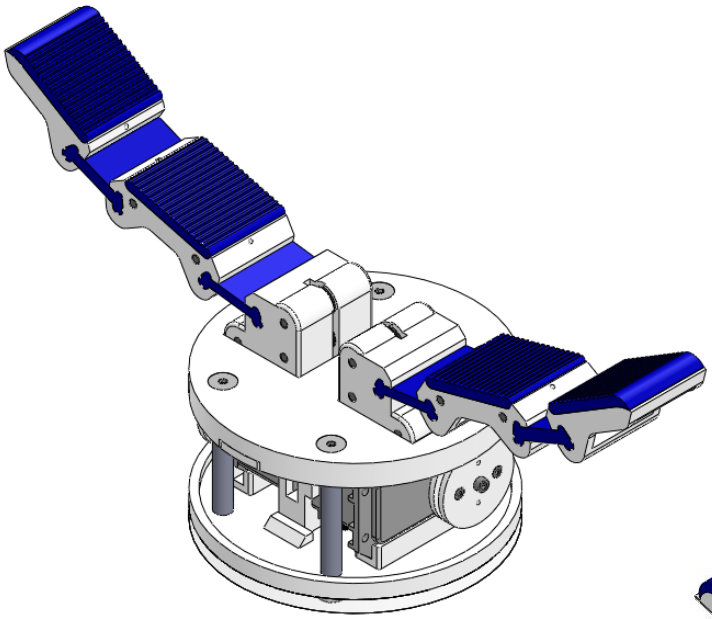
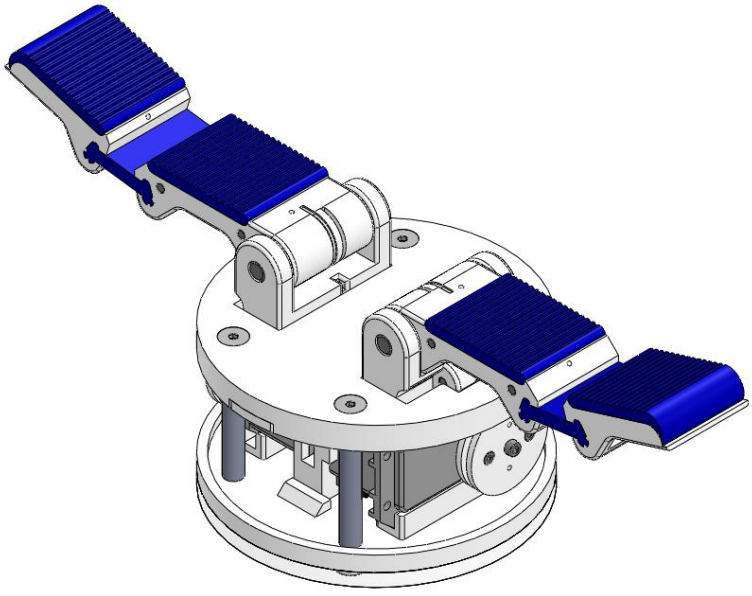
OpenHand

Model T42

Version 0.3



Flexure Base

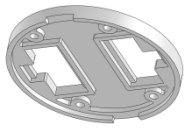
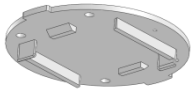
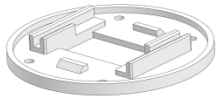
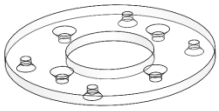
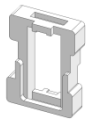
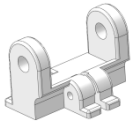
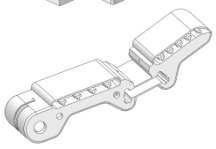
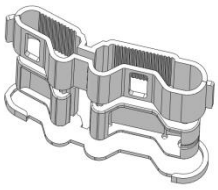


Pivot Base

Assembly Instructions

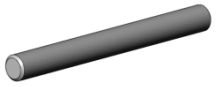
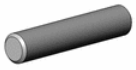
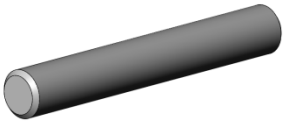
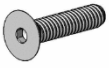
Last updated: November 28, 2013

Parts List (Pivot Base)

Part Name	Quantity	Usage	Vendor	
a1_pivot.stl	1	Top Plate	3D Print	
a2.stl	1	Top Keeper Plate	3D Print	
a3.stl	1	Bottom Plate	3D Print	
a4.stl	1	Bottom Keeper Plate	3D Print or Lasercut	
b1.stl	1	Central Coupler	3D Print	
b2.stl	2	Servo Pulley	3D Print	
c1.stl	2	Finger Pivot Base	3D Print	
finger_flexure_print.stl	2	Finger Molds – Breakaway	3D Print	
finger_ff_A.stl, finger_ff_B.stl, finger_ff_C.stl, shell_ff_A.stl, shell_ff_B.stl, shell_ff_C.stl	2	Finger Molds - Multipart	3D Print	
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]	

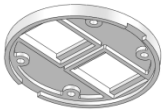
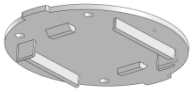
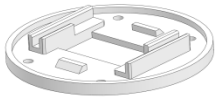
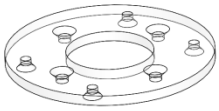
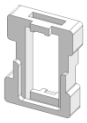
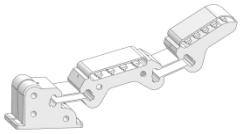
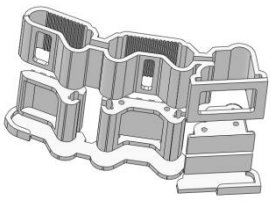
* optional

Parts List (Pivot Base)

Part Name	Quantity	Usage	Vendor	
Robotis RX-28 Dynamixel	2	Actuator	Robotis [link]	
Ø1/8”, L1-1/4” steel dowel pin (J1)	4	Support Pin	McMaster [98381A477]	
Ø1/8”, L5/8” steel dowel pin (J2)	2	Support Pin	McMaster [98381A472]	
Ø1/4”, L1-3/4” steel dowel pin (J3)	2	Joint Pin	McMaster [98381A548]	
Ø3/8”, Wd1/8” nylon pulley (P1)	6	Tendon Routing	McMaster [3434T31]	
M2.5, L5mm bolt	2	Fastener	Provided w/ Dynamixel McMaster [92290A055]	
M2, L5mm bolt	4	Fastener	McMaster [91290A012]	
Socket Cap Screw 8-32, L3/4”	8	Fastener	McMaster [91253A197]	
Ø1/4”, L1-1/2” zinc-plated female standoff (S1)	4	Support	McMaster [93330A482]	
Torsion Spring, Ø0.34”, 0.028” wire diameter, 180˚, left-hand wound	4	Joint Return Spring	McMaster [9271K605]	

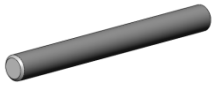
* optional

Parts List (Flexure Base)

Part Name	Quantity	Usage	Vendor	
a1_pivot.stl	1	Top Plate	3D Print	
a2.stl	1	Top Keeper Plate	3D Print	
a3.stl	1	Bottom Plate	3D Print	
a4.stl	1	Bottom Keeper Plate	3D Print or Lasercut	
b1.stl	1	Central Coupler	3D Print	
b2.stl	2	Servo Pulley	3D Print	
finger_flexure_print.stl	2	Finger Molds – Breakaway	3D Print	
finger_ff_A.stl, finger_ff_B.stl, shell_ff_A.stl, shell_ff_B.stl, shell_ff_C.stl	2	Finger Molds – Multipart	3D Print	

* optional

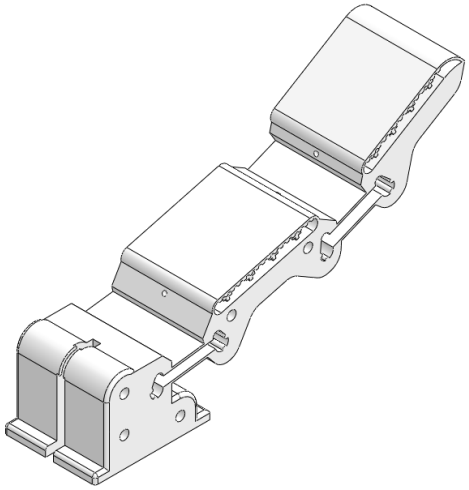
Parts List (Flexure Base)

Part Name	Quantity	Usage	Vendor	
Robotis RX-28 Dynamixel	2	Actuator	Robotis [link]	
Ø1/8”, L1-1/4” steel dowel pin (J1)	10	Support Pin	McMaster [98381A477]	
Ø3/8”, Wd1/8” nylon pulley (P1)	6	Tendon Routing	McMaster [3434T31]	
M2.5, L5mm bolt	2	Fastener	Provided w/ Dynamixel McMaster [92290A055]	
M2, L5mm bolt	4	Fastener	McMaster [91290A012]	
Socket Cap Screw 8-32, L3/4”	8	Fastener	McMaster [91253A197]	
Ø1/4”, L1-1/2” zinc-plated female standoff (S1)	4	Support	McMaster [93330A482]	
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]	

