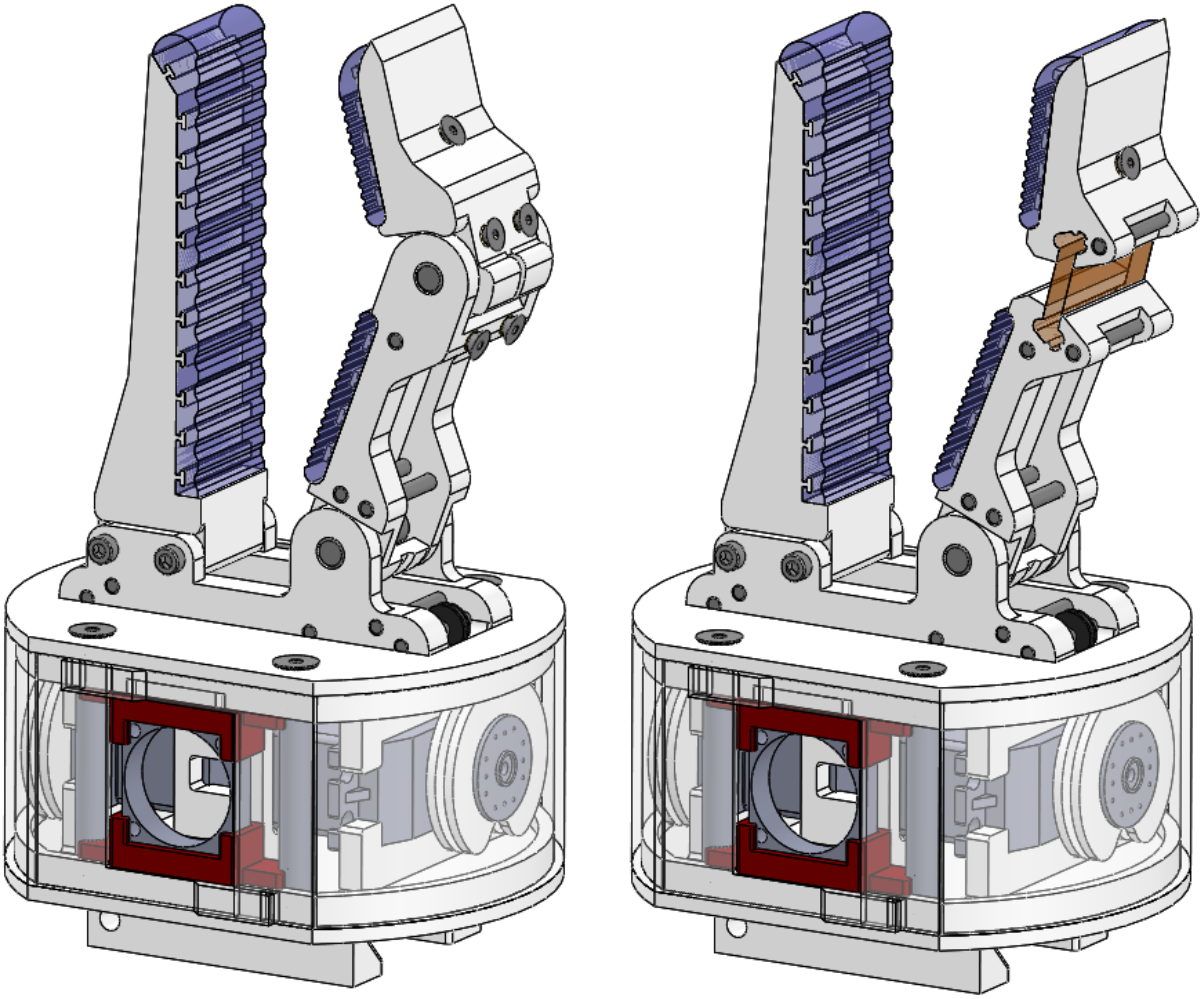
OpenHand

Model M²

Version 1.0



Assembly Instructions

Last updated: February 20, 2015

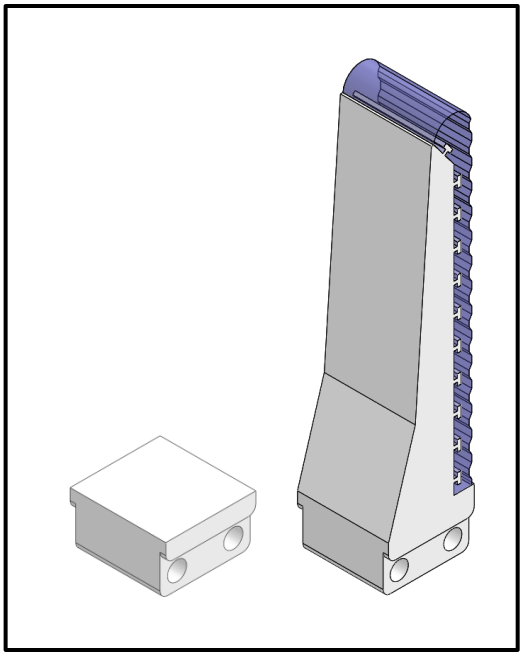
OTS Parts List

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”, L1-1/2”, 8-32 zinc-plated female standoff	4	Support	McMaster [93330A482]
Ø1/4”, L1-1/4” steel dowel pin	2	Joint pin	McMaster [98381a544]
Ø1/8”, L1-1/4” steel dowel pin	10	Routing pin	McMaster [98381A477]
M3, L8mm bolt	4	Thumb mounting bolt	McMaster [91292A112]
M3, L6.4mm heat-set insert	4	Insert for mounting bolt	McMaster [94180A333]
8-32, L3/4” countersunk bolt	8	Support bolt	McMaster [92210A197]
M2.5, L8mm bolt	2	Center bolt for Dynamixel (included w/ Dynamixel)	McMaster [91292A012]
M2, L5mm bolt	4	Mounting bolts for Dynamixel	McMaster [91290A012]
4-40, L0.135” heat-set insert	5	Insert for fingers	McMaster [93365A120]
4-40, L1/4” countersunk screw	5	Tendon/spring anchors	McMaster [91253A106]
Ø3/8”, nylon pulley	4	Tendon-routing pulley	McMaster [3434t31]
Extension spring, 0.188” OD, L3/4”, 0.016” wire diameter	4	Return spring	McMaster [9654k955]
Dynamixel RX/MX-28, or RX24-F	2	Actuator, alternative to Power HD servo	Various [Link]
Power HD 1501 MG Servo	2	Actuator, alternative to Dynamixel	Various [Link]
Sunon DC 25x25x7mm Fan 5V	1	Cooling fan for Power HD servo	Various [259-1573-ND]
Sunon DC 25x25x10mm Fan 12V	1	Cooling fan for Dynamixel	Various [259-1570-ND]

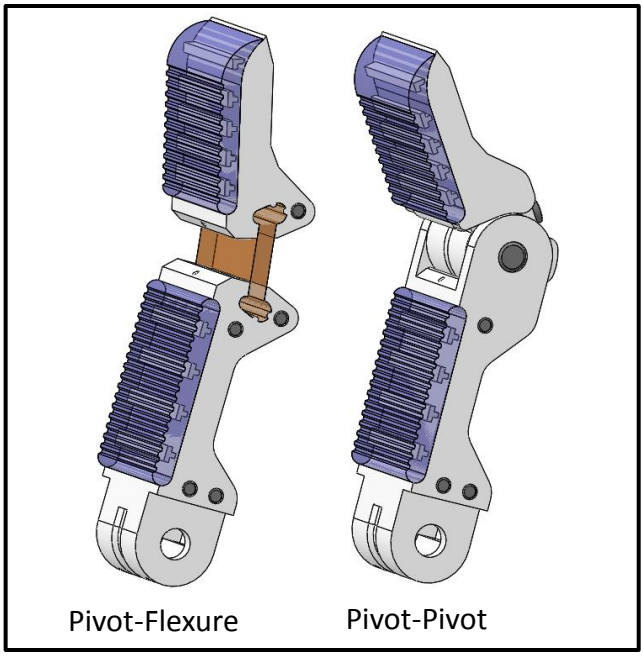
*** Note *** There are certainly other combinations of fasteners that may work with these designs. We do not even claim that the parts list provided here is optimal for these designs. They are merely the components that we have used in past builds.

