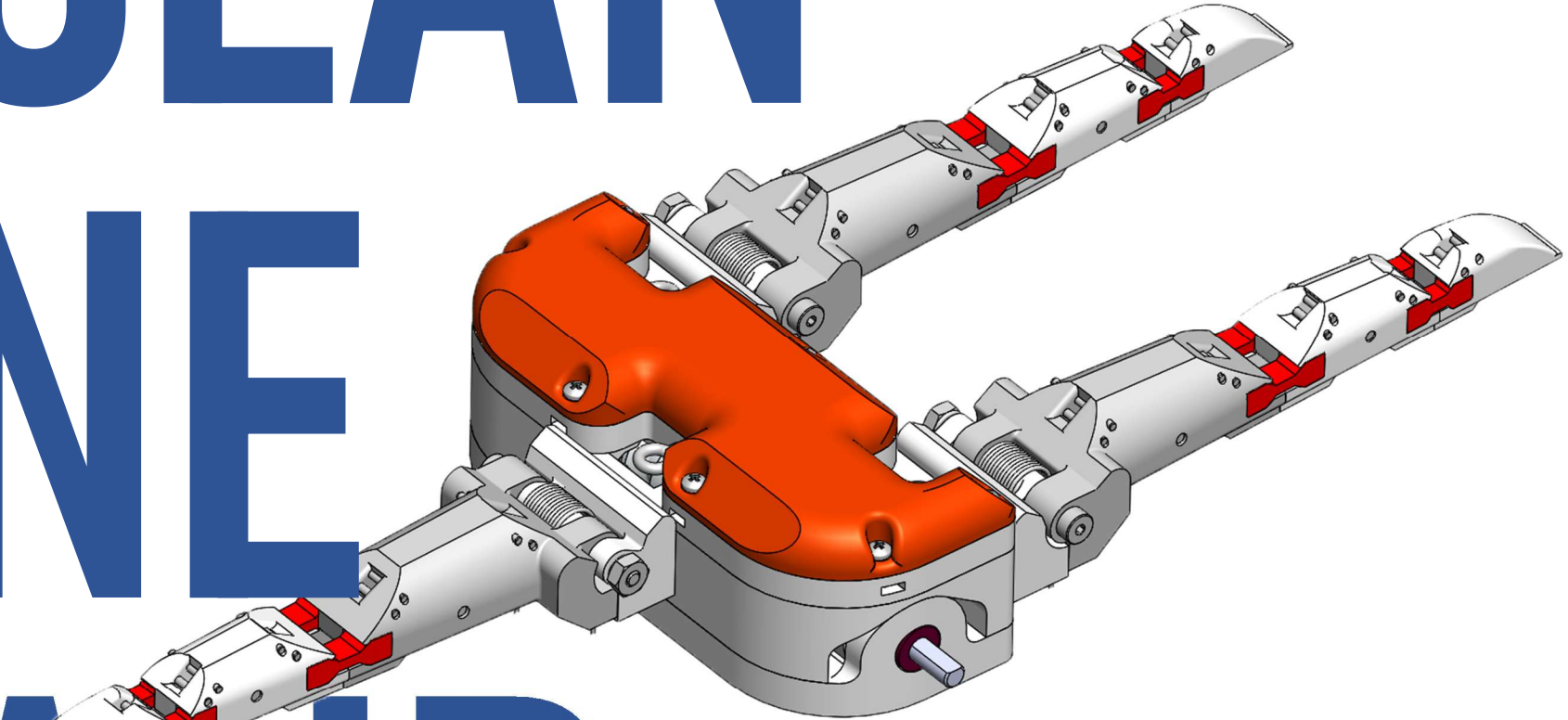


OCEAN ONE HAND



ASSEMBLY INSTRUCTIONS

Written by Junlong Li in
collaboration with Professor
Hannah Stuart and Embodied
Dexterity Group

Based on the paper "*The Ocean
One hands: An adaptive design
for robust marine manipulation*"
by Hannah Stuart et al. at
Stanford University

PROJECT OVERVIEW

The Ocean One Hand was developed by UC Berkeley Professor Hannah Stuart during her time studying at Stanford University. The Hand was designed for deep-sea exploration with its elastic finger joints and spring transmission which can achieve variety of grasp. With this open source project, Professor Stuart and EDG wish to “empower the general marine science and technology community to start exploring the potential benefits and uses” of this type of compliant grippers.

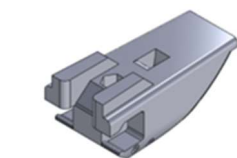
The first iteration of the Open Source Ocean One Hand Project requires elaborate tools and lab space. It might only be suitable to those with access to a full maker space. A laser cutter, a 3D printer, a power drill and proper chemical disposal are required for this project. The time required to complete this project will depend on the access to tools and off the shelf parts. The estimate cost for raw material of the project, assuming that the main prototyping tools and equipment are \$ 350.

Please consider all the above and be prepared before starting the project.

Please submit any questions or feedback to junlong21li@berkeley.edu

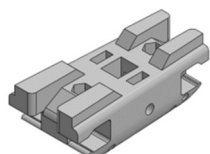
Thank you for your interest in testing the first iteration of the Open Source Ocean One Hand.

A



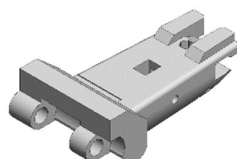
DISTAL JOINT

A1 X3



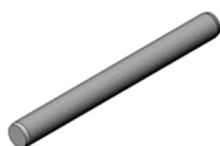
MIDDLE JOINT

A2 X3



PROXIMAL

JOINT A3 X3



93600A195 A10X3

93600A376 A11X3

93600A246 A12X3

93600A163 A13X6

93600A249 A14X6

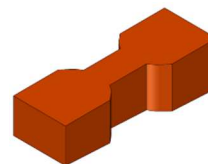
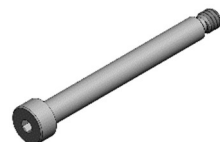
93600A233 A15X6

93600A238 A16X6

93600A223 A17X3

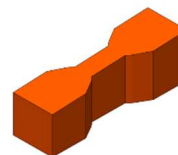
94035A172

A18X3



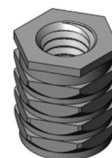
DIST FLEXURE

***A4 X6**



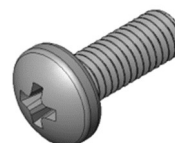
MID FLEXURE

***A5 X6**



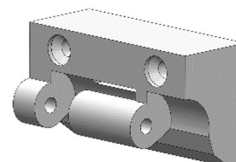
92398A121

A6 X12



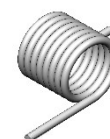
90116A153

A7 X19



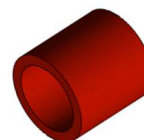
BASE JOINT

A8 X3



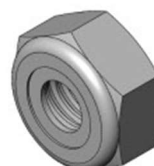
9287K208

A9 X3



6362K100

A19 X6



90101A009

A20 X3

B

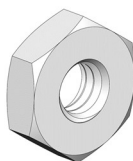
PARTS LIST



**TORSION SPRING
HOUSING 1 B1 X3**



**TORSION SPRING
HOUSING 2 B2 X3**



**93935A310
B3 X3**



**Spring Inside
Spacer B4 X3**



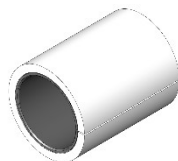
**7532K110
B5 X7**



**93600A200
B6 X3**



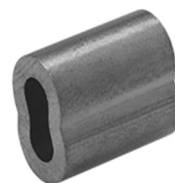
**9287K143
B7 X3**



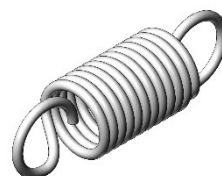
**STAINLESS STEEL IN
PTFE BUSHING* B8 X3**



**92029A097
B9 X3**



**3755T12
B10 X3**



**9065K113
B11 X3**

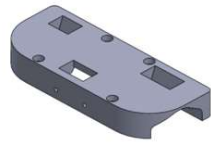


**9065K59
B12 X3**

Braided Dyneema Fishing Line B13
(Or any string with the safety factor of 10 based on max load)