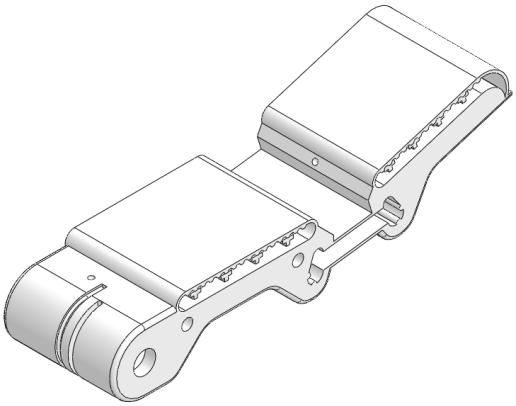
* optional

Part Preparation

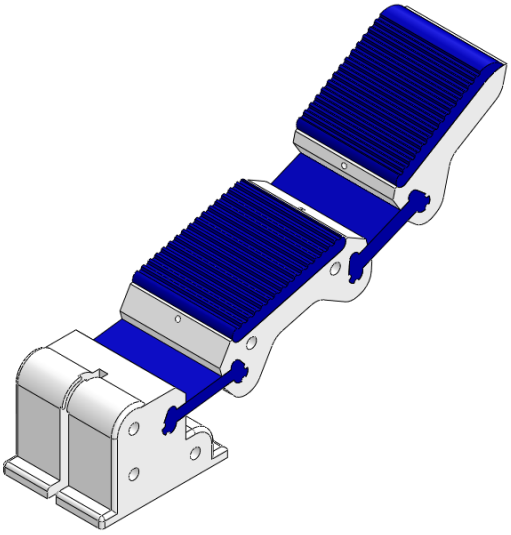
FINGER MOLDING

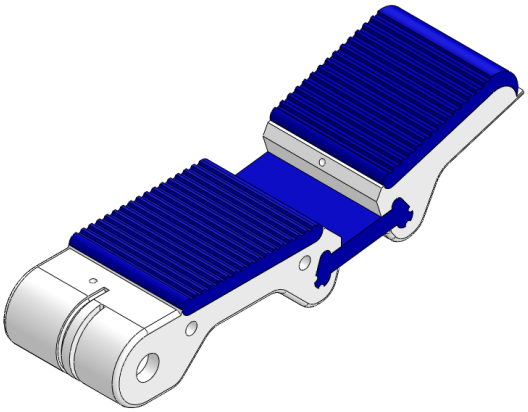


finger_flexure_print.stl



finger_pivot_print.stl

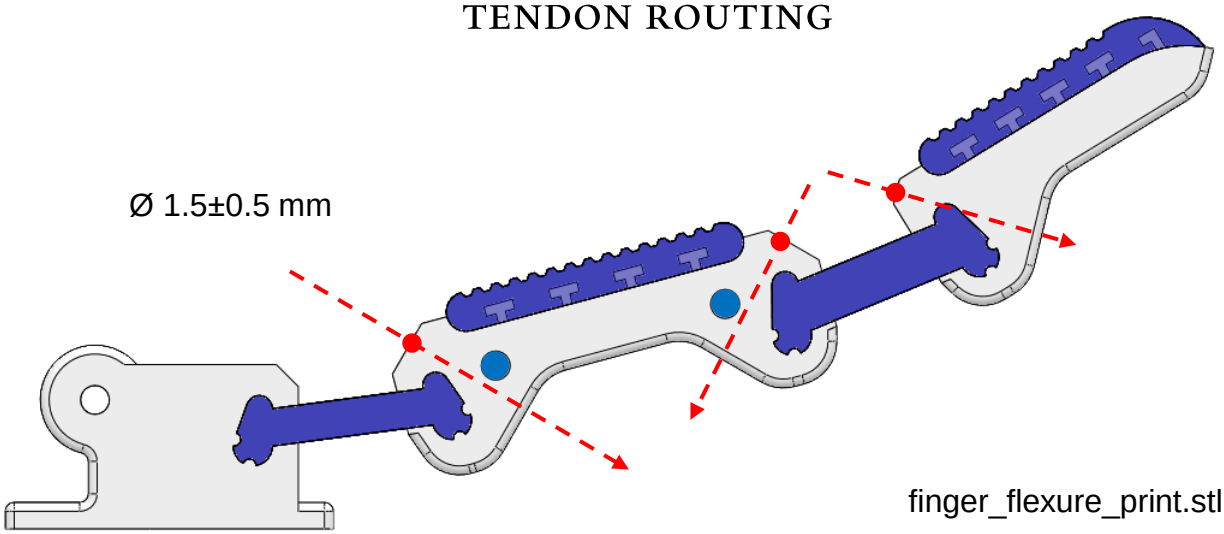




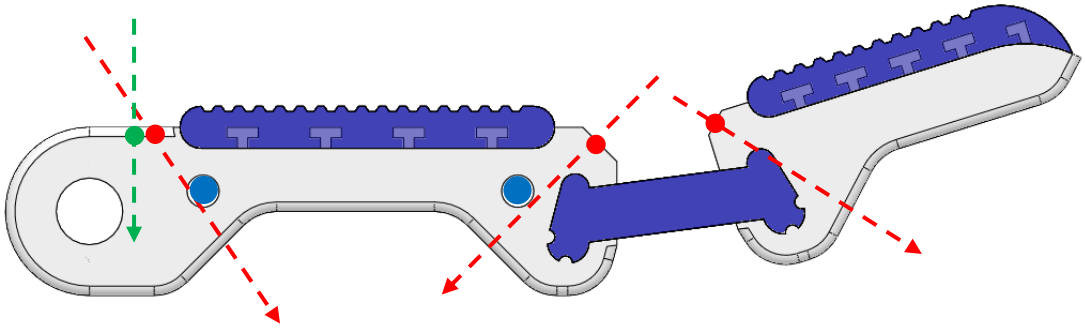
Consult DDM (Dieless Deposition Manufacturing) guide for further details on pouring/preparing the joints and pads for fingers

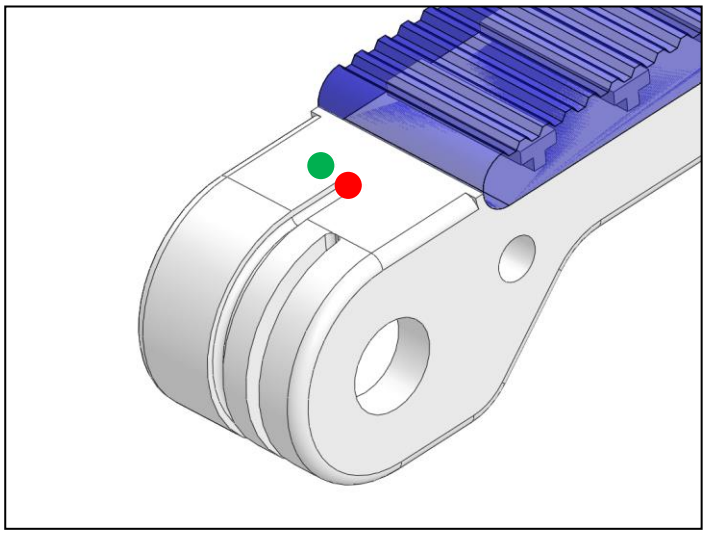
Part Preparation

TENDON ROUTING



finger_flexure_print.stl (x4)



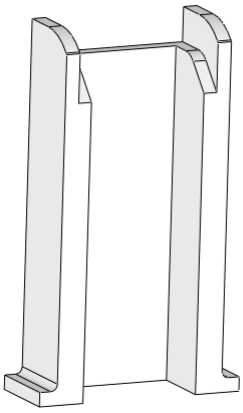


finger_pivot_print.stl (x4)

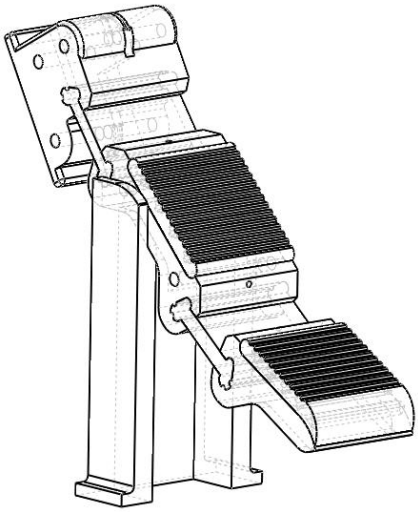
Drill tendon routing holes such that tendon will run tangent to inserted pin. Minimize contact between tendon and ABS but ensure that tendon runs freely. For the pivot base design, the fingers also have a torsional spring mounting hole to be drilled as shown.

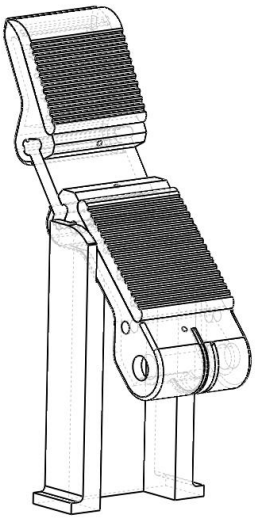
Part Preparation

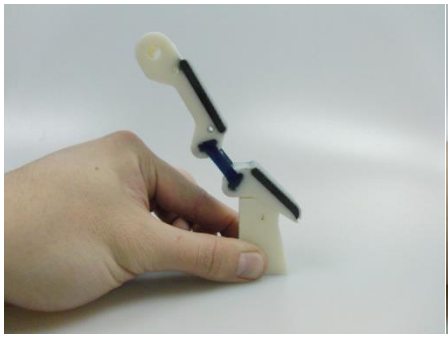
tendon routing (2/2)