Overview

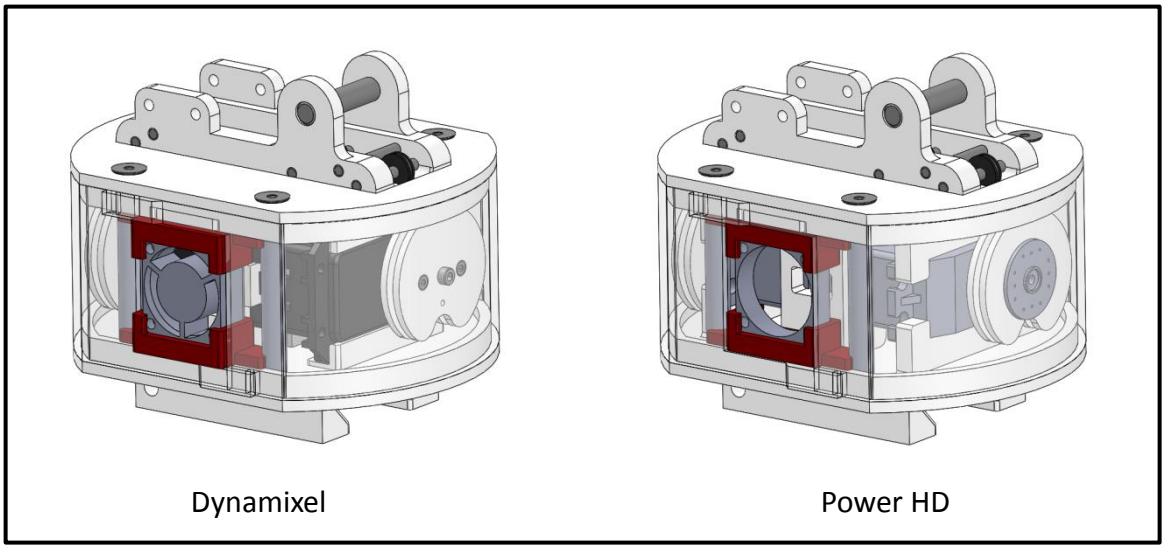
Thumb



Forefinger



Actuator Base

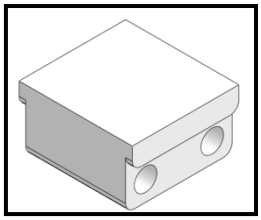


Thumb Sub-Assembly

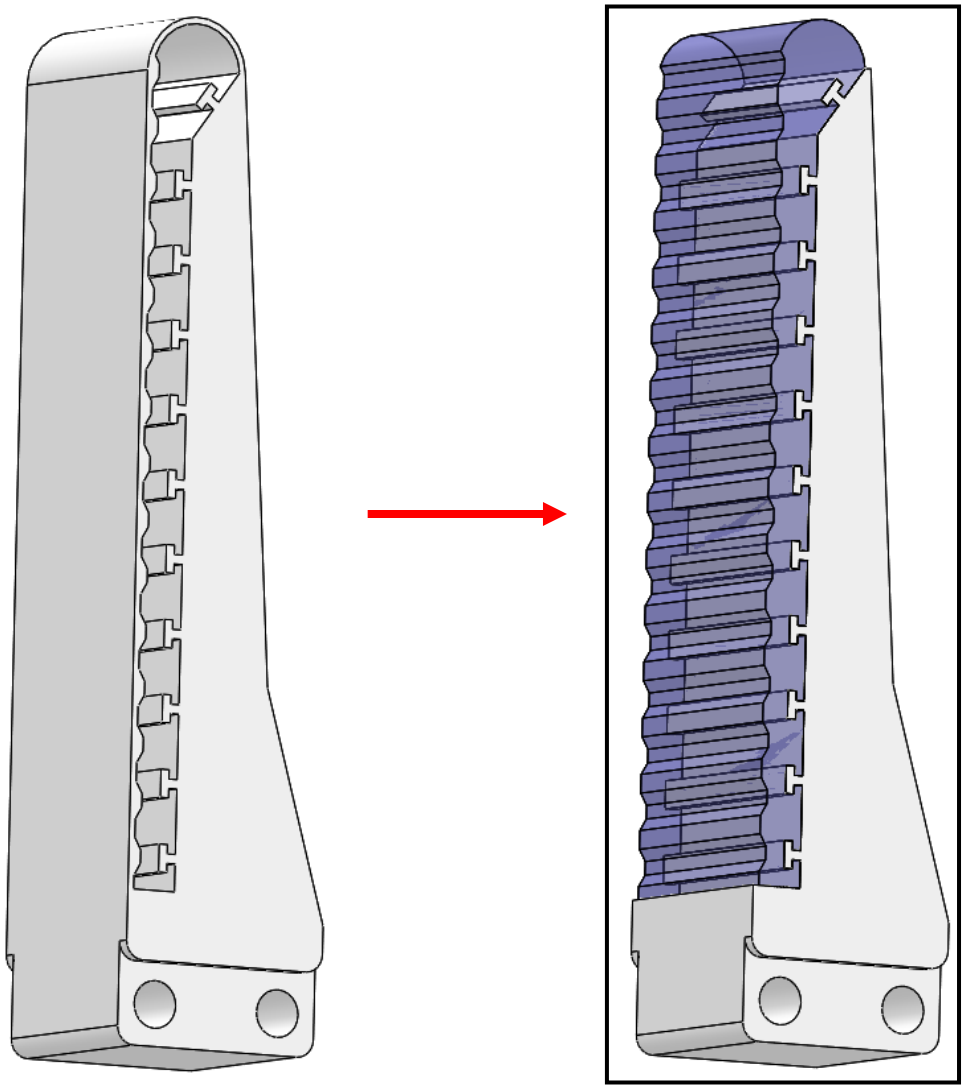
THUMB FABRICATION

Parts
thumb1.stl
Vytaflex 30 urethane (1:1)