*SEE BUSHING SPECIFICATION IN OFF THE SHELF PARTS SPECIFICATION

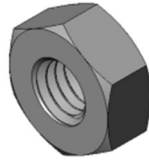
C



FINGER MOUNTING
PLATE **C1** X1



92010A130
C3 X6



94150A325
C2 X13

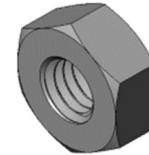


92290A182
C4 X4

D



EYEHOOK MOUNTING
PLATE **D1** X1



94150A335
D3 X4

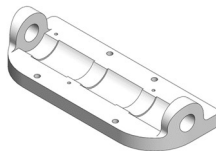


30425T230
D2 X6



PALM PLATE
*

E



SHAFT SUPPORT
E1 X1

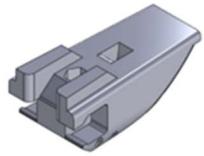


7763K100
E3 X2

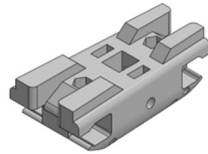


D SHAFT
(2 options see
below)

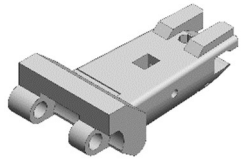
KEY 3D PRINTS ORIENTATION SUGGESTION



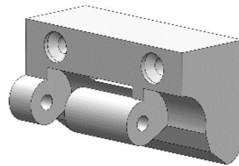
**DISTAL
JOINT A1**



**MIDDLE
JOINT A2**



**PROXIMAL
JOINT A3**



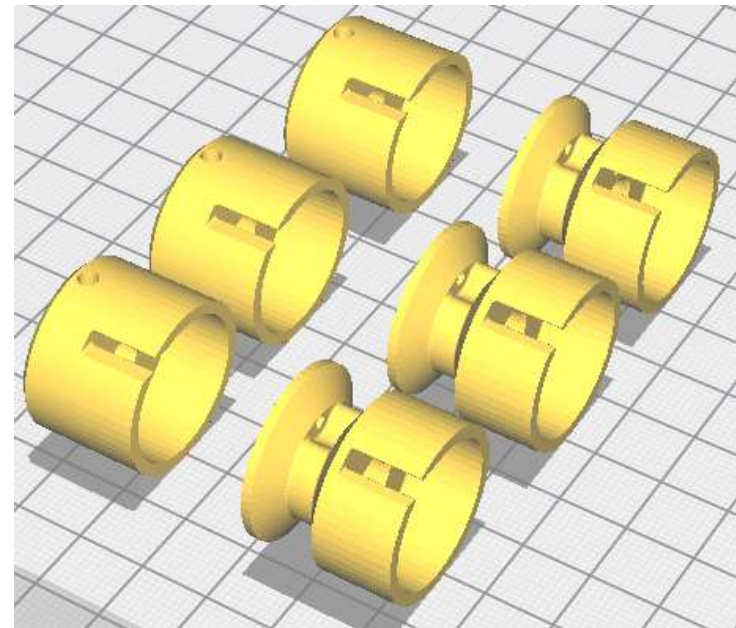
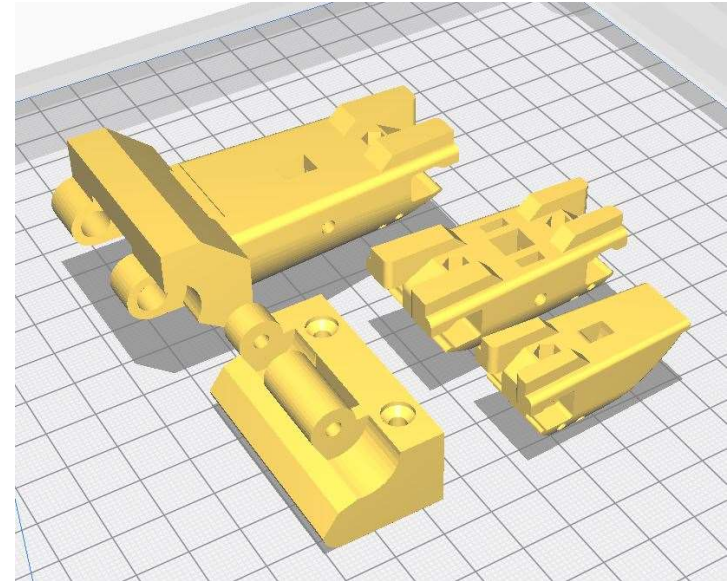
**BASE
JOINT A8**



**TORSION SPRING
HOUSING 1 B1**



**TORSION SPRING
HOUSING 2 B2**

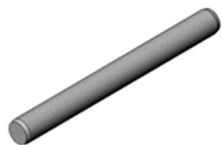


This is a suggestion only as an attempt to minimize support material and maximize the strength of the structure. Results will vary depending on specific 3D print settings.

OFF THE SHELF PARTS SPECIFICATIONS

ALL OTS PARTS SHOULD BE STAINLESS STEEL UNLESS STATED OTHERWISE. ALL PART NUMBERS LISTED CORRESPOND TO PART NUMBERS IN McMASTER-CARR (June 2020) UNLESS STATED OTHERWISE.

SPECIFICATION



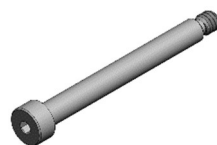
Chamfered End
Dowel Pins

93600A195 A10X3 (3mm DM, 26mm L) @\$1.66/PACK OF 1
93600A376 A11X3 (3mm DM, 20mm L) @\$4.58/PACK OF 10
93600A246 A12X3 (2mm DM, 24mm L) @\$8.68/PACK OF 25
93600A163 A13X6 (2mm DM, 22mm L) @\$6.73/PACK OF 5
93600A249 A14X6 (2mm DM, 20mm L) @\$7.71/PACK OF 25
93600A233 A15X6 (2mm DM, 16mm L) @\$7.26/PACK OF 25
93600A238 A16X6 (2mm DM, 18mm L) @\$7.51/PACK OF 25
93600A223 A17X3 (2mm DM, 14mm L) @\$7.02/PACK OF 25
93600A200 B6 X3 (2mm DM, 10mm L) @\$6.55/PACK OF 25



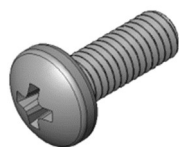
Hex-
Shaped
Inserts

92398A121 A6 X12
@\$9.34/PACK OF 25
(M3X0.5mm Thread,
5.8mm L)



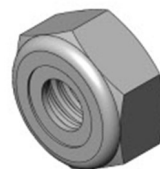
Shoulder
Screw

94035A172 A18 X3
@\$4.66 EACH
(8-32 Thread, 1 3/4" L)



Pan Head
Philips
Screws

90116A153 A7 X19
@\$6.95/PACK OF 100
(M3X0.5mm Thread,
8mm L)



THIN
NYLON-
INSERT
LOCKNUT

90101A009 A20 X3
@\$6.77/PACK OF 100
(8-32 Thread, 11/64" H)



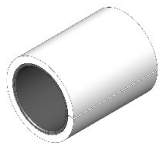
Thin Hex Nuts

93935A310 B3 X3 @\$5.34/PACK OF 50
(M2.5 X 0.45mm Thread, 1.6mm High)



Cup-Point Set Screws

92029A097 B9 X3 @\$9.36/PACK OF 50
(M2.5 X 0.45mm Thread, 5mm L)



Stainless Steel coated in Teflon Bushing

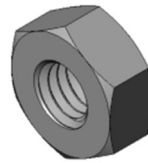
B8 X3 @AUSTRALIAN\$1.65 EACH
(8mm OD, 6mm ID, 10mm L)

<https://www.minibearings.com.au/store/item/bp006000800100s6/?v=1057>



Compression Sleeve

3755T12 B10 X3 @\$14.19/PACK OF 10
For 3/64" dia rope, sleeve length 3/8"



Hex Nuts

94150A325 C2 X13 @\$3.08/PACK OF 50
(M3 X 0.5mm Thread)

94150A335 D3 X4 @\$3.42/PACK OF 50
(M4 X 0.7mm Thread)