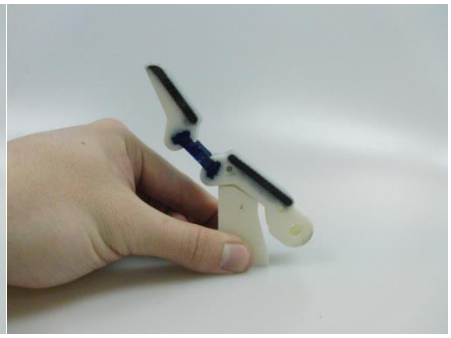


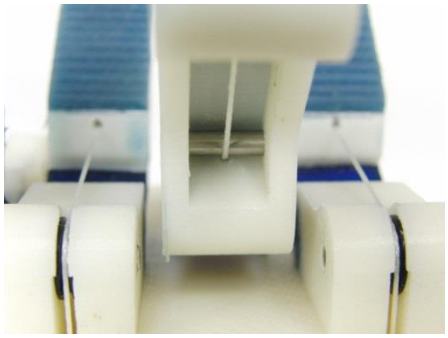
helper_jig.stl

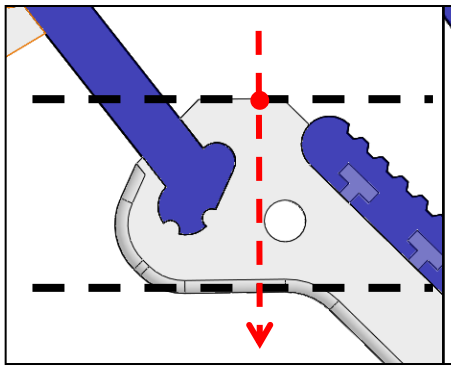


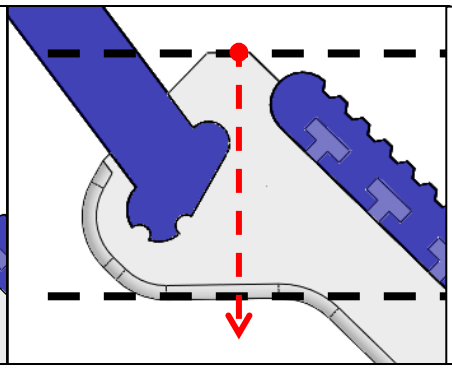


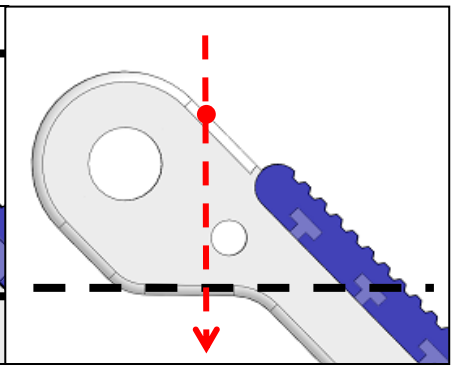








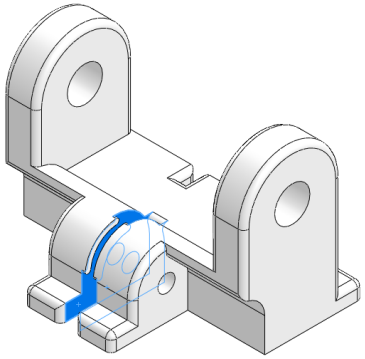




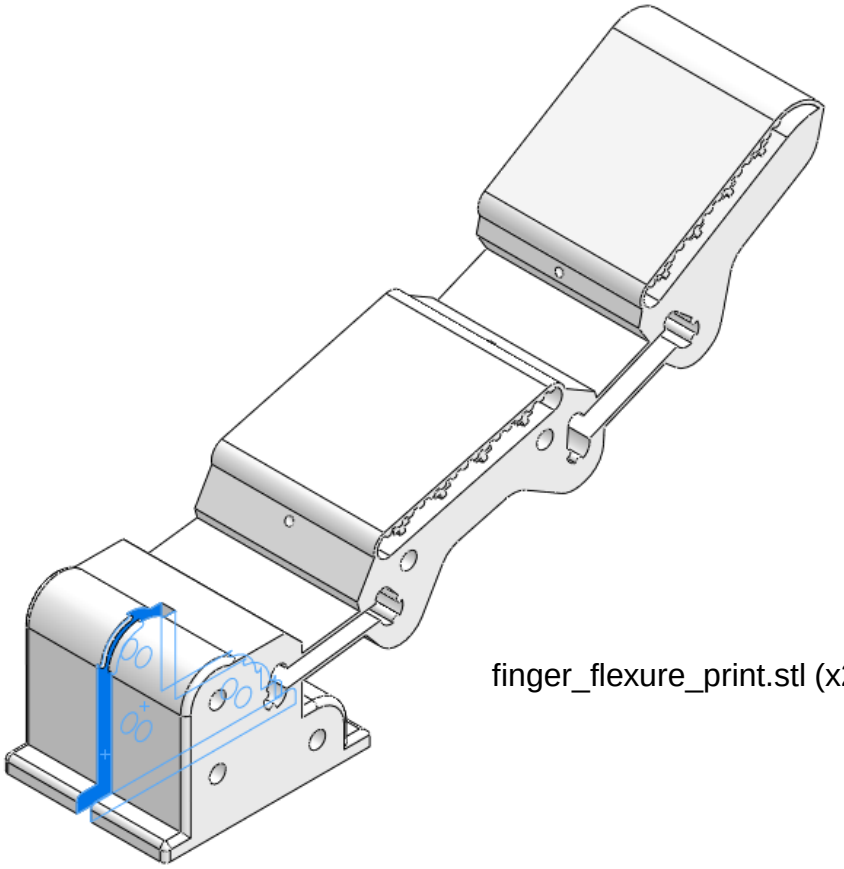
Use *helper_jig.stl* to aid in positioning and orientation during drilling if desired. Routing holes should be drilled perpendicular to hole surface. The fingers are designed such that for each routing hole, there is at least one feature surface that is perpendicular to the direction of drilling, as shown above. It is ideal to minimize the diameter of the tendon routing holes if possible.

Part Preparation

SURFACE FILING/DEBURRING



c1.stl (x2)

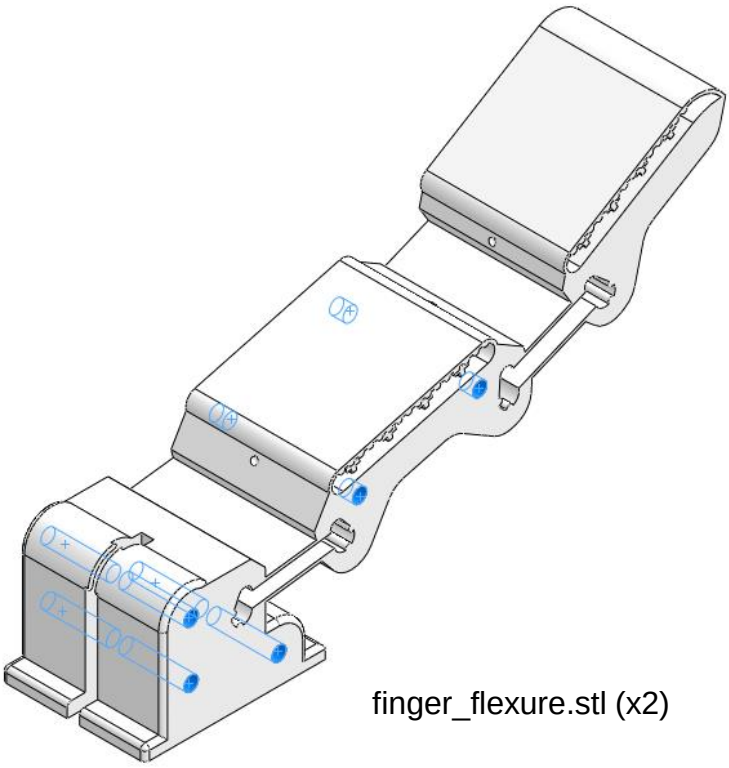


finger_flexure_print.stl (x2)

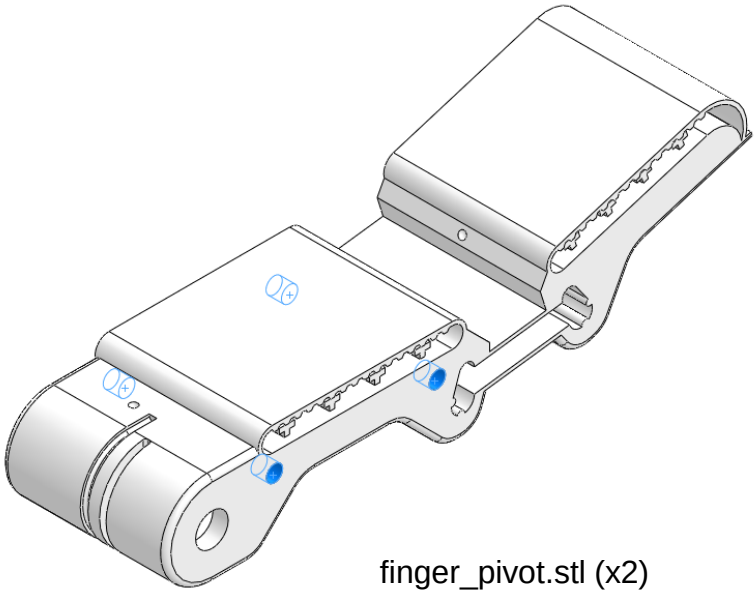
File down and deburr bearing surfaces as indicated above. Ensure that no support material remains, if applicable. Complementary piece (ie. pulley, finger) should slide in freely.

Part Preparation

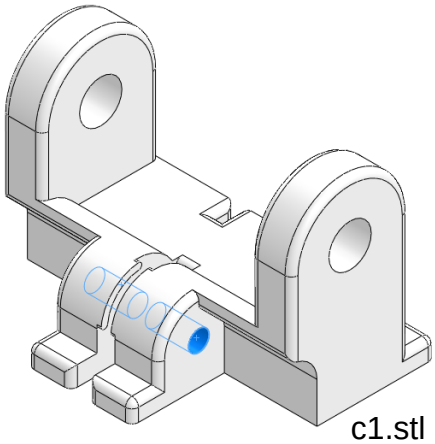
reaming (1/8" pin holes)



finger_flexure.stl (x2)



finger_pivot.stl (x2)

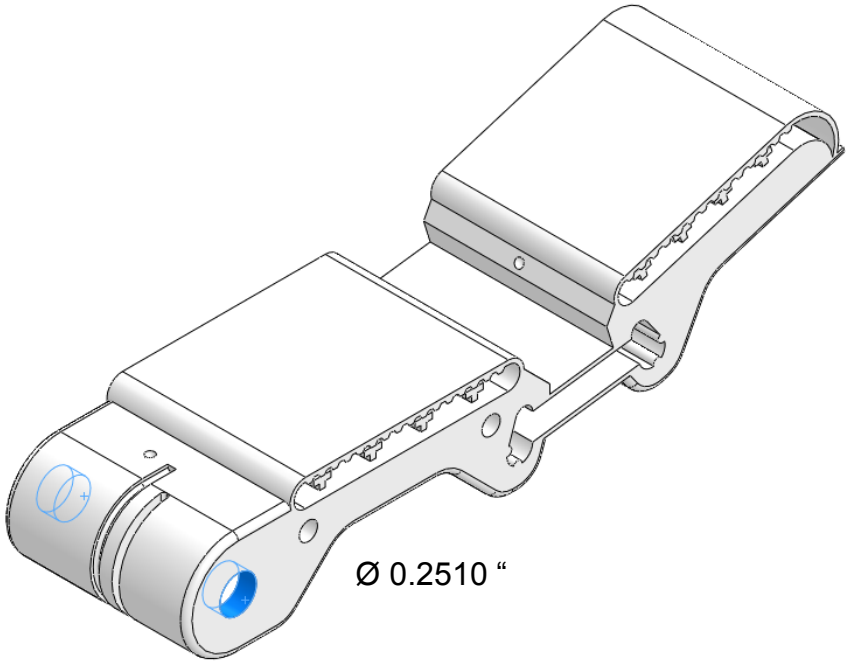


c1.stl (x2)

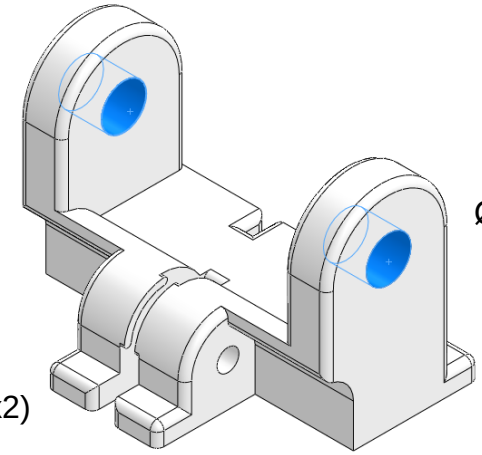
Use Ø0.1240" reamer to prepare pin holes as indicated above. This step can be skipped in lieu of precise 3D printer calibration and parameter selection, but manual reaming is the recommended approach.