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

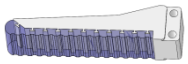


thumb_base.sldprt

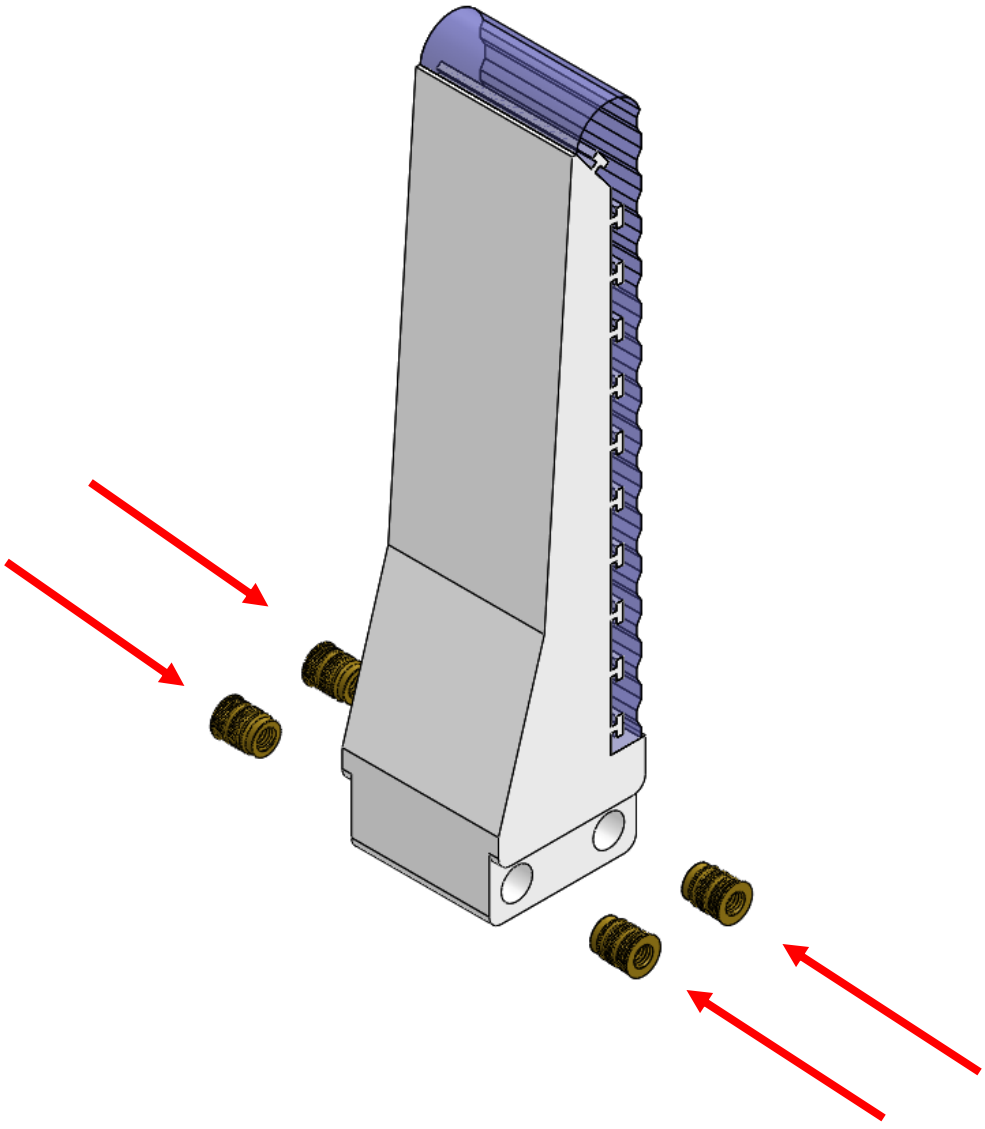


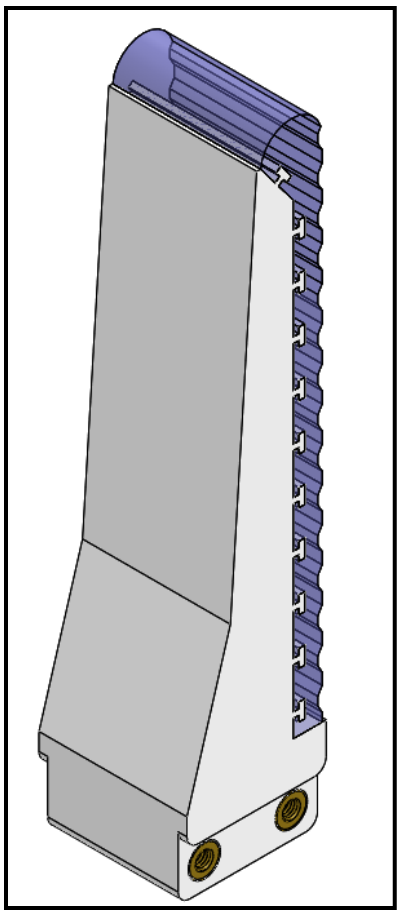
Thumb Sub-Assembly

THUMB FABRICATION

Parts	
Thumb from page 3	
M3, L6.4 heat-set insert (x4)	

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

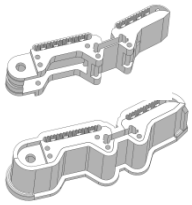




Forefinger Sub-Assembly

PIVOT-FLEXURE

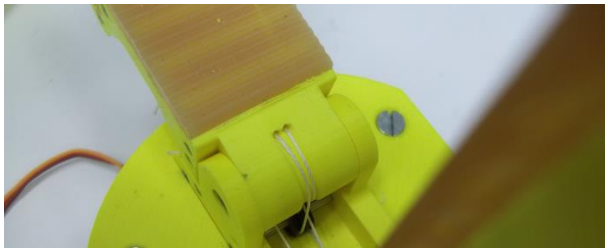
Parts
finger_pf_m2.stl - or - finger_pf_mold1_A_m2.stl finger_pf_mold1_B_m2.stl finger_pf_mold[2-4]_m2.stl
PMC-780 (2:1)
Vytaflex 30 (1:1)

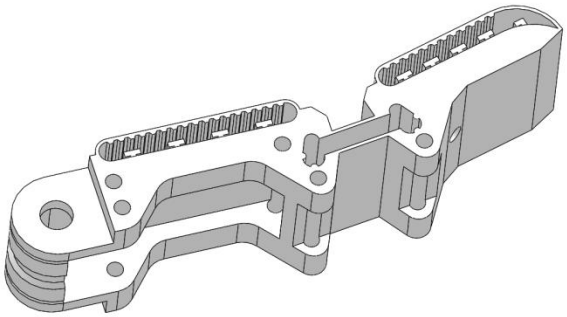


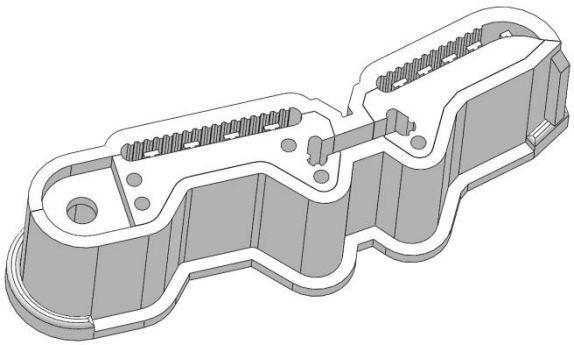
Go to page 7 for Pivot-Pivot Forefinger sub-assembly

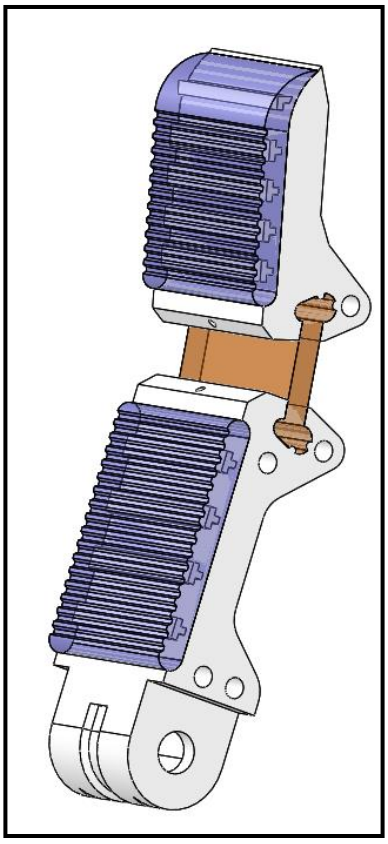
You have the option of using whether a thin-wall mold or multi-part mold. For the M2, you cannot use torsions springs as the return spring. Refer to the *OpenHand Finger Guide* for more detail on casting these pads and flexures.