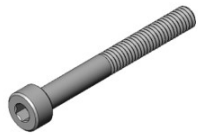
Routing Eyebolts

30425T230 D2 X6 @\$8.38/PACK OF 25
(Total Length 3/4", Shank Length 3/8", Wire Diameter 7/64")



Philips Flat Head Screws

92010A130 C3 X6 @\$8.39/PACK OF 100
(M3 X 0.5mm Thread, 25mm L)



Socket Head Screws

92290A182 C4 X4 @\$9.26/PACK OF 25
(M4 X 0.7mm Thread, 35mm L)

D SHAFT E2 X1

(Option 1) @\$55.79 EACH

(3mm Radius, 164mm L, D Slot Depth
2mm from Center of Circle)(Locations
of slots are specified in CAD file)

(Option 2)

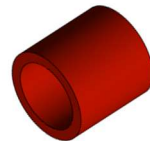
(3mm Radius, 164mm L, D Slot Depth
2mm from Center of Circle)(One D-slot
through the shaft)

**OPTION 1, CUSTOM MADE D-SHAFT, IS PREFERRED AND CAN BE
ORDERED AT MISUMI CUSTOM PARTS: Rotary Shafts - D Cut**
USING PART NUMBER: SSFRV6-164-F2-T30-WFC46-J6-W69-V6
USE OPTION 2 IF CUSTOM PART SERVICE IS NOT ACCESSIBLE.

Rulon® LR Plastic Bearings Water-Resistant Dry-Running



7763K100 E3 X2 @\$18.13 EACH
(12mm OD, 6mm ID, 10mm L)



6362K100 A19 X6 @\$6.90 EACH
(3/16"ID, 1/4"OD, 1/4"L)



7532K110 B5 X7 @\$2.72 EACH
(5/8" OD, 1/4" ID 1/16" Thick)

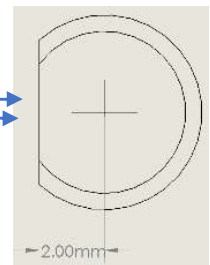
SPECIFICATION



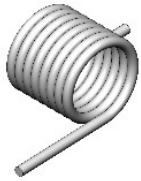
Option 1



Option 2

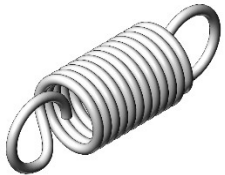


OFF THE SHELF SPRINGS



360° Deflection Left-Hand Wound Torsion Springs

9287K208 A9X3 @\$2.48 EACH
(0.508" OD, 0.04" Wire Diameter,
Spring Length at Max Torque
0.54", Max Torque 1.14 in-lbs)



**Extension Springs
with Loop Ends**

9065K113 B11 X3 @\$6.51/PACK OF 3
(0.75" L, 0.240" OD, 0.029" Wire
Diameter, 8.52 lbs/in)

9065K59 B12 X3 @\$6.51/PACK OF 3
(1" L, 0.180" OD, 0.029" Wire
Diameter, 10.6 lbs/in)



360° Deflection Left-Hand Wound Torsion Springs

9287K143 B7 X3 @\$2.99 EACH
(0.798" OD, 0.516" ID, 0.063" Wire
Diameter, # of Coils 11.5, Spring
Length at Max Torque 0.82",
Max Torque 5.15 in-lbs)

**TOTAL COST OF OTS PARTS,
ASSUMING ALL PARTS ARE
NEW AND NEED TO BE
PURCHASED IN BULK,
INCLUDING CASTING RUBBER,
NOT INCLUDING TOOLS AND
PROTOTYPING EQUIPMENTS**

~ \$350

RUBBER CASTED PART FABRICATION PARTLIST



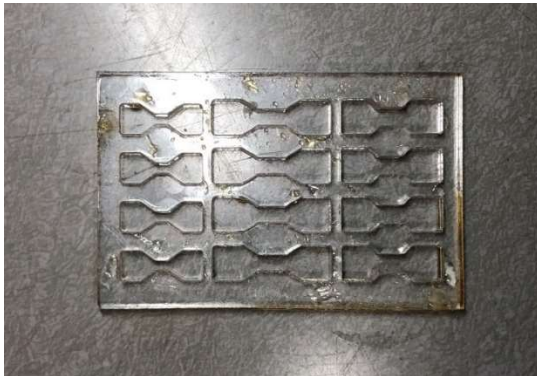
Smooth-On
PMC™-780 (Dry)
* @\$34.08/3 lbs



Universal™ Mold Release
To release casted rubber from molds, spray Universal™ Mold Release, or other mold release spray, on the mold before pouring the uncured rubber mixture. See <https://www.smooth-on.com/products/universal-mold-release/>

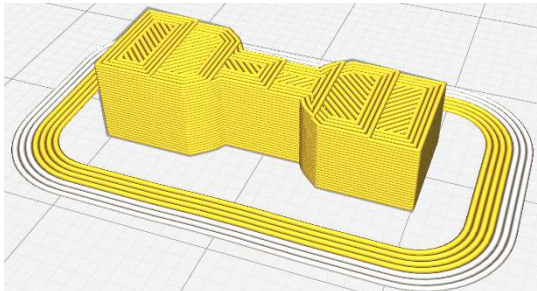
The Smooth-on PMC™-780 (Dry) is used in this project. It is a mixture of two parts that cure over time. See handling instruction on <https://www.smooth-on.com/products/pmc-780-dry/>

* low-cost alternative: Econ™80 from Smooth-On @\$27.78/1.9 lbs



Finger Flexure Mold & Palm Mold

Finger flexure mold is laser cut using 5mm acrylic. Palm mold is 3d printed. Both flexures and palm can be directly printed using NinjaFlex or other flexible 3D print material. Flexure mold template is located in the Finger Assembly folder and Palm mold is located in the Full Assembly folder.



*For 3D printed Flexure using FDM 3D printing, it is recommended that grain direction is parallel to the length of the flexure as shown.

For casting, you will also need:

- Disposable Cup for resin mixture
- Popsicles stick for mixing
- Nitrile Gloves
- Digital Scale

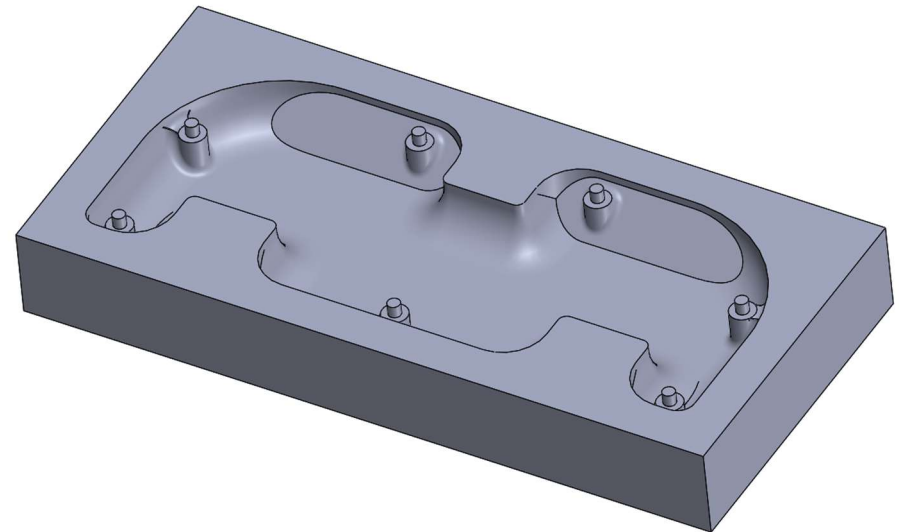
RUBBER CASTED PART FABRICATION

Disclaimer!! Uncured resin is toxic, please refer to Smooth-On product website for safety guideline!!

1. Follow the Smooth-On product website for mixing the resin mixture, pouring, and curing process.
2. Before pouring, seal one side of the flexure mold template with tape. Then spray Mold Release on both molds.