Part Preparation

reaming (pivot bases)



finger_pivot.stl (x2)

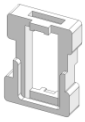


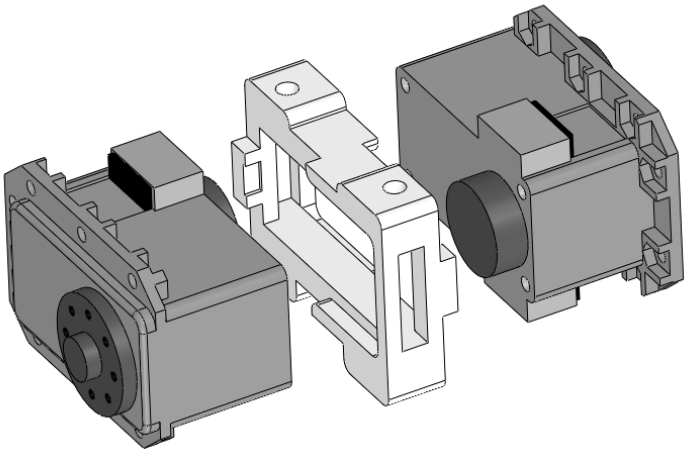
c1.stl (x2)

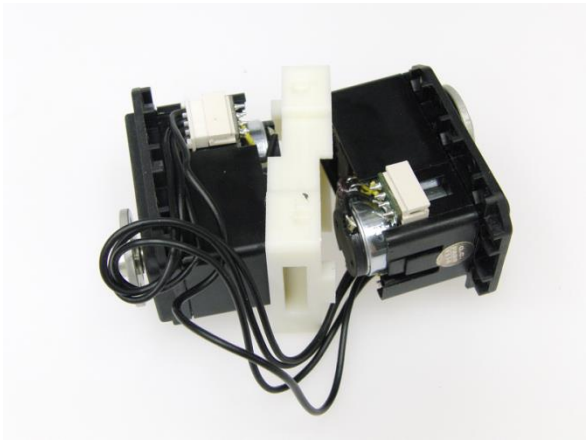
Use Ø0.2490” reamer to prepare pin holes on pivot bases *c1.stl*, and Ø0.2510” reamer to prepare pin holes on the corresponding fingers *finger_pivot.stl.* Finger should spin freely and loosely on a Ø0.25” steel pin

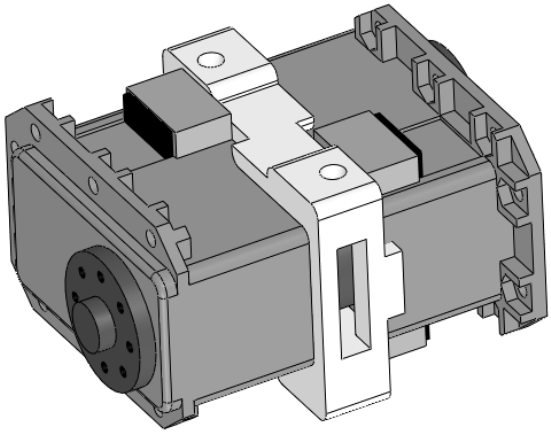
ASSEMBLY

BLOCK_ACTUATOR

Parts	
Dynamixel RX-28 (x2)	
b1.stl	



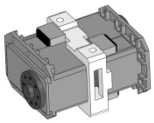


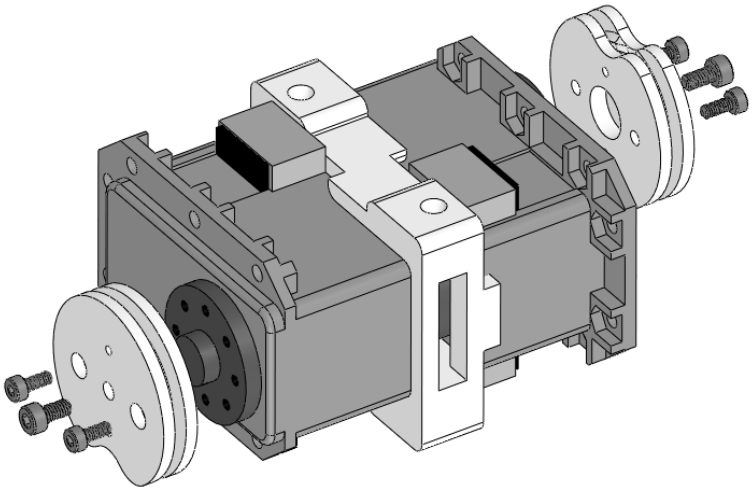


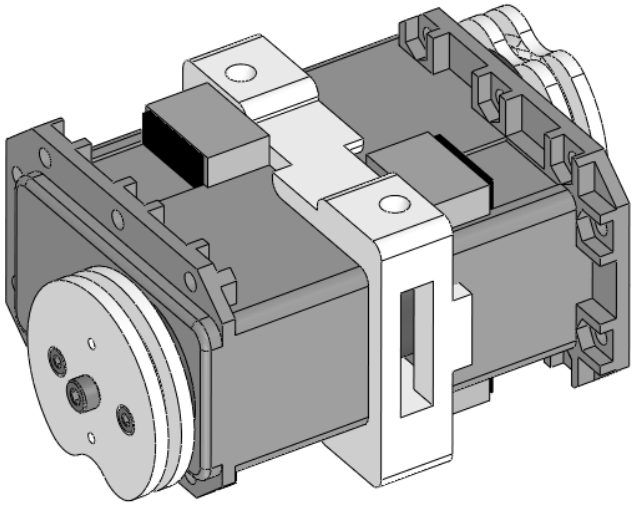
Remove back of Dynamixel RX-28's. The two Dynamixel servo's snap onto the coupler piece *b1.stl* as shown above. Connect the two Dynamixel servos in a daisy-chain configuration.

ASSEMBLY

BLOCK_ACTUATOR

Parts	
Sub-assembly from step 7	
b2.stl (x2)	
M2.5 L5mm bolt (x2)	
M2 L5mm (x4)	



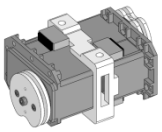
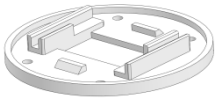
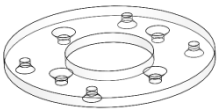
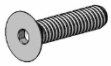


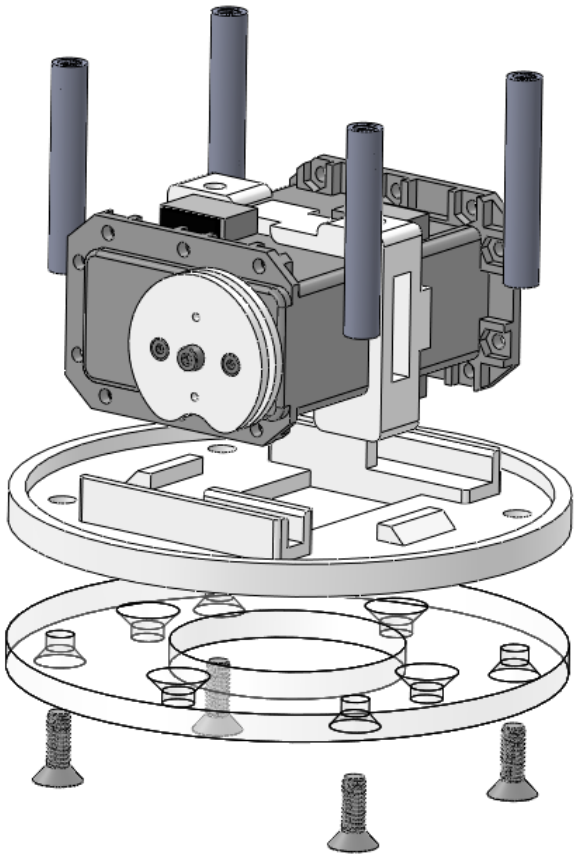
Assemble main drive pulleys onto actuator block sub-assembly as shown. Do not worry about zero-position of servo at this time.

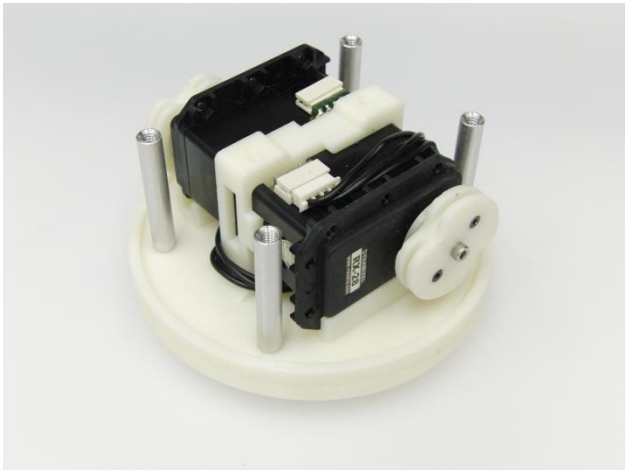
(Optional): It may be beneficial to attach one end of the tendons to the pulleys at this point. Use enough tendon to wrap around the pulley fully at least once and also reach the end of the fingertips after routing.