Note that the proximal base needs TWO tendon ports drilled, as shown below:



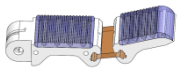




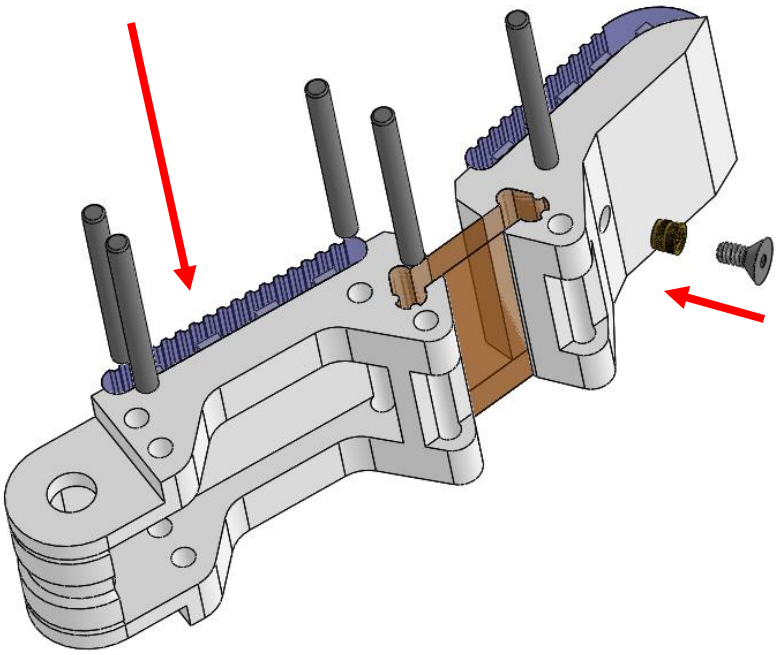


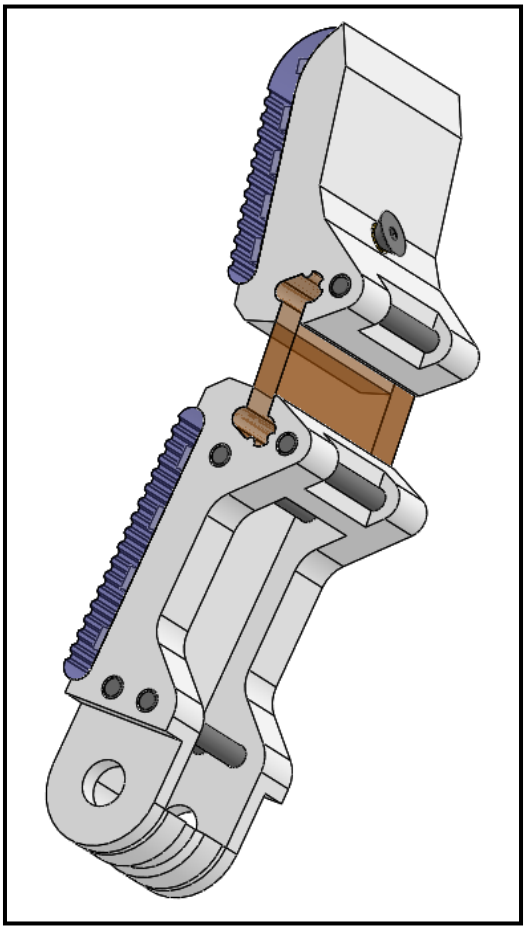
Forefinger Sub-Assembly

PIVOT-FLEXURE

Parts	
Pivot-Flexure Forefinger	
4-40, L0.135” heat-set insert	
4-40, L1/4” countersunk screw	
Ø1/8”, L1-1/4” steel dowel pin (x5)	

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.



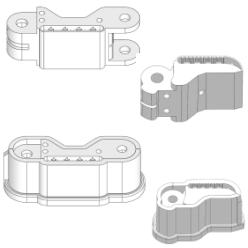


Skip to page 9

Forefinger Sub-Assembly

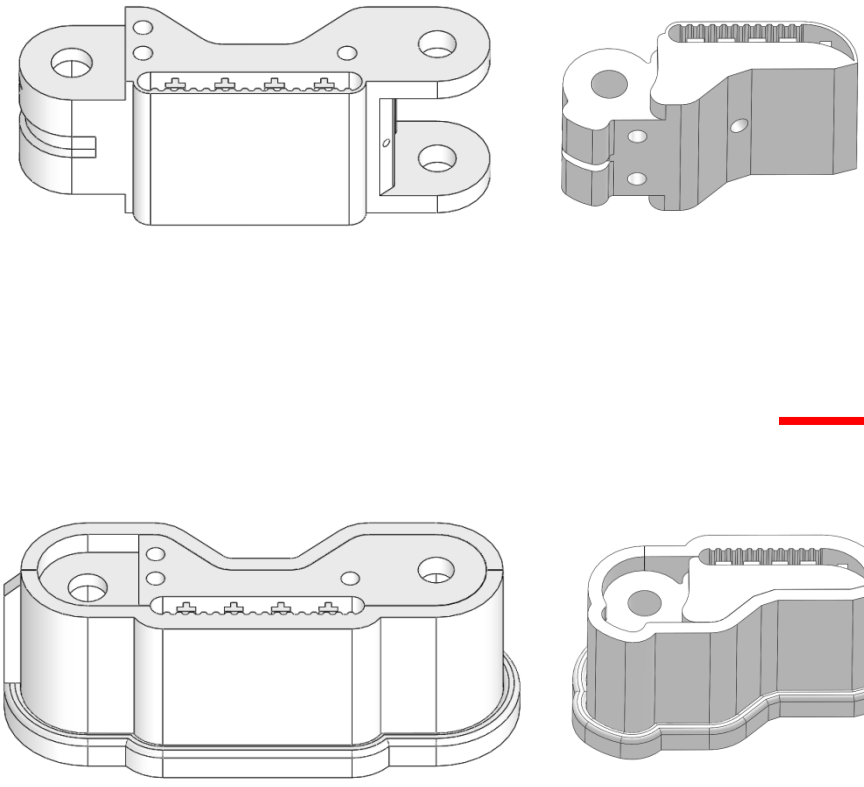
PIVOT-PIVOT

Parts
finger_pp_A_m2.stl finger_pp_B_m2.stl - or - finger_pp_mold1_A_m2.stl finger_pp_mold[2-4]_A_m2.stl finger_pp_mold1_B_m2.stl finger_pp_mold[2-4]_B_m.stl
Vytaflex 30 (1:1)



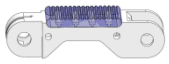
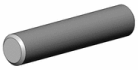
Go back to page 5 for Pivot-Flexure Forefinger sub-assembly

You have the option of using whether a thin-wall mold or multi-part mold. Refer to the *OpenHand Finger* for more detail on casting these pads. There are no flexures needed for Pivot-Pivot finger design. Note that some of the mold parts are the same as that for Model M