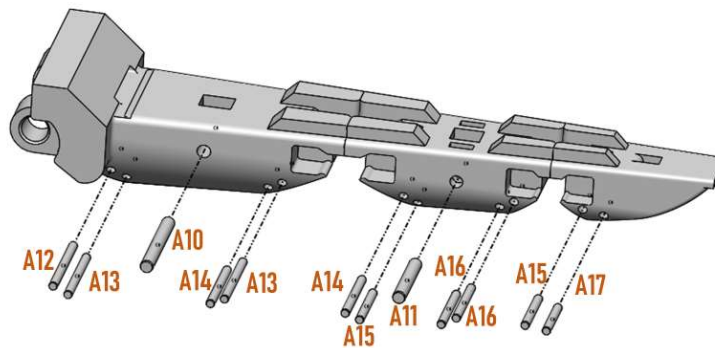
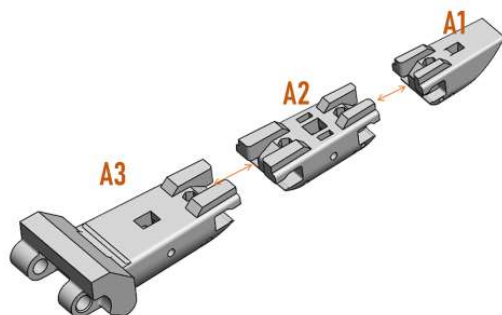
Expected result of the flexures



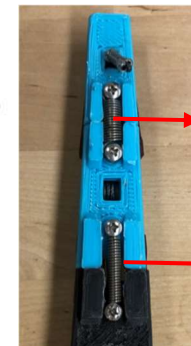
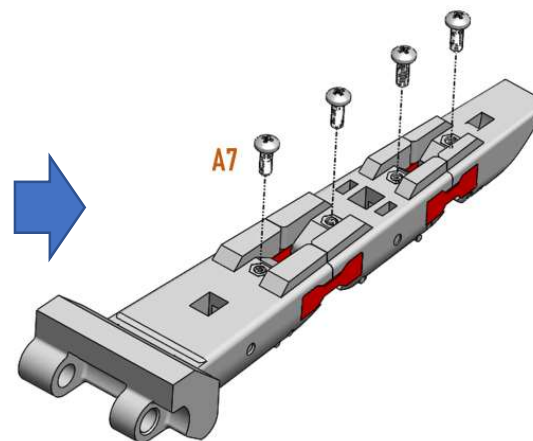
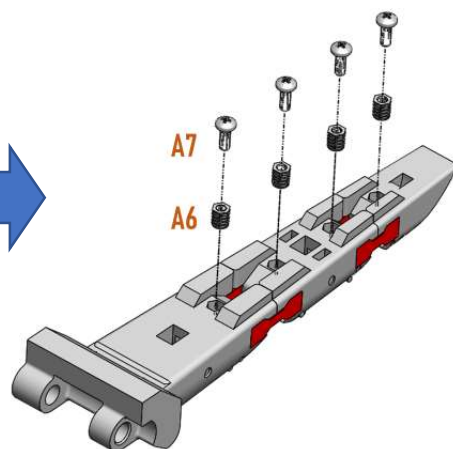
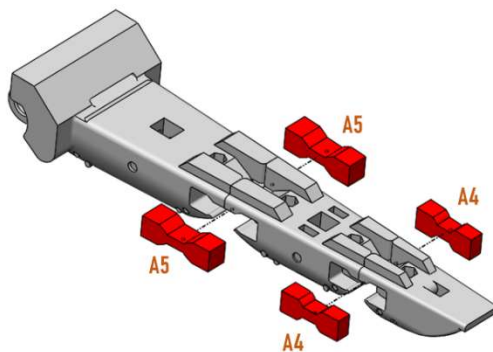
FINGER X3

ASSEMBLY

1



2

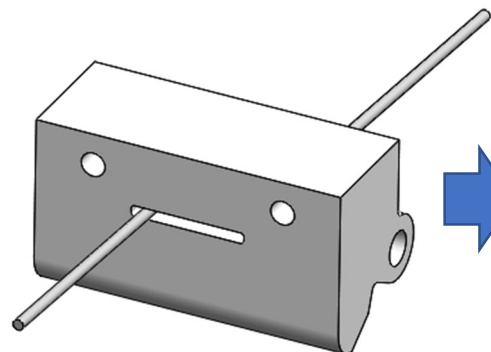
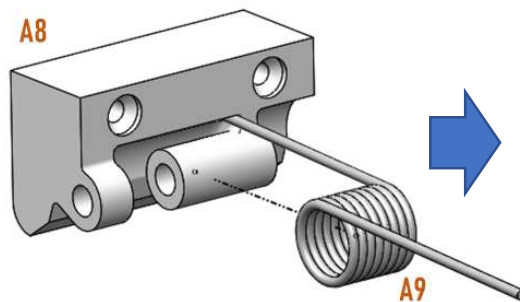
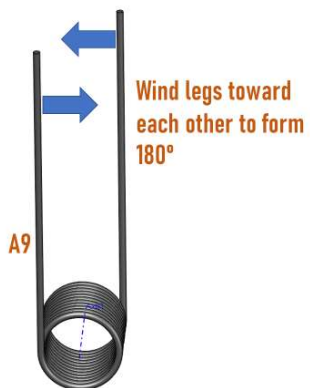