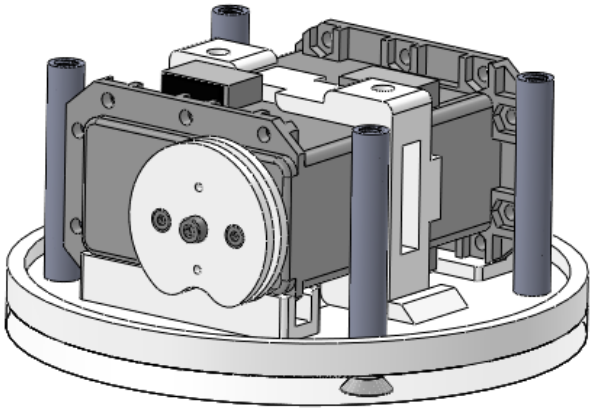
ASSEMBLY

BLOCK_ACTUATOR

Parts	
Sub-assembly from step 8	
a3.stl	
a4.stl	
Ø1/4”, L1-1/2” standoffs S1 (x4)	
Socket Cap Screw 8-32, L3/4” (x4)	



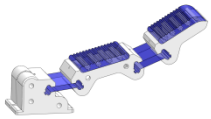
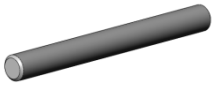


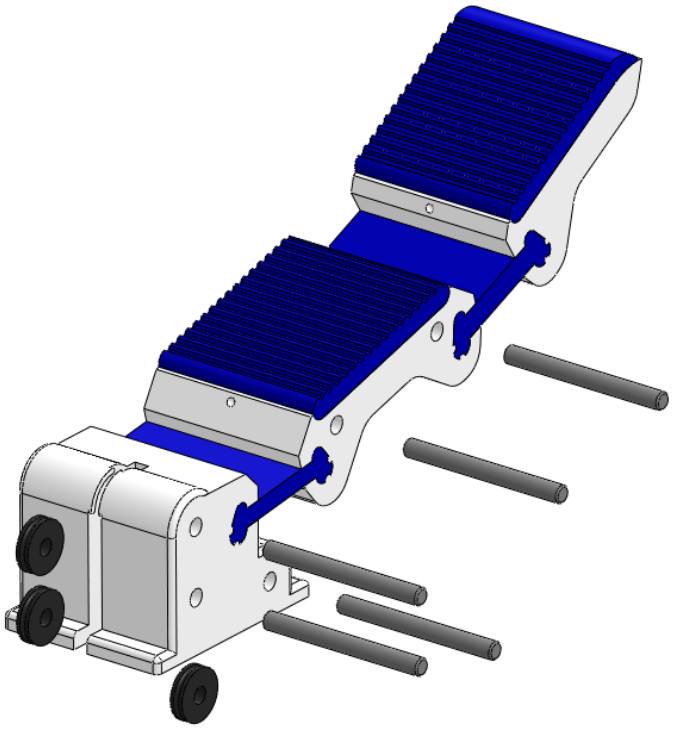


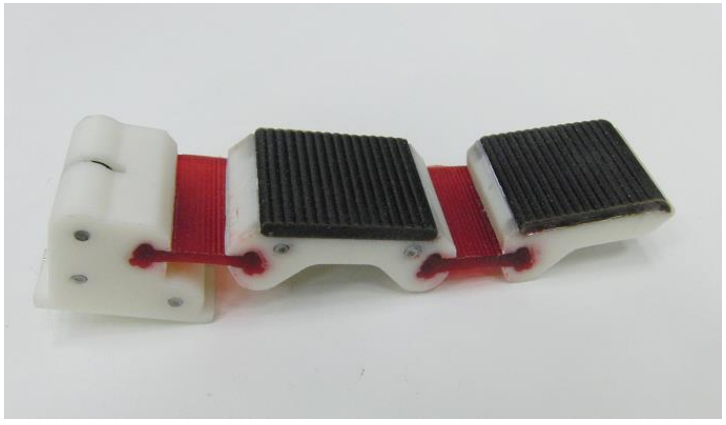
Assemble main drive pulleys onto actuator block sub-assembly as shown. Do not worry about zero-position of servo at this time.

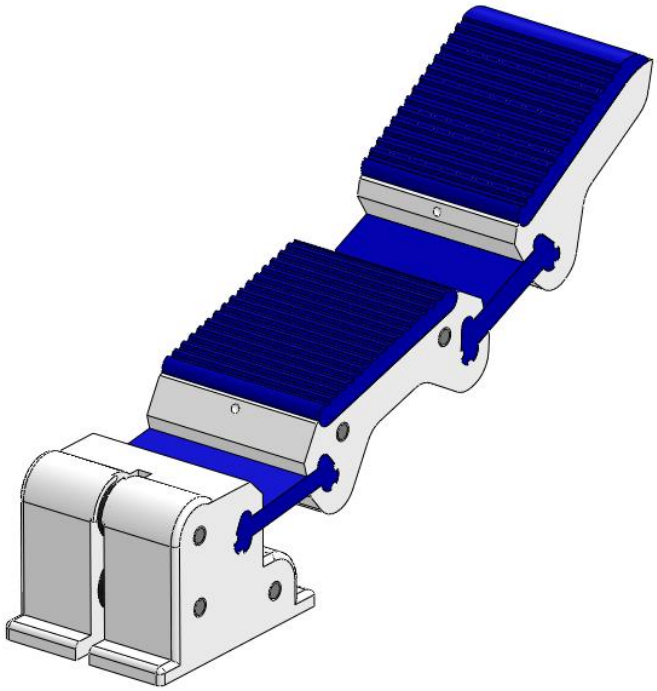
ASSEMBLY

FLEXURE-BASE FINGERS

Parts	
Flexure-based finger (x2)	
Pulley P1 (x6)	
L1-1/4” pin J1 (x10)	





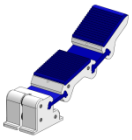


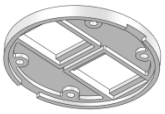
For pivot-base fingers, skip to step 12. Use a shim while press-fitting the pins to help ensure that nylon pulley spins freely at finger base

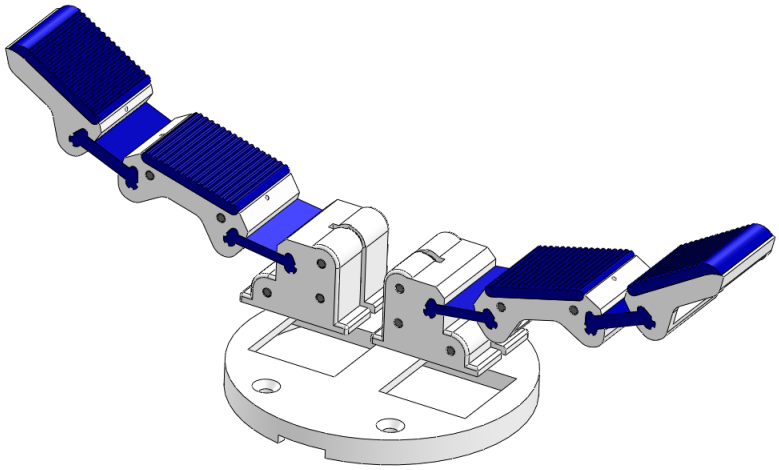
Assembly

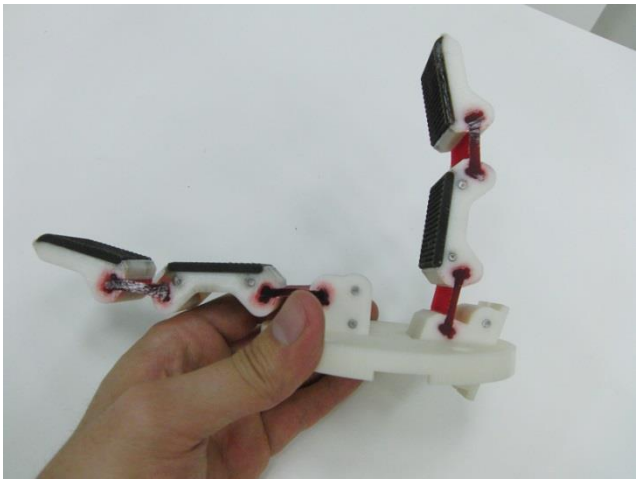
FLEXURE-BASE FINGERS TOP

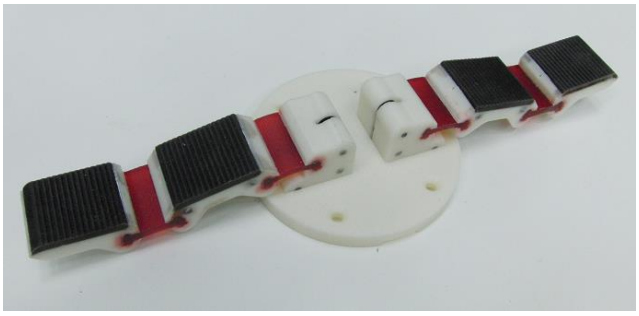
Parts
Finger sub-assembly from step 10 (x2)
a1_flexure.stl

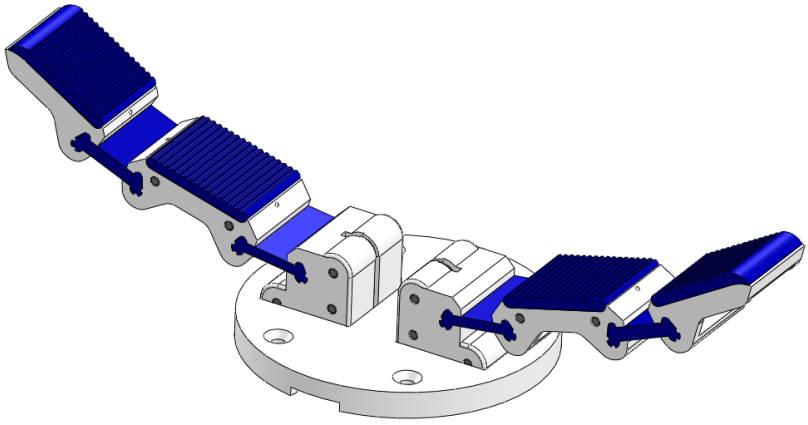








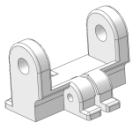
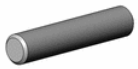