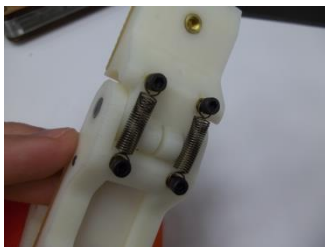
Forefinger Sub-Assembly

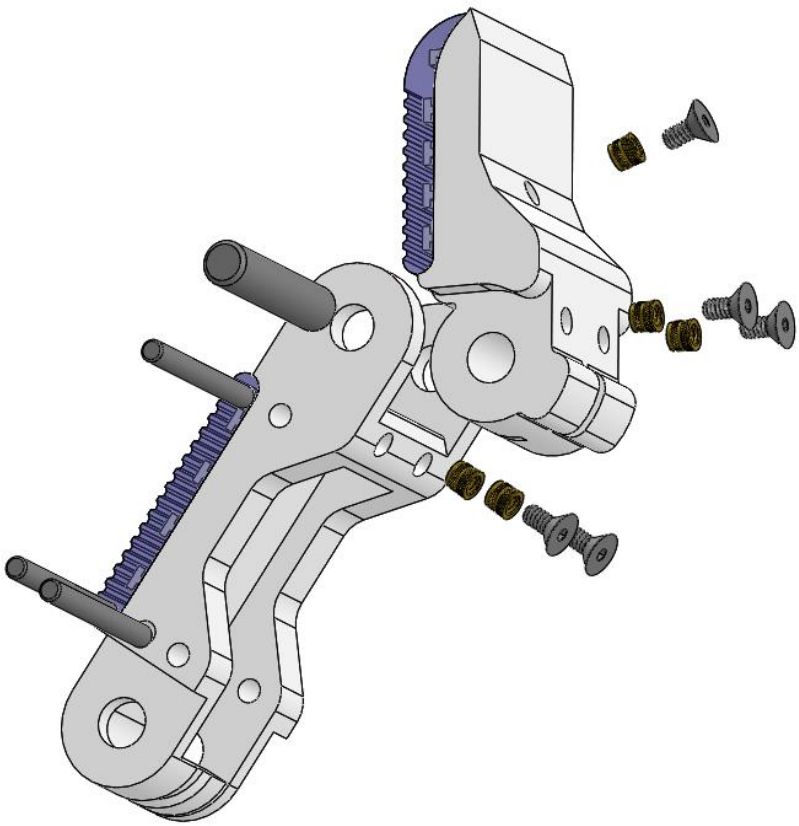
PIVOT-PIVOT

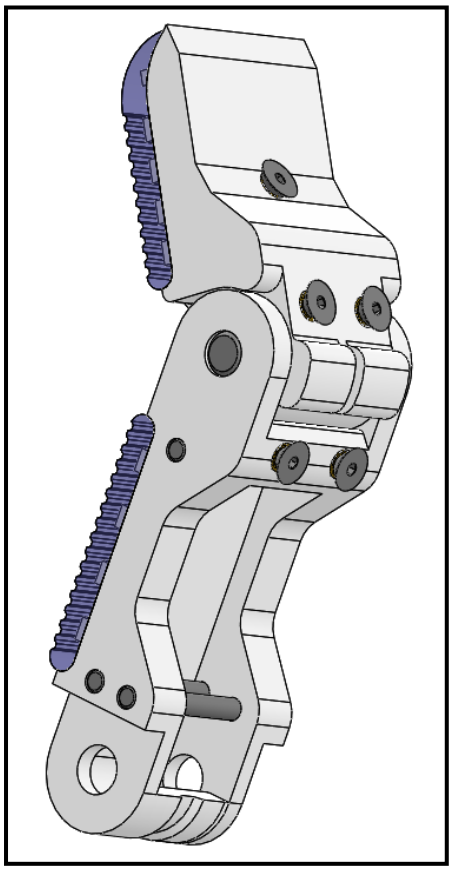
Parts	
Pivot-Pivot finger distal link	
Pivot-Pivot finger proximal link	
4-40, L0.135” heat-set insert (x5)	
4-40, L1/4” countersunk screw (x5)	
Ø1/8”, L1-1/4” steel dowel pin (x3)	
Ø1/4”, L1-1/4” steel dowel pin	
Extension spring (x2)	

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. A pair of extension springs or elastic bands should be anchored on bolts threaded into the inserts closest to the distal joint.

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

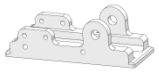
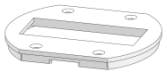




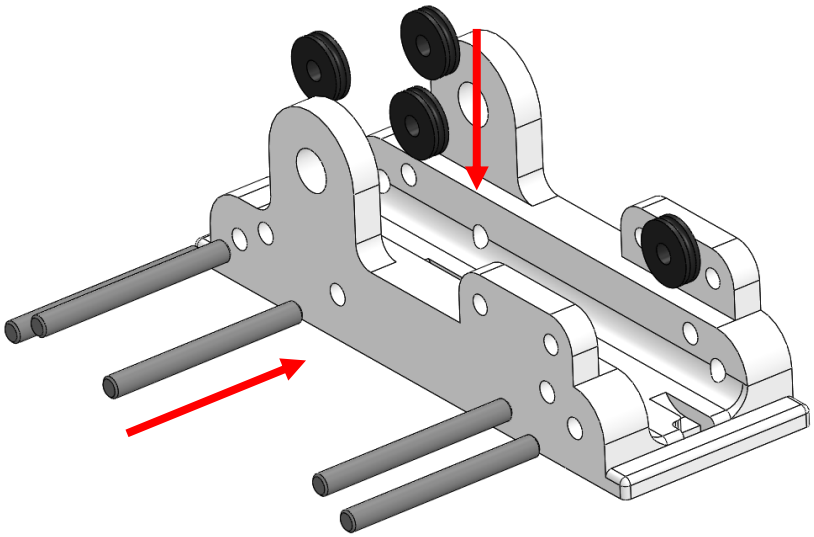


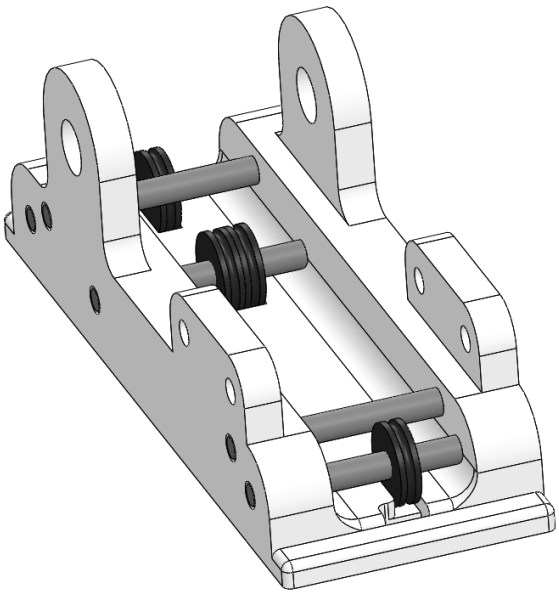
Actuator Sub-Assembly

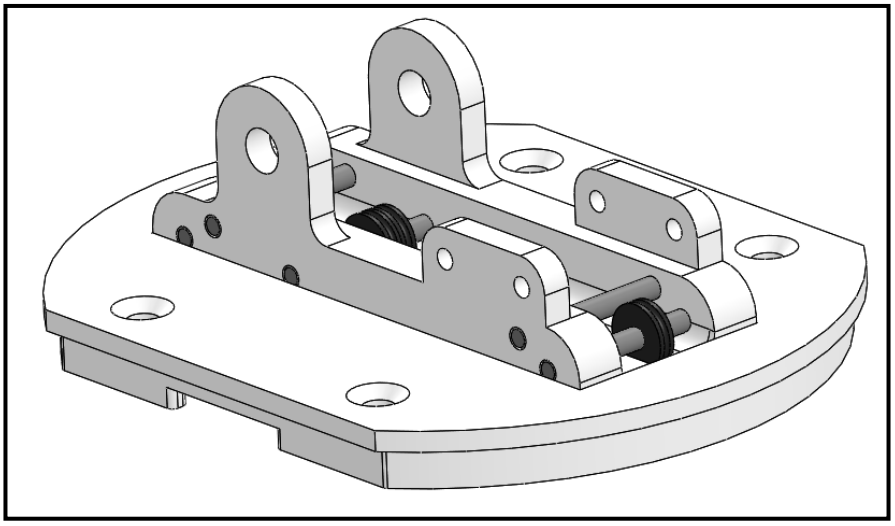
TOP BASE

Parts	
c1_m2.stl	
a1_m.stl	
Ø1/8”, L1-1/4” steel dowel pin (x5)	
Ø3/8” nylon pulley (x4)	

Insert the 1/8” pins and nylon pulleys first into the finger base part *c1_m2.stl*. Then insert through the clearance of top piece *a1_m.stl*. There are recesses in *c1_m2.stl* designating where the nylon pulleys should be positioned.