B11

B12

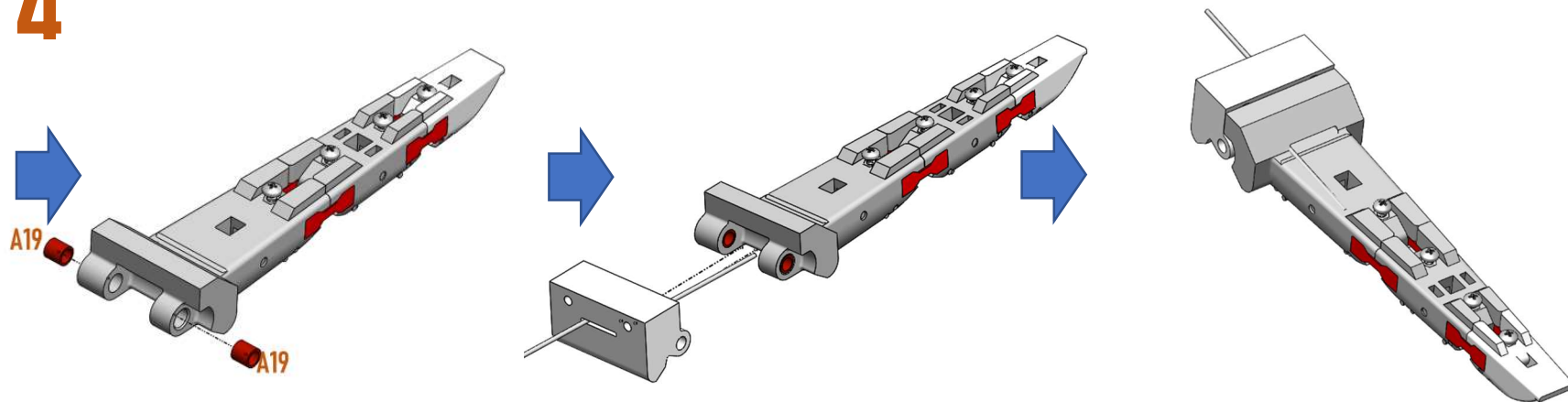
ATTACH SPRINGS
ON THE SCREWS

3

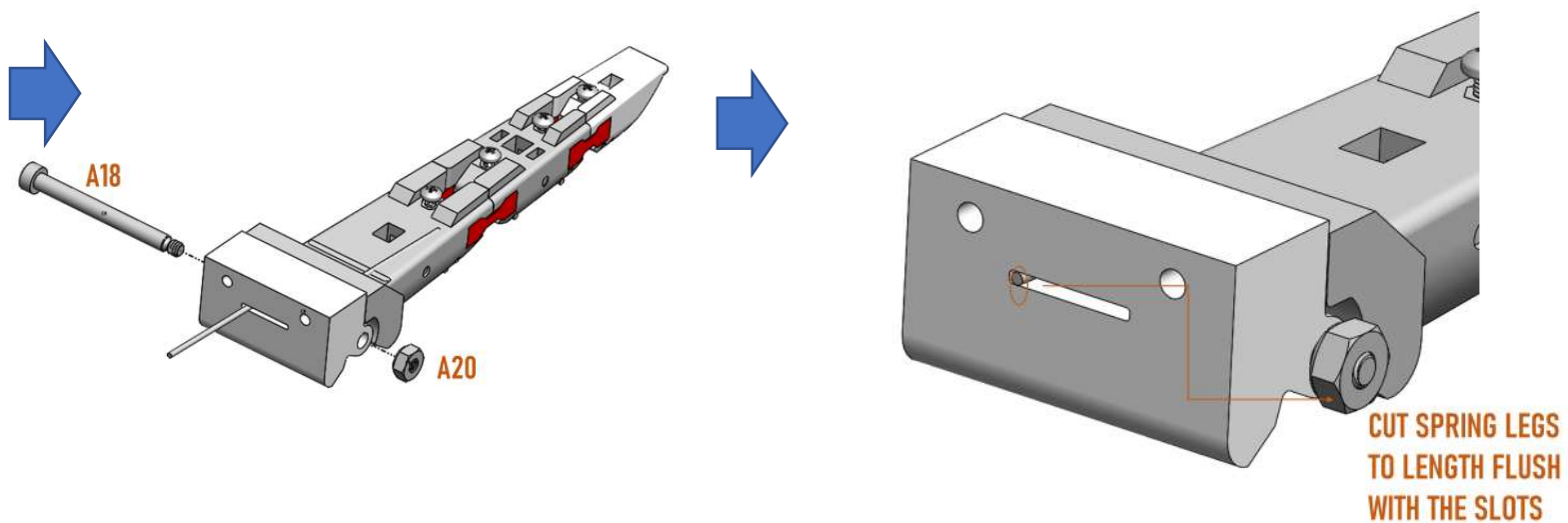


4

4



5



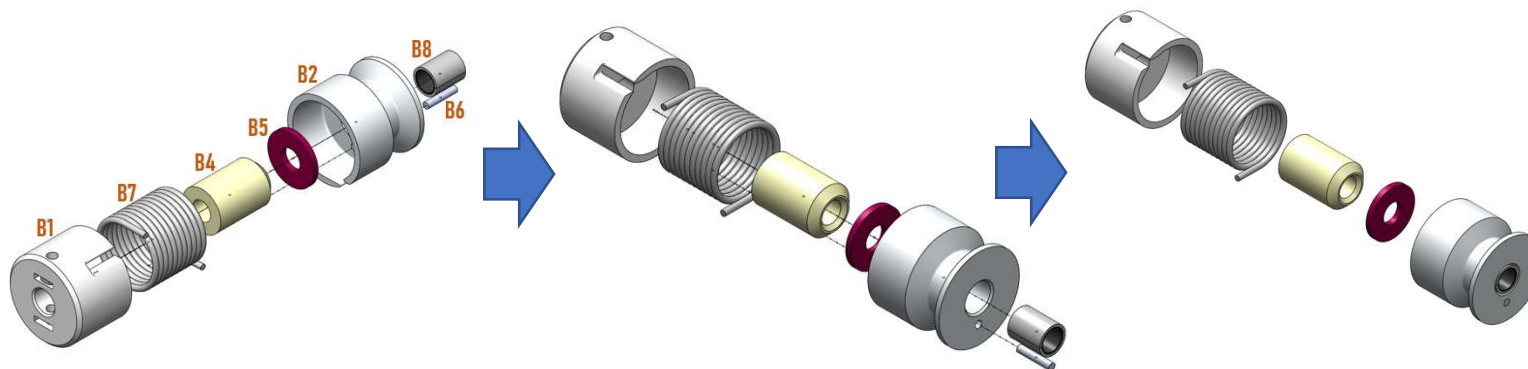
FINGER ASSEMBLY

1. Put dowel pins into the respective holes on the fingers.
2. Insert flexures A5 and A4 into the finger to connect the joints.
3. Insert A6 threaded inserts into the hex slots. (If the slots are undersize, heat up the threaded inserts and push them into the slots as the hot metal melts the plastic)
4. Use A7 screws to fix the two ends of springs. (Between A1 and A2, use B11, between A2 and A3, use B12)
5. Wind A9 Torsion Spring inward to create 180° between legs
6. Place A9 torsion springs through the slot of the base joint.
7. Fit A19 bushings into the holes of the A3 finger joint
8. Fit the other legs of the torsion springs into the slots of the A3 finger joint.
9. Insert A18 pin into the joint to connect the base joint and A3 finger joint, tighten A20 locknut and cut off the excess length of the legs of the torsion springs.