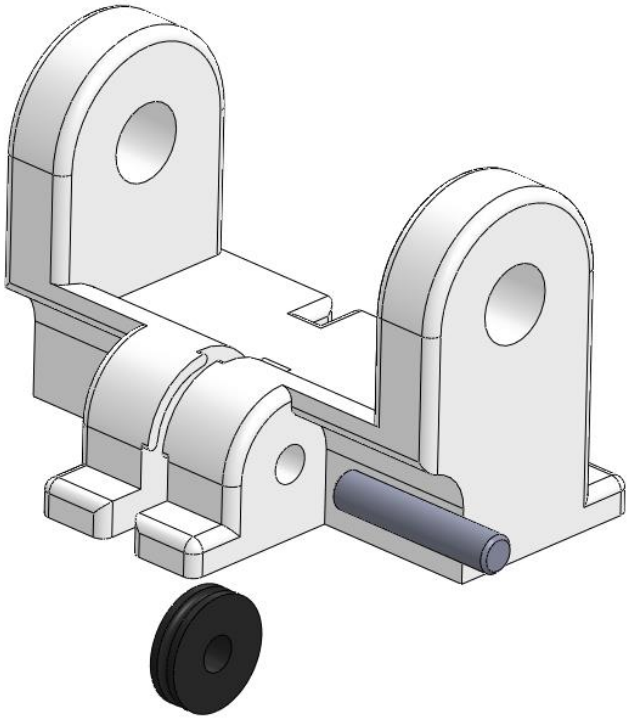


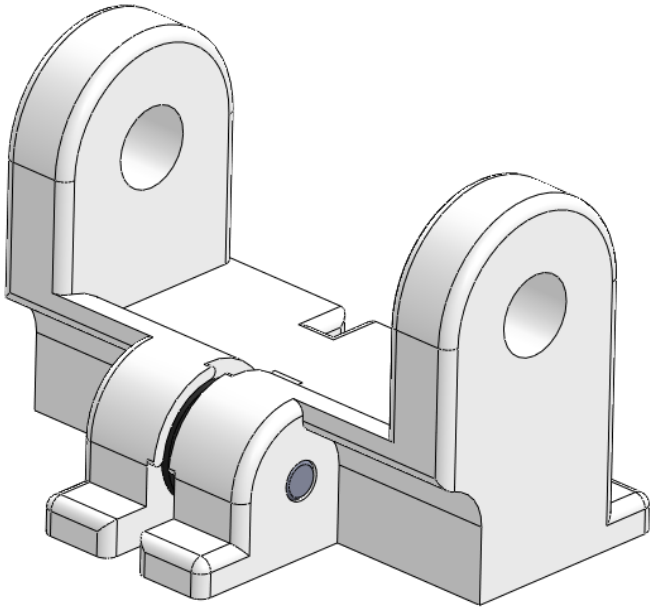
Insert fingers into top plate from above as illustrated in the figures. Finger base should lie flush with plate *a1_flexure.stl*

Assembly

PIVOT-BASE FINGERS

Parts	
c1.stl (x2)	
L5/8” pin J2 (x2)	
Pulley P1 (x2)	



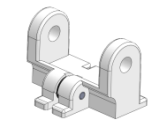


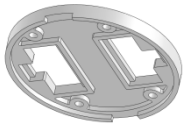
Assemble pivot base sub-assembly as shown. Use shim when press-fitting the pin and pulley to ensure that the pulley spins freely after assembly.

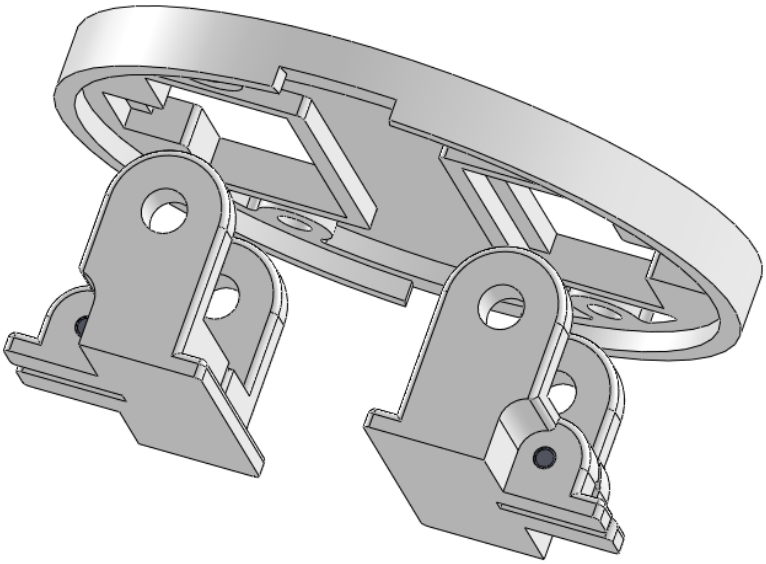
Assembly

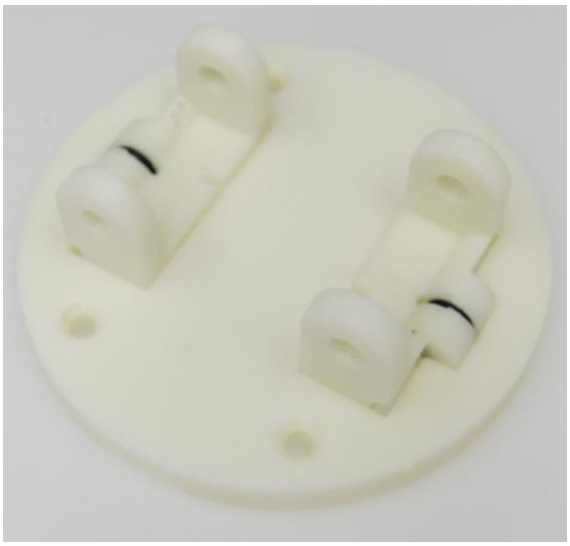
PIVOT-BASE FINGERS TOP

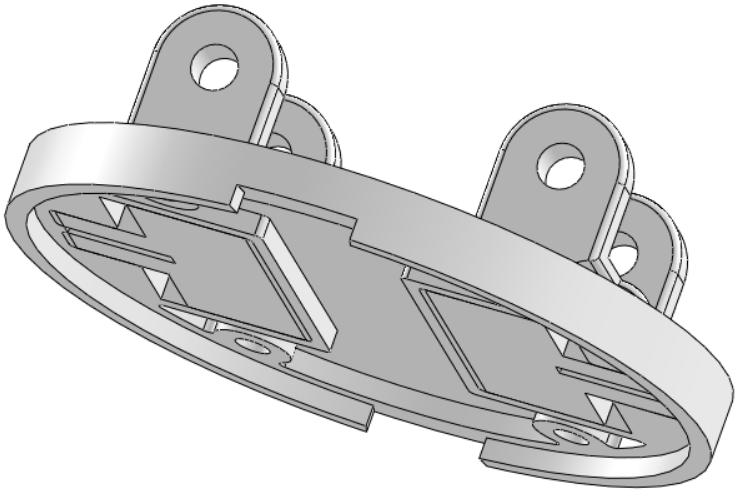
Parts
Sub-assembly from step 12 (x2)
a1_pivot.stl









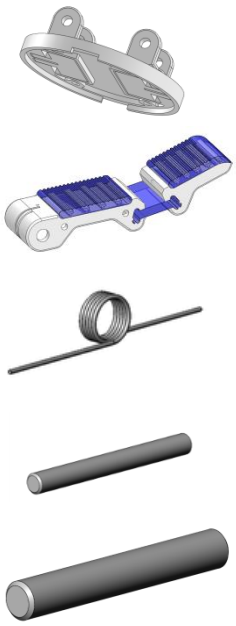


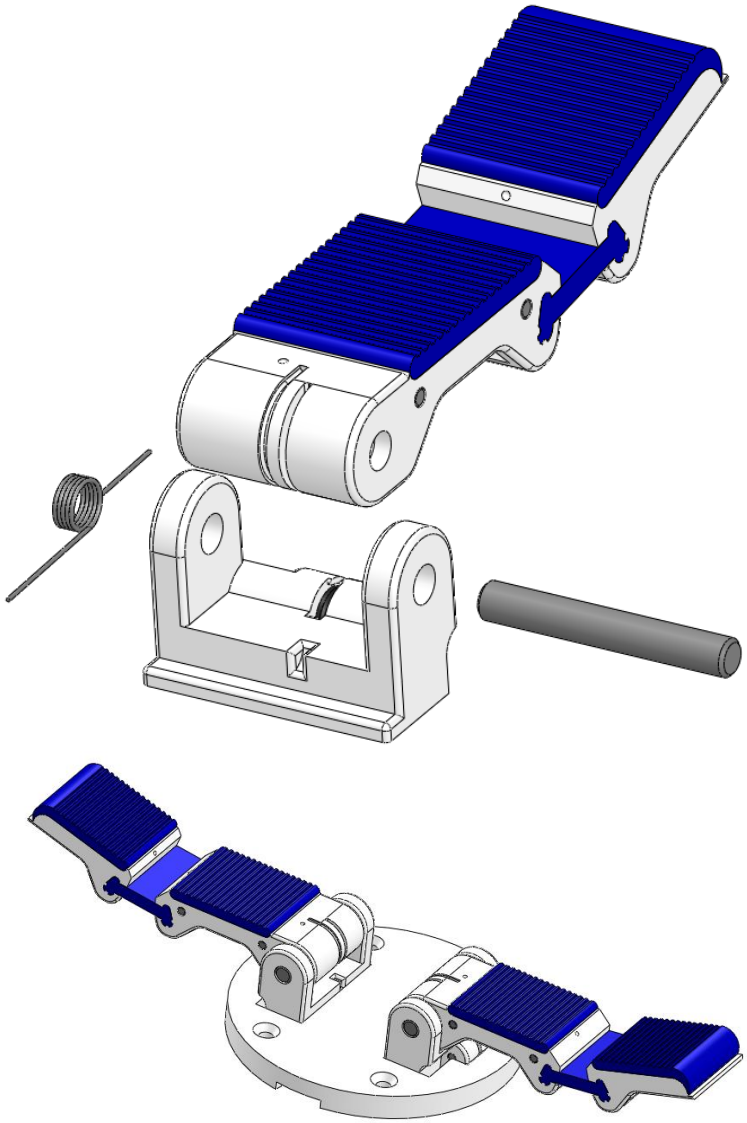
Assemble top pivot base plate as shown above. The finger pivot bases should fit flush with the top plate.