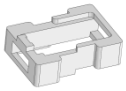






Actuator Sub-Assembly

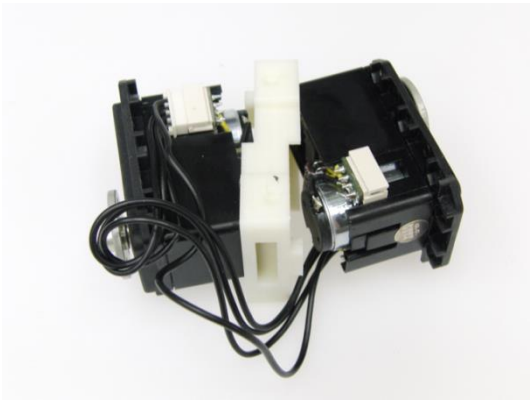
DYNAMIXEL

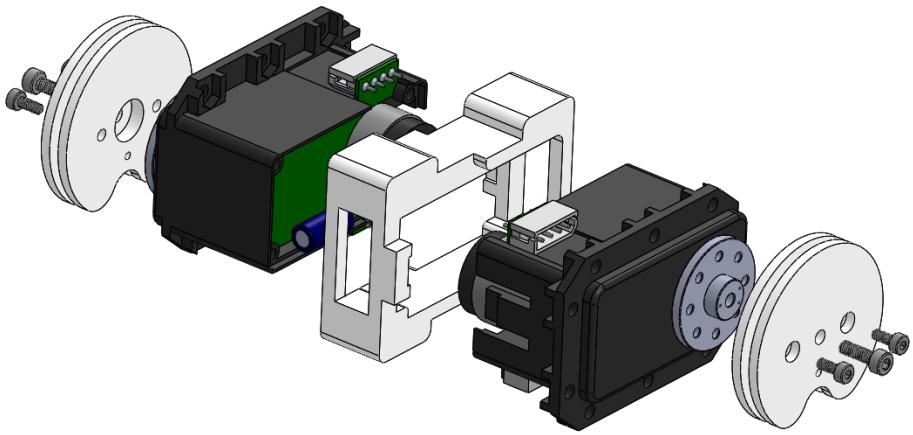
Parts	
Dynamixel RX-28 or MX-28 or RX24-F (x2)	
b1_dynamixel_m.stl (x2)	
b2_dynamixel_m2.stl	
Spectra tendon line	
M2.5, L8mm bolt (x2)	
M2, L5mm bolt (x4)	

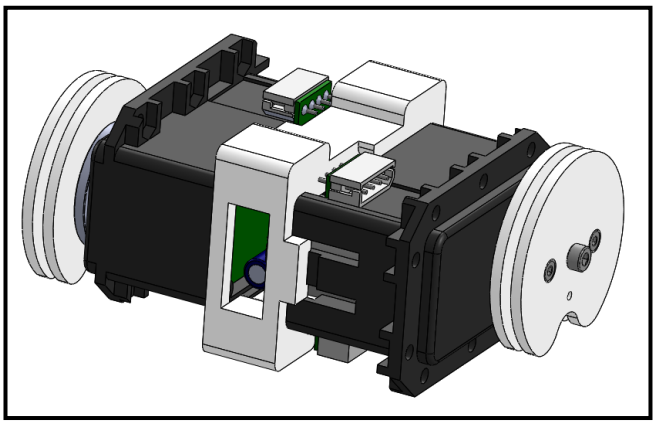
Go to page 12 for Power HD servo actuator sub-assembly

Either the RX-28 or MX-28 or RX24-F can be used as the Dynamixel actuator. Take the back off of the Dynamixel servos by unscrewing the 4 main bolts. Snap on piece *b2_dynamixel_m2.stl* as the servo's new back. The two Dynamixels will sit back to back.

Tie about a foot (~30cm) of tendon line to the servo pulley *b1_dynamixel_m.stl* through the non-bolt hole. It's a good idea to wire the two Dynamixels together in a daisy-chain setup in this step.

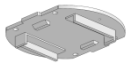
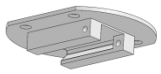
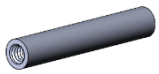
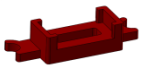






ACTUATOR SUB-ASSEMBLY

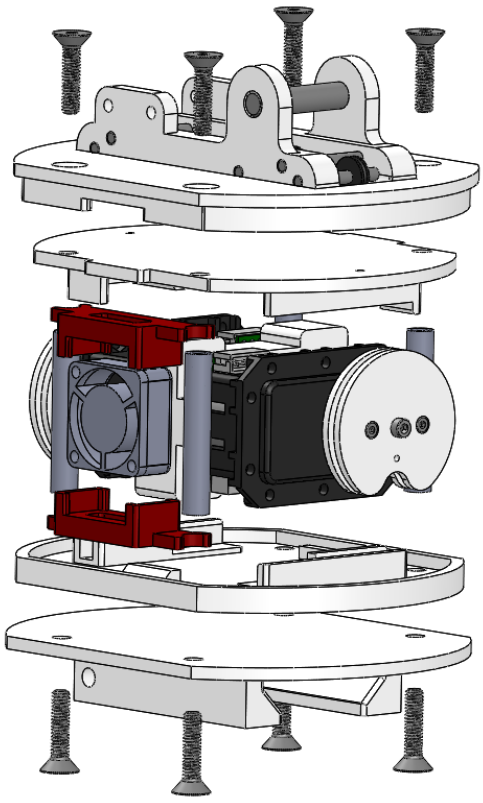
DYNAMIXEL

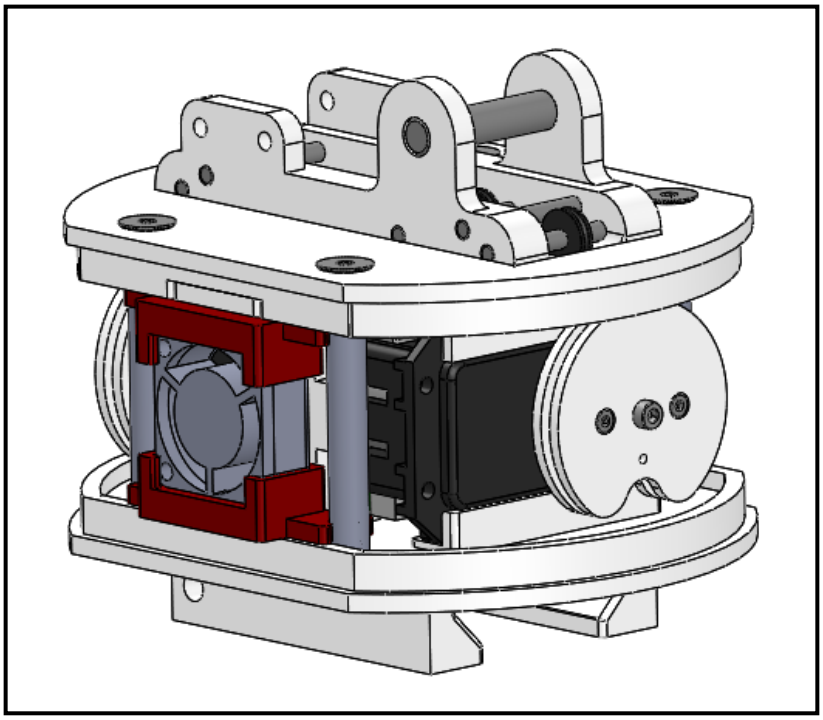
Parts	
Dynamixel sub-assembly from page 10	
Top sub-assembly from page 9	
a2_dynamixel_m2.stl	
a3_dynamixel_m2.stl	
a4_coupling_m.stl - or - a4_blank_m.stl	
8-32, L3/4" countersunk bolt (x8)	
Ø1/4", L1-1/2", 8-32 zinc-plated female standoff (x4)	
d2_m2.stl (x2)	
Sunon 25x25x10mm 12V fan	

