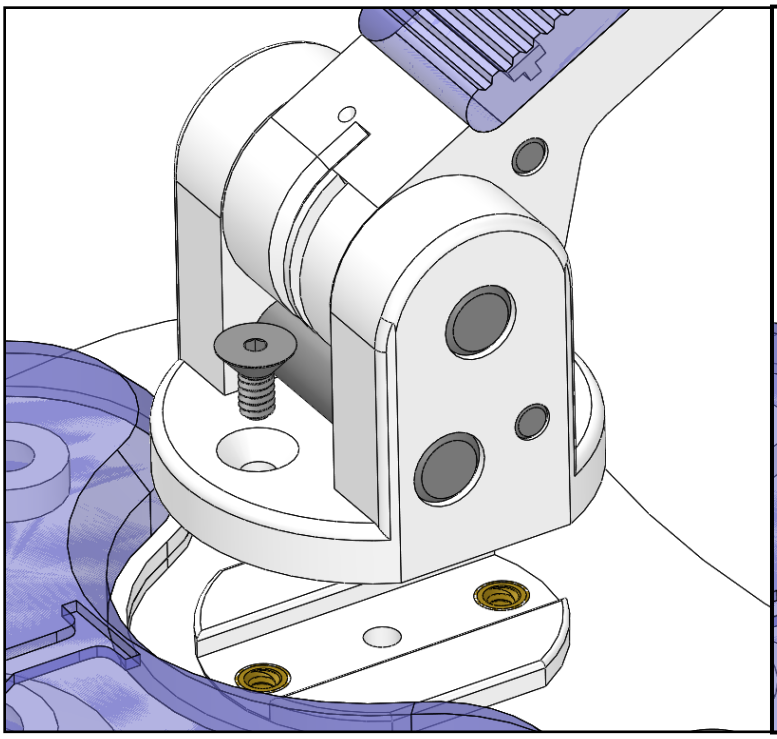
ASSEMBLING FINGERS

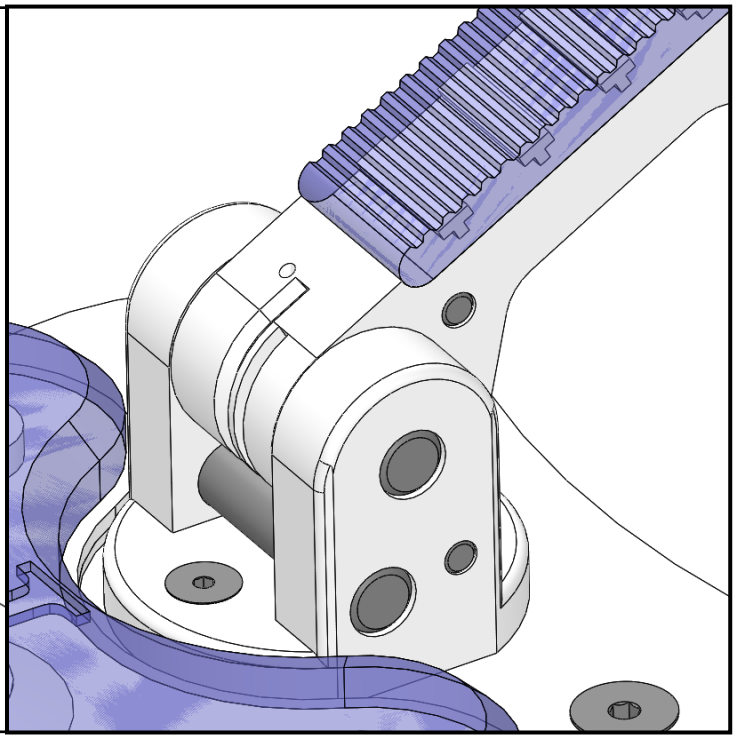
Parts	
sub-assembly from previous page	
Pivot-Flexure finger sub-assemblies - or - Pivot-Pivot finger sub-assemblies	
4-40, L1/2” countersunk screw (x6)	

For each finger sub-assembly with base, regardless if it is Pivot-Flexure or Pivot-Pivot, it is attached to the hand frame with two 4-40 countersunk bolts. They thread into the inserts that were installed on page 11. As you’re assembling the fingers, make sure the tendons are still accessible.









Final Assembly

TENDON ROUTING

Parts
Hand assembly
Spectra tendon line

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