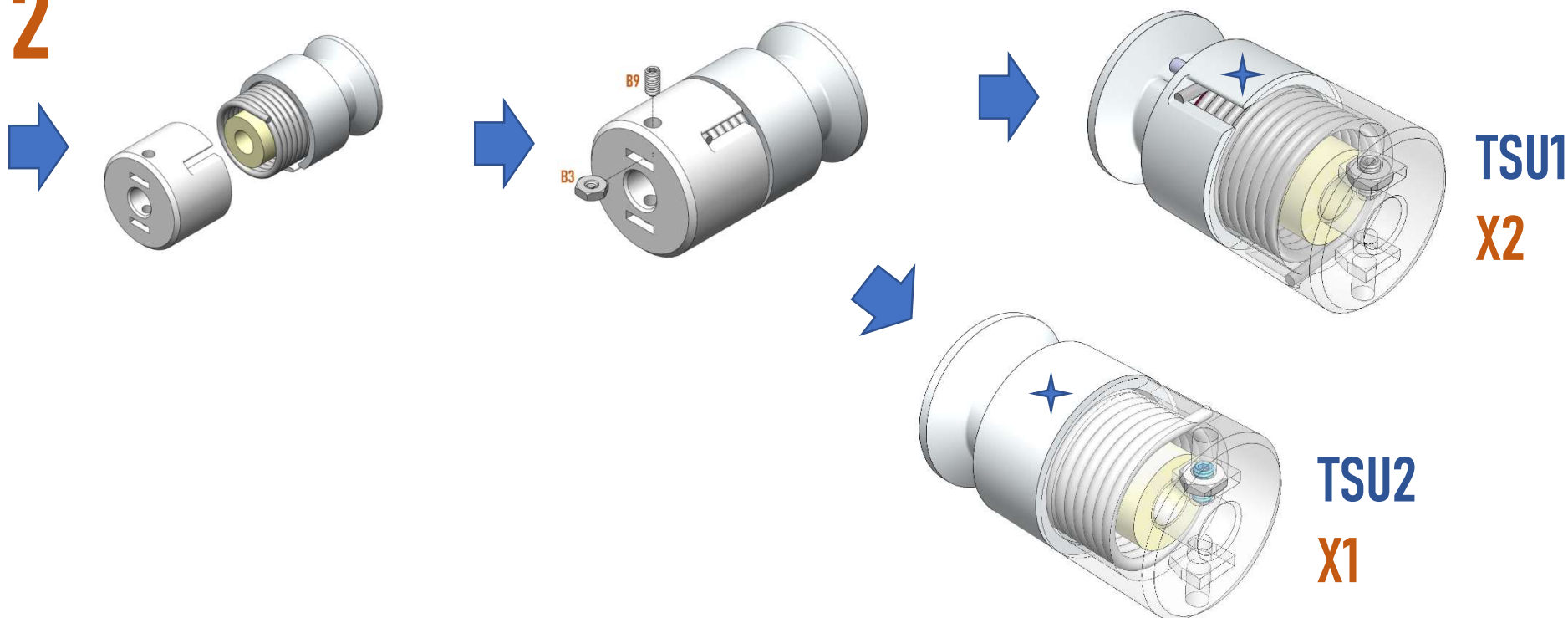
TORSIONAL SPRING UNIT X3

ASSEMBLY

1



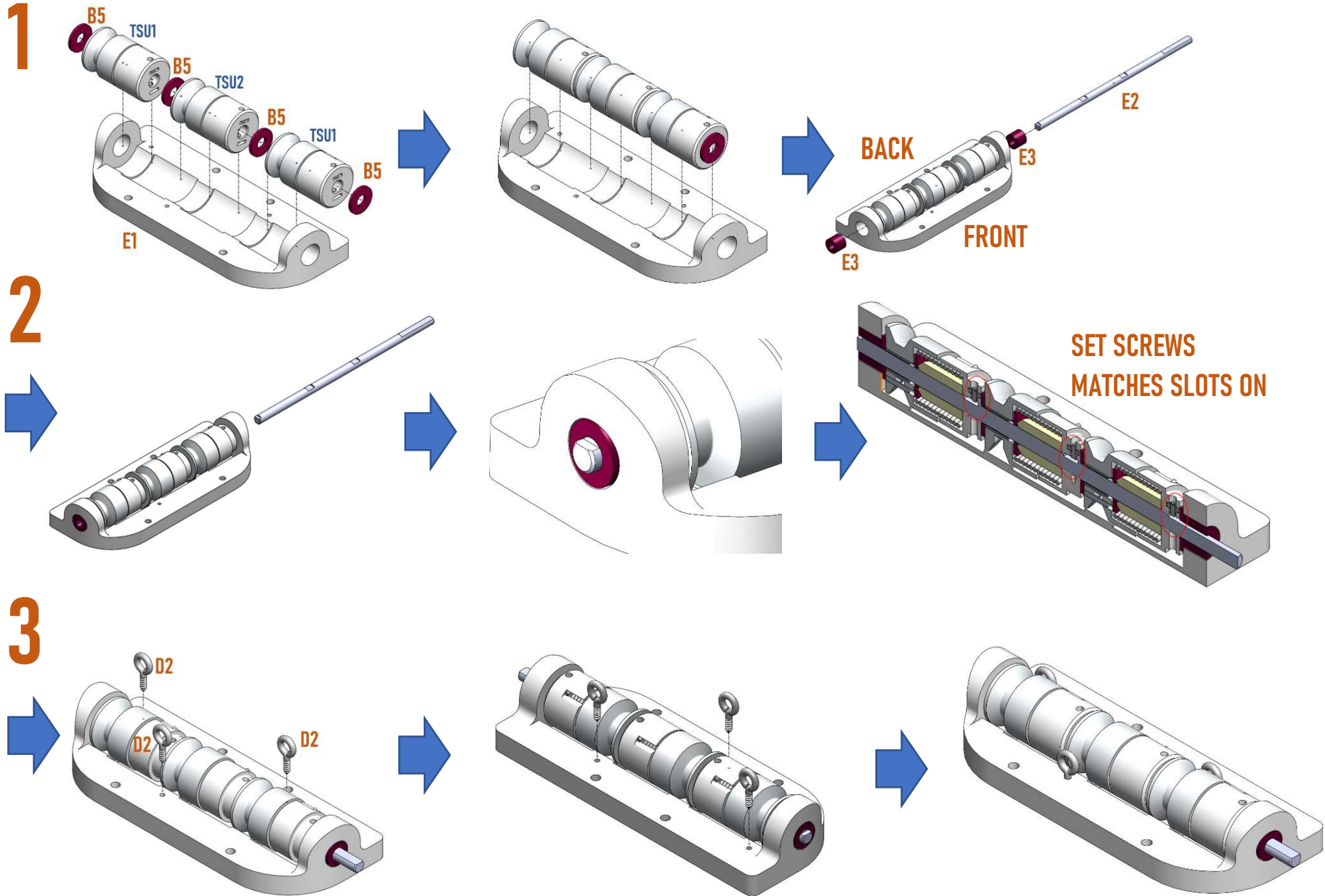
2



TORSIONAL SPRING UNIT ASSEMBLY

1. Enclose parts B7, B4, B5 using B1 and B2 as shown above.
2. Fit B6 and B8 into their respective slots on B2. (Extra reaming might be required to enlarge the slots depending the tolerance of the 3D print)
3. Fit the B3 thin nuts and B9 set screws into their respective slots on B1.
(Attention: there are 2 sets of slots on B1. Please see illustration for which set of slots to use for the respective part)

SHAFT SUPPORT X1

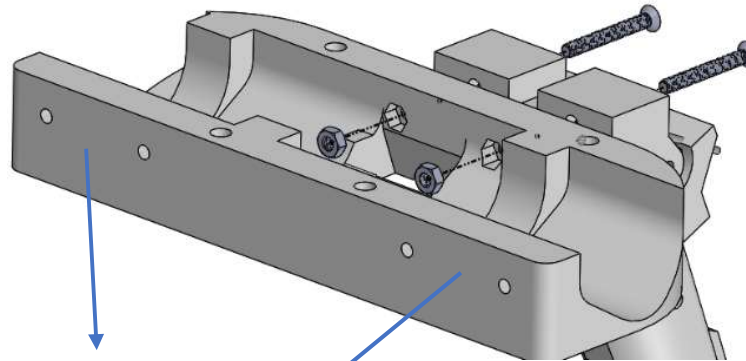
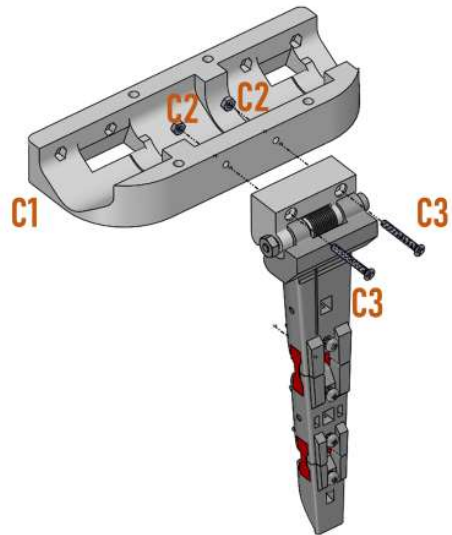


SHAFT SUPPORT ASSEMBLY

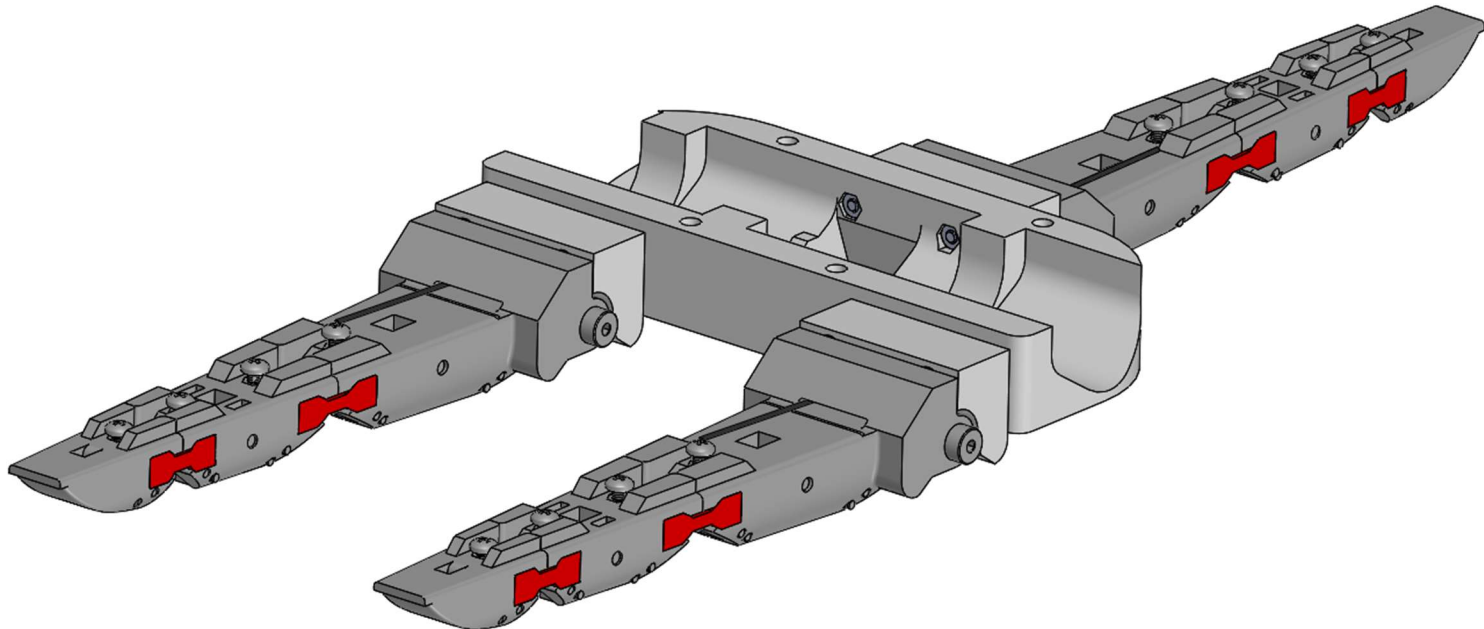
1. Align parts in the order shown above and leave the parts in E1 the shaft support, and all set screws facing up.
2. Fit E3 bushing into the slots on the two ends of the shaft support.
3. Facing the front of the shaft support, fit E2 D-shaft through the bushing on the right end of the shaft support with the shorter end of the D-shaft.
4. Continue threading the D shaft through the parts until the short end of the D-shaft is flushed with the end of the bushing.
5. Turn all three torsion spring units so that they are aligned with the flat surface of the D-shaft.
6. Slowly screw in the set screws and wiggle the D-shaft to make sure the set screws are in the D-shaft slots. (As illustrated above)
7. Screw on D2 eyehooks on the shaft support.