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

The optional part *d2_m2.stl* is for implementations that incorporate a cooling fan. This tends to be a lot more helpful for Dynamixels than the Power HD servos.

This sub-assembly is essentially identical to that for the Model T42





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Actuator Sub-Assembly

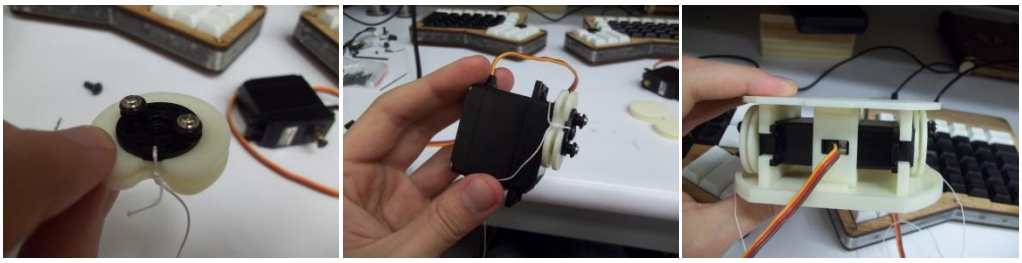
POWER HD SERVO

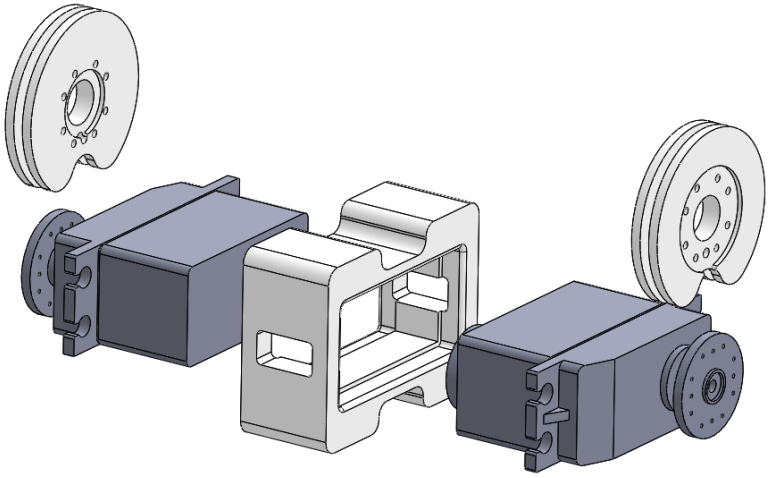
Parts	
Power HD servo (or any other servo with same dimensions) (x2)	
b1_power_m.stl (x2)	
b2_power_m2.stl	
Spectra tendon line	

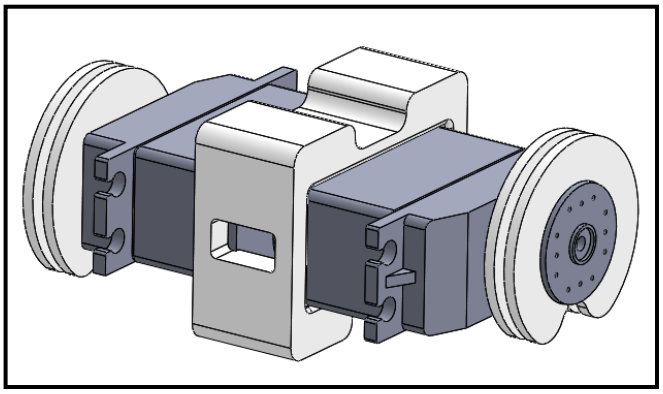
Go back to page 10 for Dynamixel actuator sub-assembly

The Power HD servo is assembled into the actuator sub-assembly much like the Dynamixel is. The pulley part *b1_power_m.stl* is assembled counter-intuitively. The part will sit between the servo body and the round servo horn that comes with the Power HD servo. You can choose to secure the printed pulley to the default servo horn however you like, but we chose to use the screws and bolt included with the servo.

Tie about a foot (~30cm) of tendon line to the servo pulley *b1_dynamixel_m.stl* through the non-bolt hole.

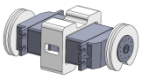
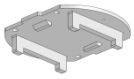
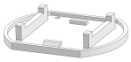
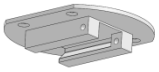
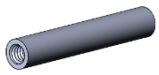
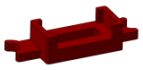