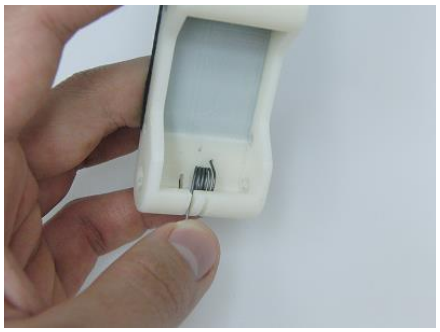
Assembly

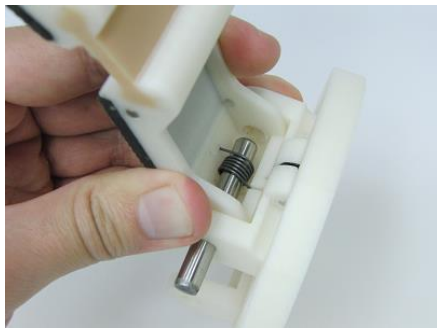
PIVOT-BASE FINGERS TOP

Parts
Sub-assembly from step 13
Pivot-based Finger (x2)
Torsion spring (x2)
Ø1/8”, L1-1/4” pin J1 (x4)
Ø1/4”, L1-3/4” pin J3 (x2)







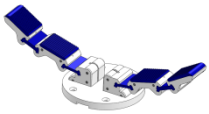


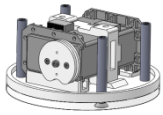
Install the torsion spring as shown above. Position the finger appropriately in *c1.stl*, and then slide the ¼” pin J2 in place to secure this sub-assembly for each finger.

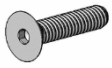
Assembly

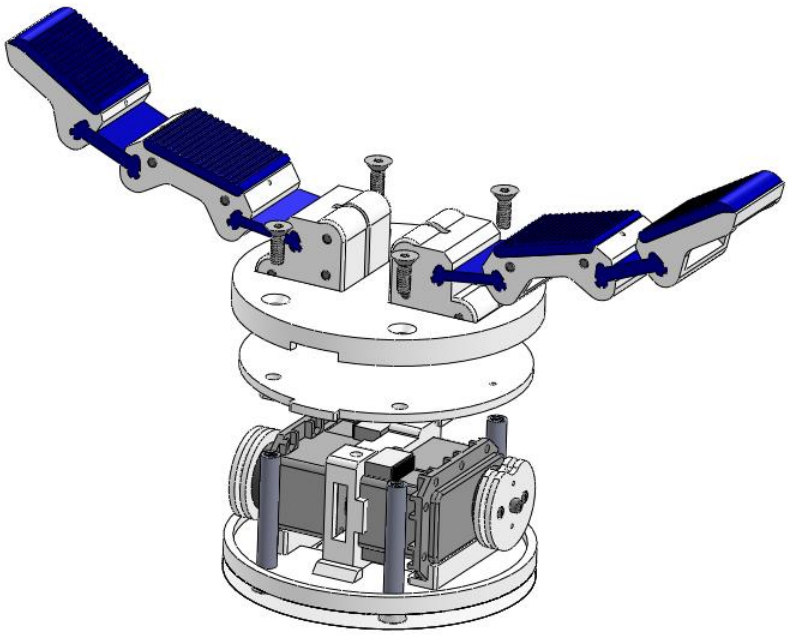
FINAL ASSEMBLY – FLEXURE BASE

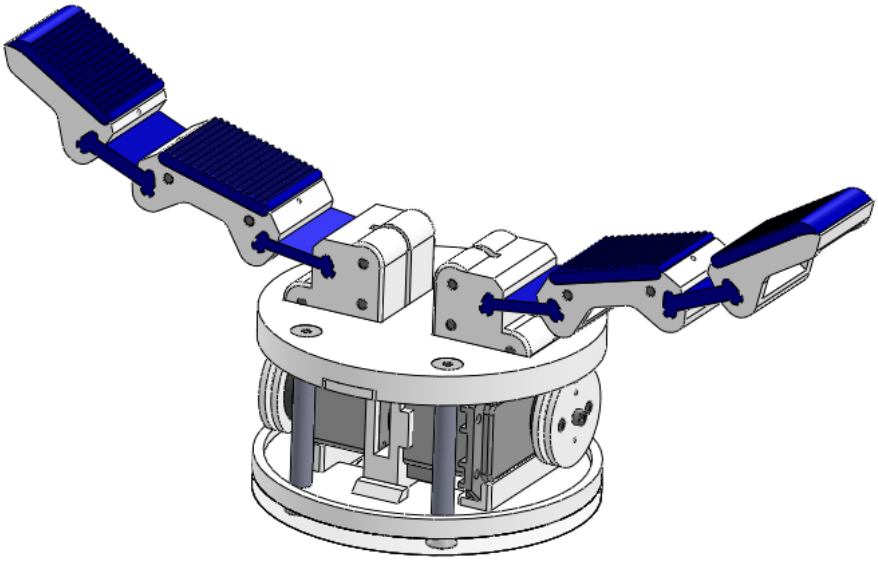
Parts
Top sub-assembly from step 11
Base sub-assembly from step 9
Socket Cap Screw 8-32, L3/4" (x4)







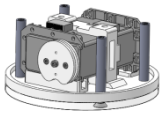
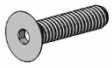


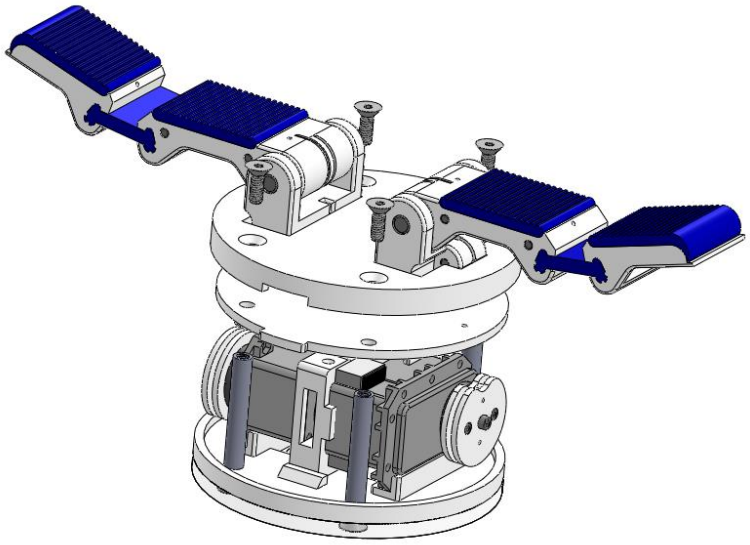


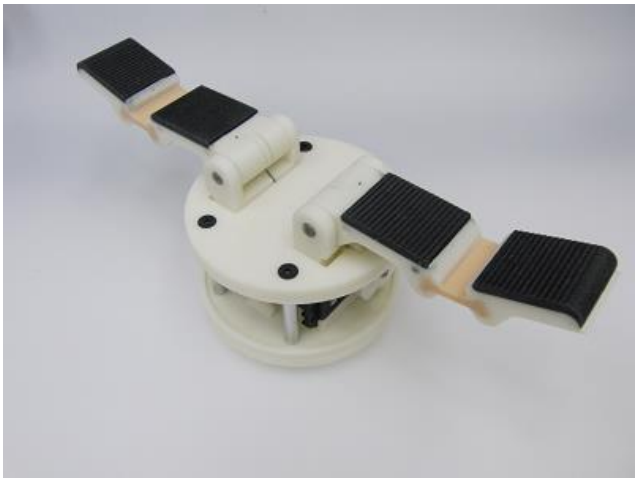
Use remaining socket screws to clamp the entire assembly together in place. The actuator block sub-assembly from step 9 should fit snugly

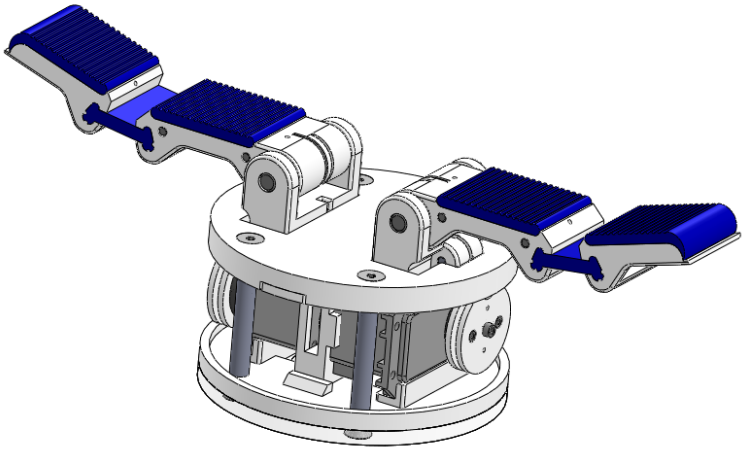
Assembly

FINAL ASSEMBLY – PIVOT BASE

Parts	
Top sub-assembly from step 14	
Base sub-assembly from step 9	
Socket Cap Screw 8-32, L3/4” (x4)	