FINGER MOUNTING PLATE X1

1



REPEAT THE PROCESS FOR
THESE TWO FINGERS LOCATION

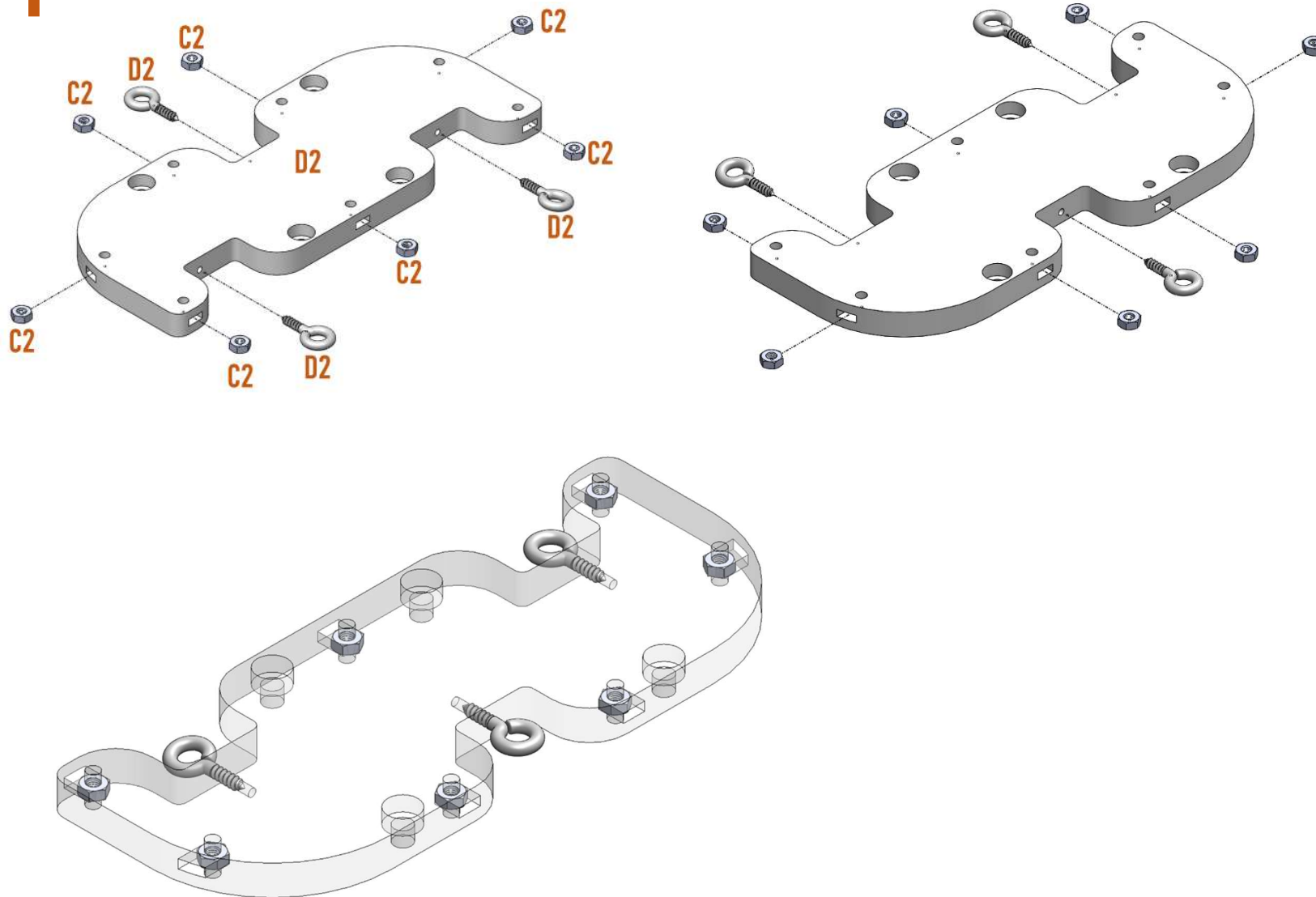


FINGER MOUNTING PLATE ASSEMBLY

1. Mount the three fingers onto the finger mounting plate using C3 screws and C2 nuts.
(Open the torsion spring joint on the finger to review the holes for the screws. Similar to what is shown on the illustration above. Do not take out the spring as shown on the illustration)