ACTUATOR SUB-ASSEMBLY

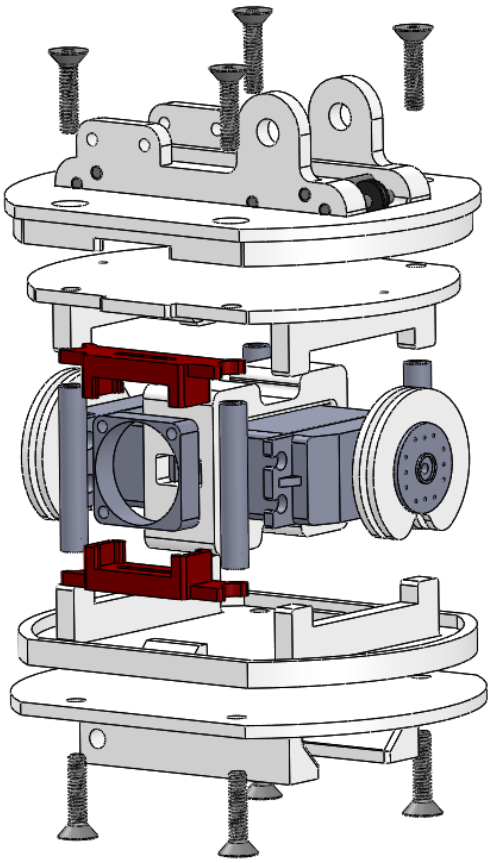
POWER HD SERVO

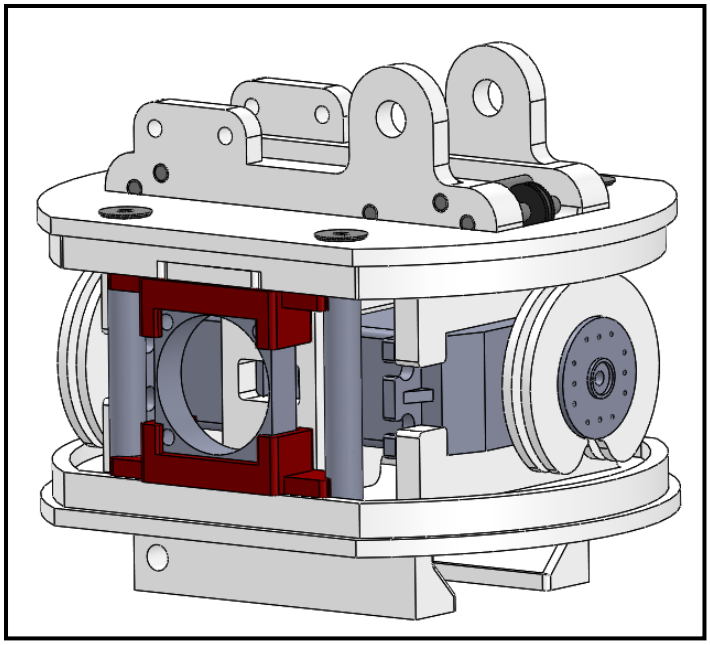
Parts	
Power HD sub-assembly from page 12	
Top sub-assembly from page 9	
a2_power_m2.stl	
a3_power_m2.stl	
a4_coupling_m.stl - or - a4_blank_m.stl	
8-32, L3/4" countersunk bolt (x8)	
Ø1/4", L1-1/2", 8-32 zinc-plated female standoff (x4)	
d2_power_m2.stl (x2, optional)	
Sunon 25x25x7mm 5V fan	

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

The cooling fan isn't really necessary for the Power HD servos, but the design accommodates them as well with the fan mount part *d2_power_m2.stl*

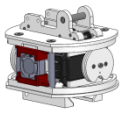
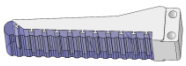
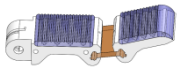
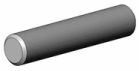
This sub-assembly is essentially identical to that for the Model T42





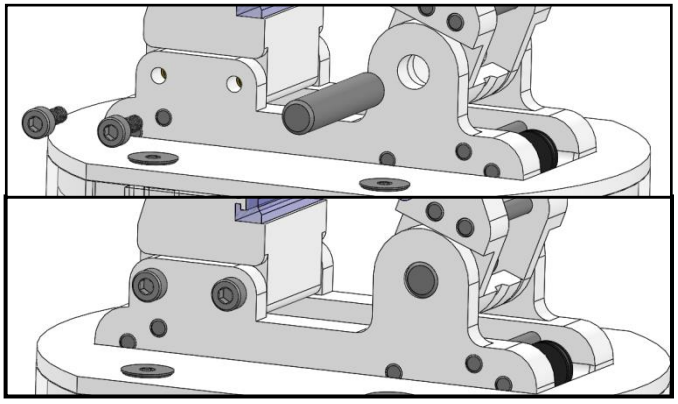
Final Assembly

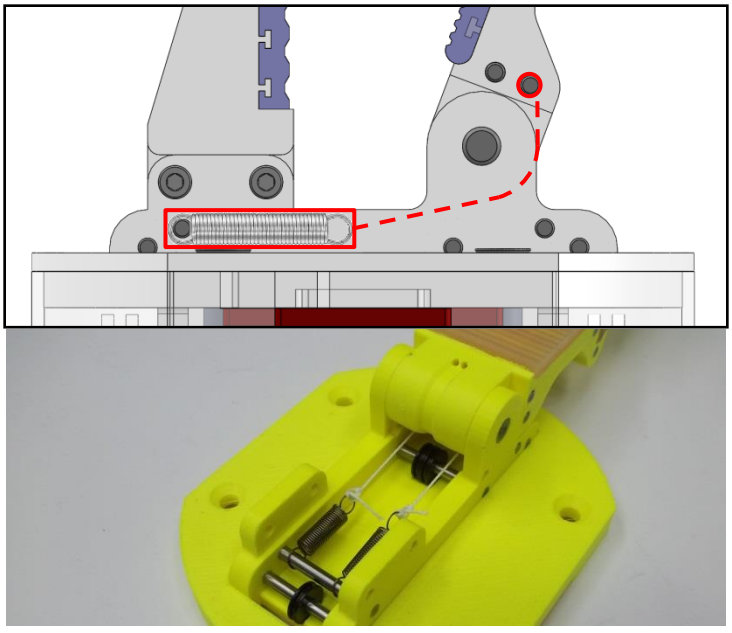
HAND FRAME

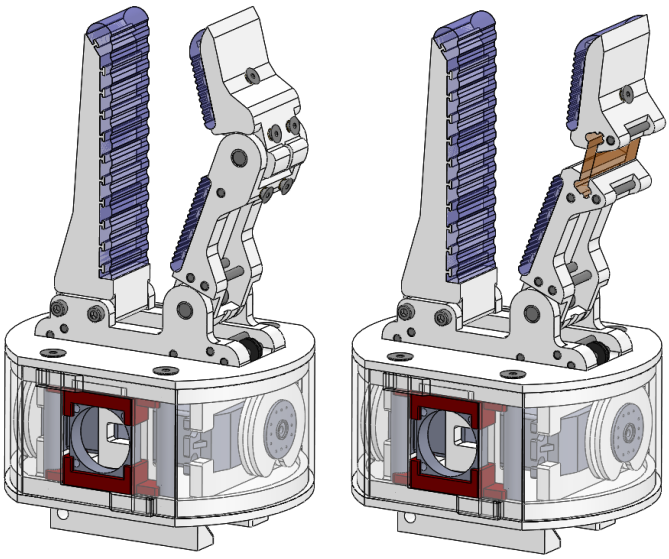
Parts	
Actuator sub-assembly (Dynamixel) from page 11 - or - Actuator sub-assembly (Power HD) from page 13	
Thumb	
Pivot-Flexure Forefinger from page 6 - or - Pivot-Pivot Forefinger from page 8	
M3, L8mm bolt (x4)	
Ø1/4", L1-1/4" steel dowel pin	
Extension spring (x2)	
d1_m.stl - or - d1_fan_m.stl (x2, optional)	
Spectra tendon line	

The final assembly step is nearly identical no matter what your design choices are. For the proximal base joint, two extension springs and Spectra tendon will connect the pin beneath the thumb and the bottomlest 1/8" pin on the forefinger.

The shell *d1_m.stl* is option but should snap together when assembled between the topmost and bottommost plates *a1_m.stl* and *a4_coupling_m.stl*.



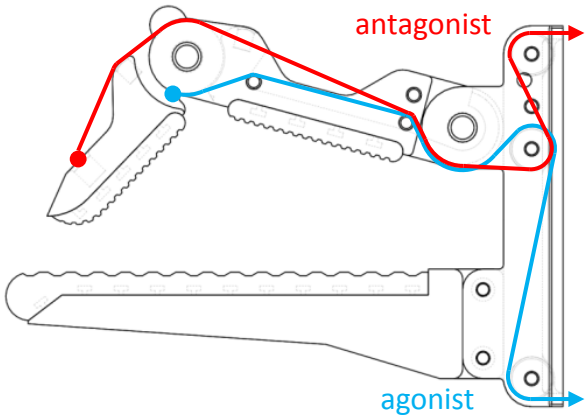




Final Assembly

TENDON ROUTING

Parts
Hand assembly
Spectra tendon line



There are two tendons: antagonist and agonist, that need to be anchored at the distal link. It doesn't matter which tendon is actuated by which servo. It also doesn't matter which of the two tendon ports at the forefinger base either tendon goes through. Both tendons will run across the front of the base proximal joint. The antagonist tendon will run along the back of the proximal and distal links.

To zero the tendon lines:

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

You will want to leave some slack in the antagonist line, but you should play around with the tendon zero-ing until you get your desired operation.