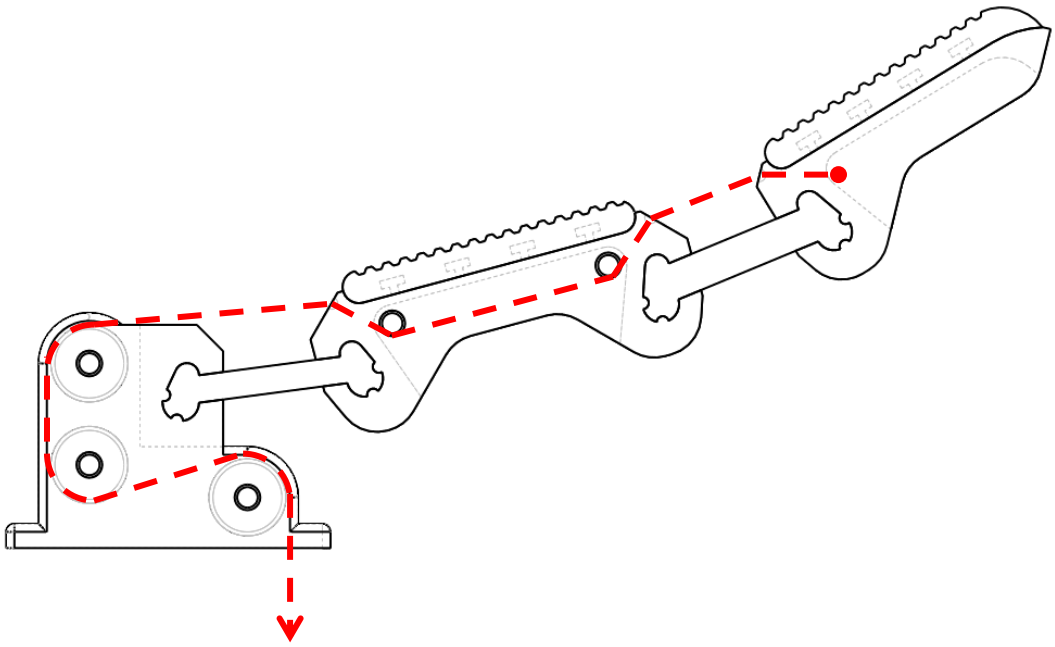


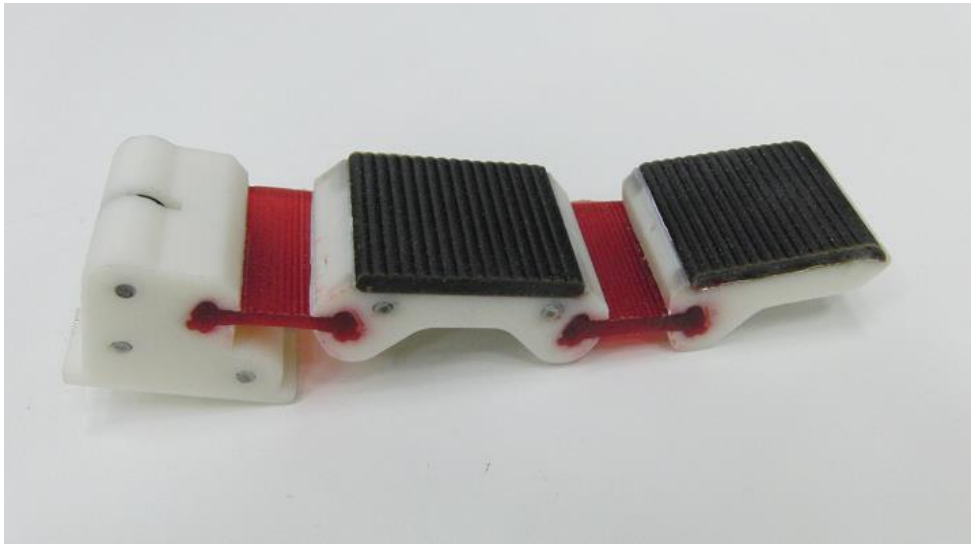


Use remaining socket screws to clamp the entire assembly together in place. The actuator block sub-assembly from step 9 should fit snugly

Tendon Routing

FLEXURE-BASE FINGERS



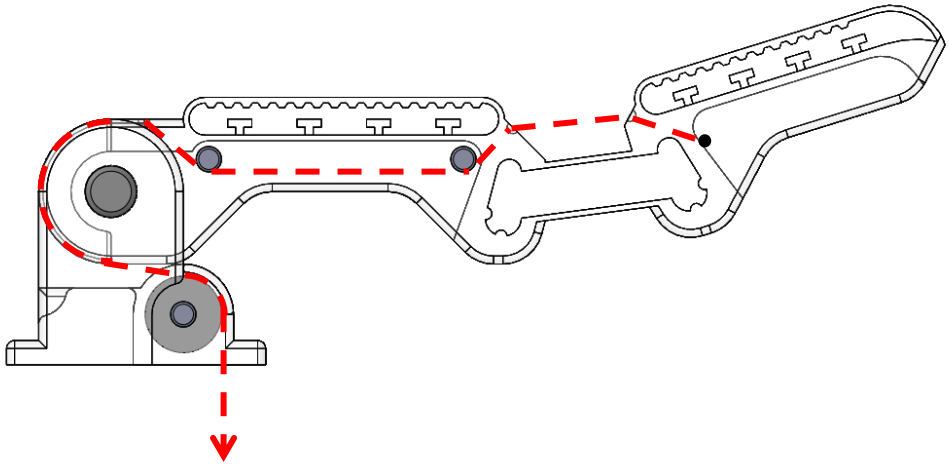


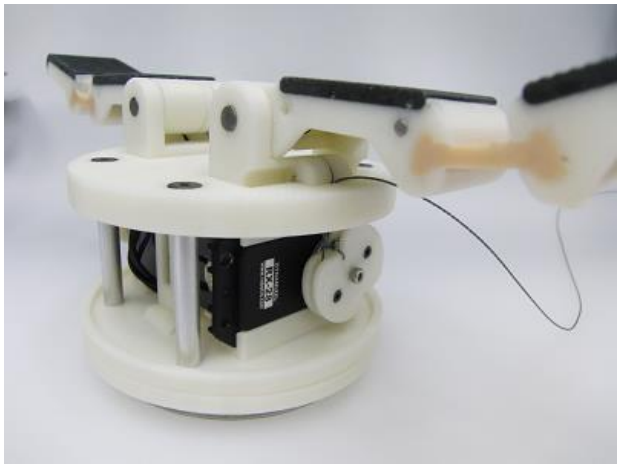
Tendons for flexure-based fingers run from the drive pulleys, through the top plate, across the 3 pulleys in the finger base, and through the finger routing ports, anchoring at the back of the fingertip, as shown above.

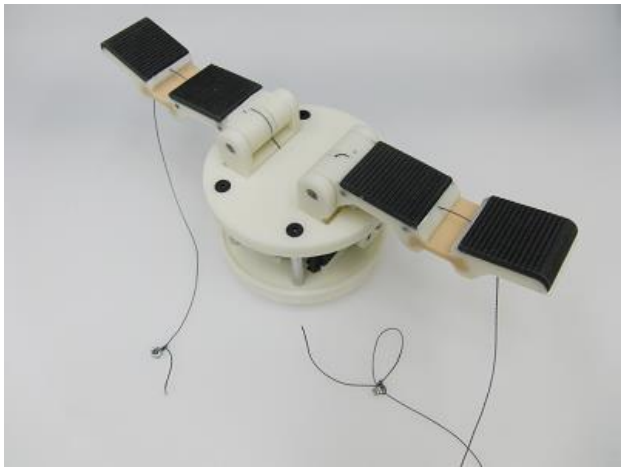
There should be enough tendon to leave slack after tying both ends. It is probably easiest to thread the tendon up from the servo to the fingertip.

Tendon Routing

PIVOT-BASE FINGERS





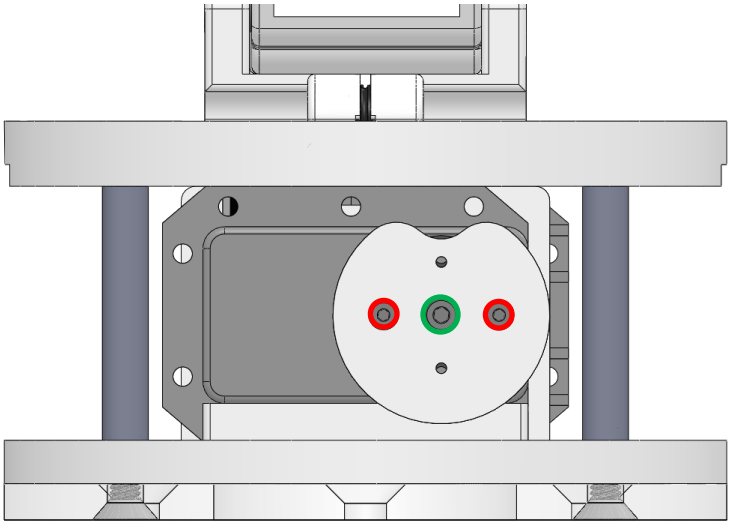


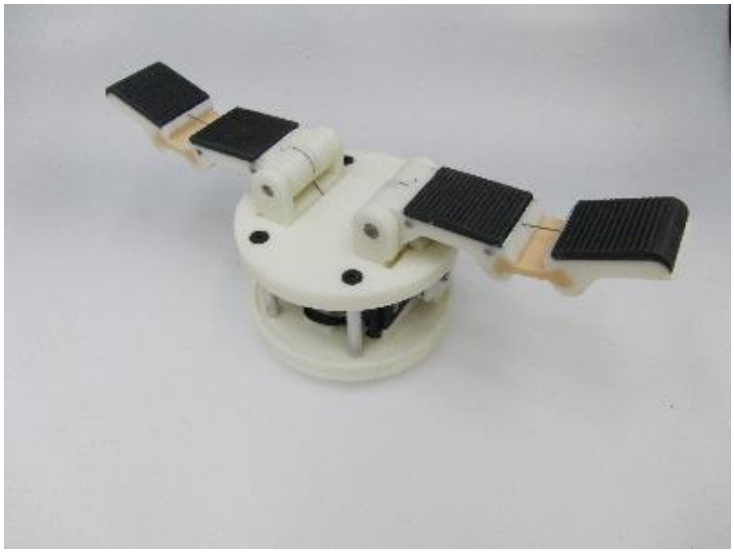
Tendons for flexure-based fingers run from the drive pulleys, through the top plate, across the pulley in the finger base, over the finger end, and through the finger routing ports, anchoring at the back of the fingertip, as shown above.

There should be enough tendon to leave slack after tying both ends.

Post-Assembly

SERVO ZERO-ING





1. Remove the M2 bolts from the servo pulley
2. Loosen, but do not remove, the central M2.5 bolt, such that the servo pulley can spin freely
3. Connect the Dynamixel and (in position mode) move it to its zero encoder position
4. By hand, turn the servo pulley until the tendon between the pulley and the main drive block is as taut as possible
5. Re-attach the M2 bolts and tighten the servo pulley
6. Repeat for other servo