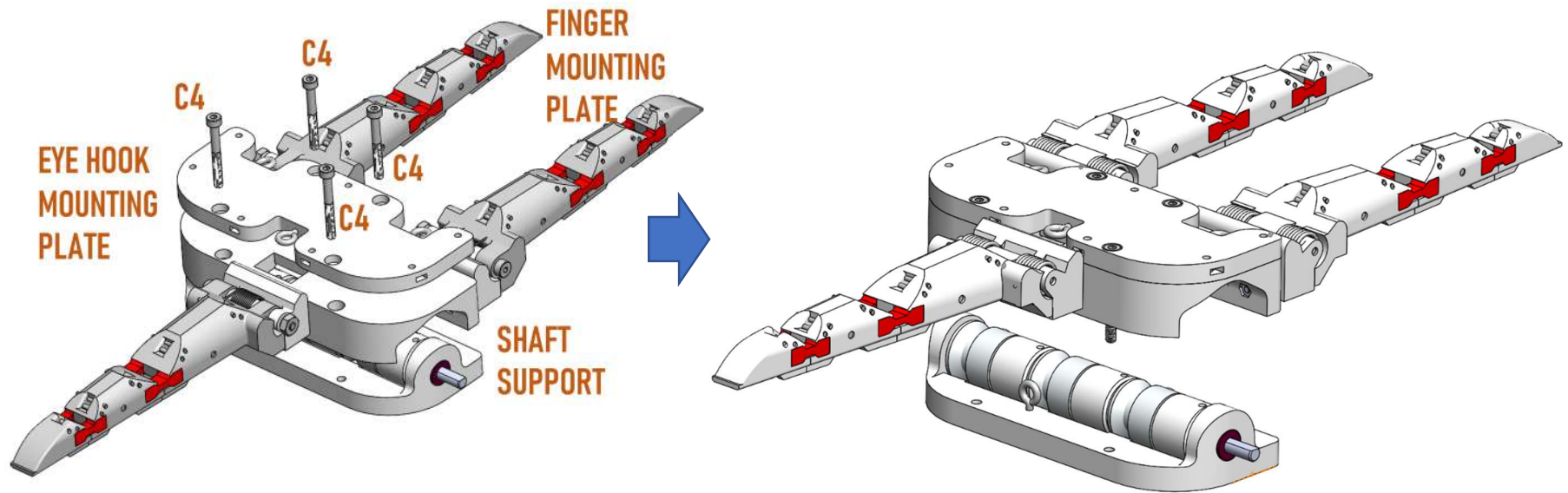
EYE HOOK MOUNTING PLATE X1

1

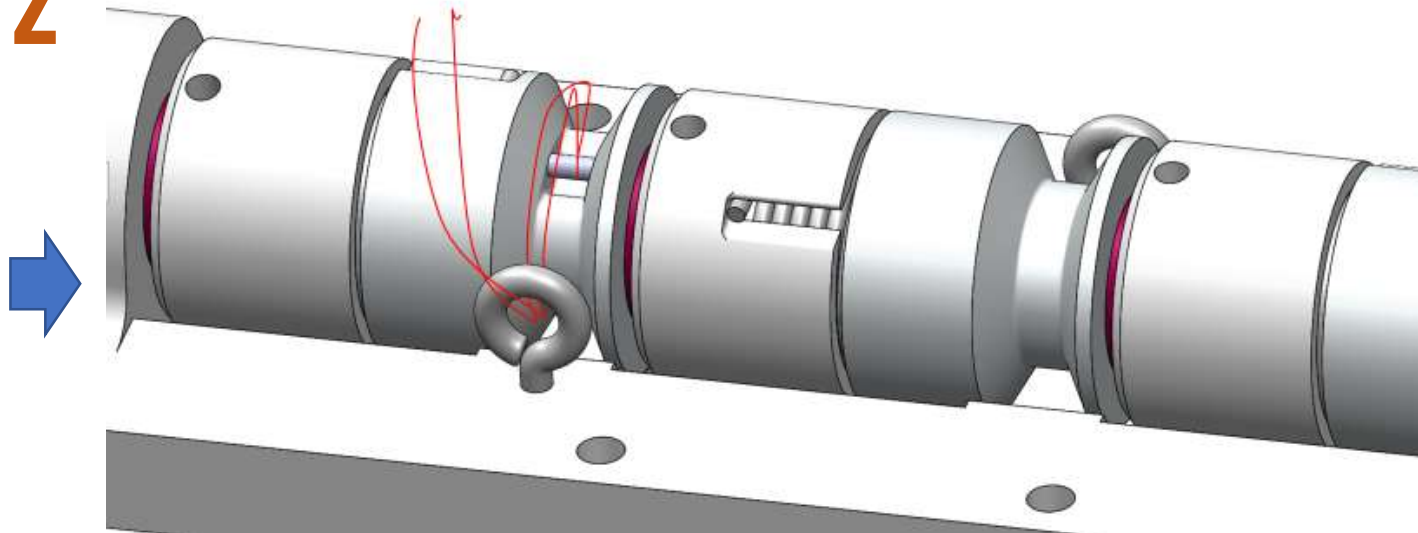


FINAL ASSEMBLY

1

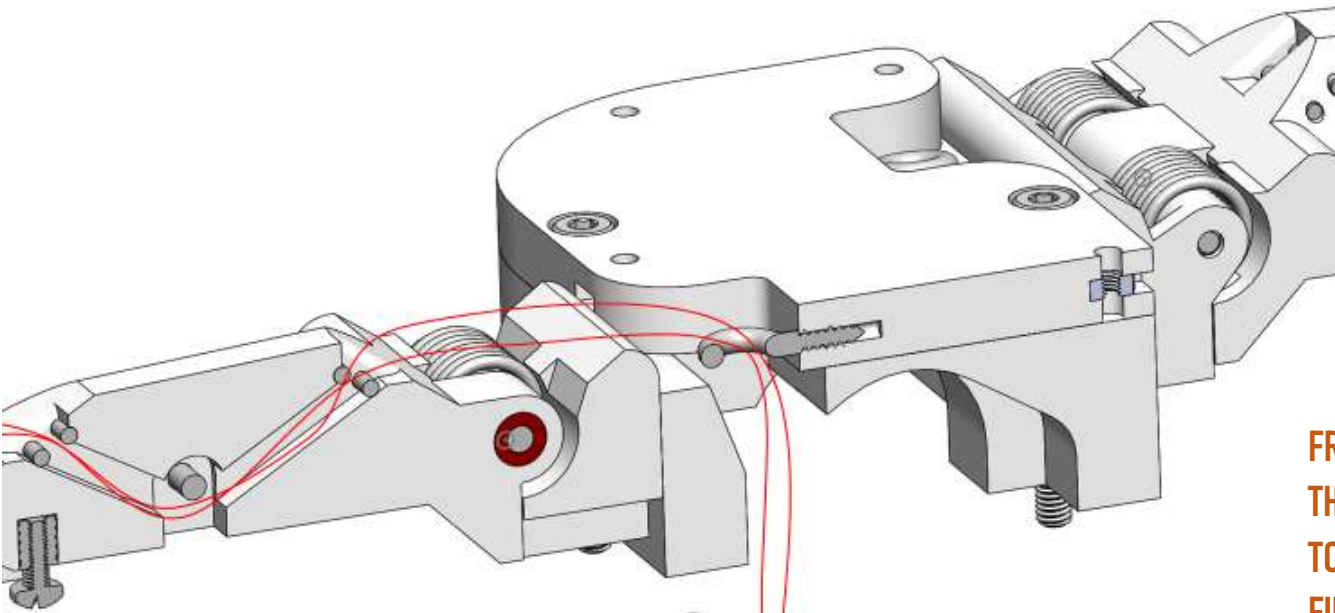


2



TREAD STRING THROUGH TORSION
SPRING UNITS AND EYEHOOK
REPEAT THE PROCESS FOR ALL
FINGERS.

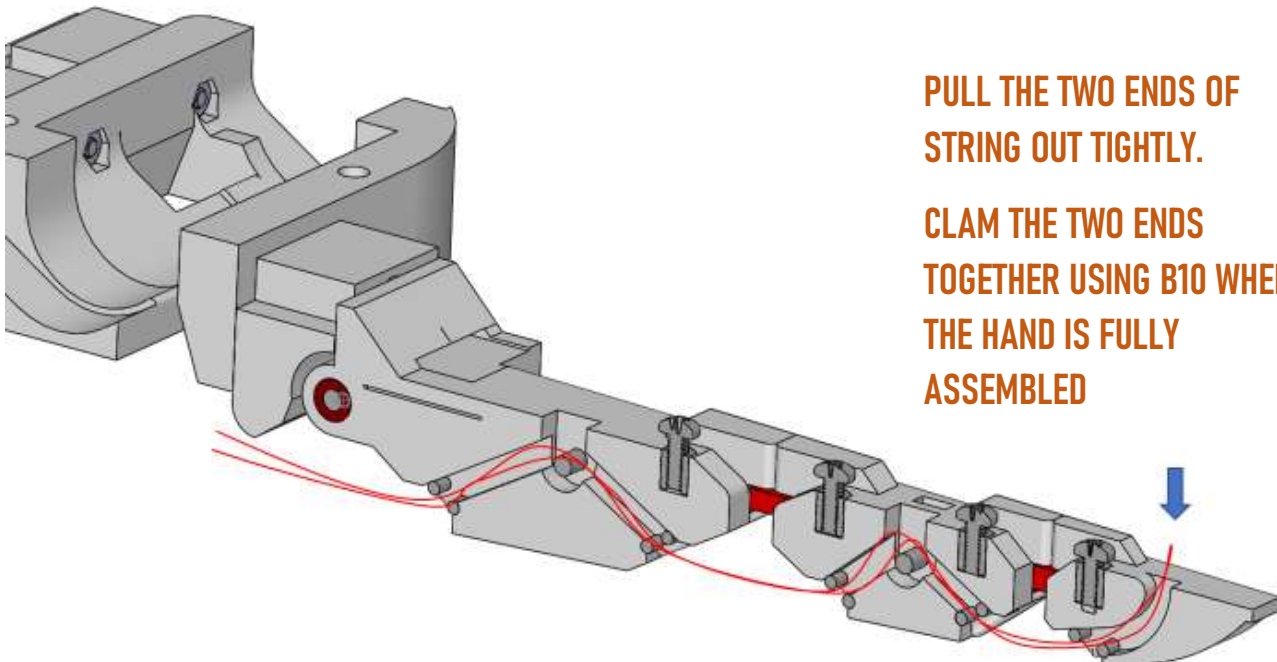
3



FROM THE BOTTOM EYE HOOK,
THREAD STRING THROUGH THE
TOP EYE HOOK AND INTO THE
FINGER JOINTS.

REPEAT FOR ALL FINGERS

4

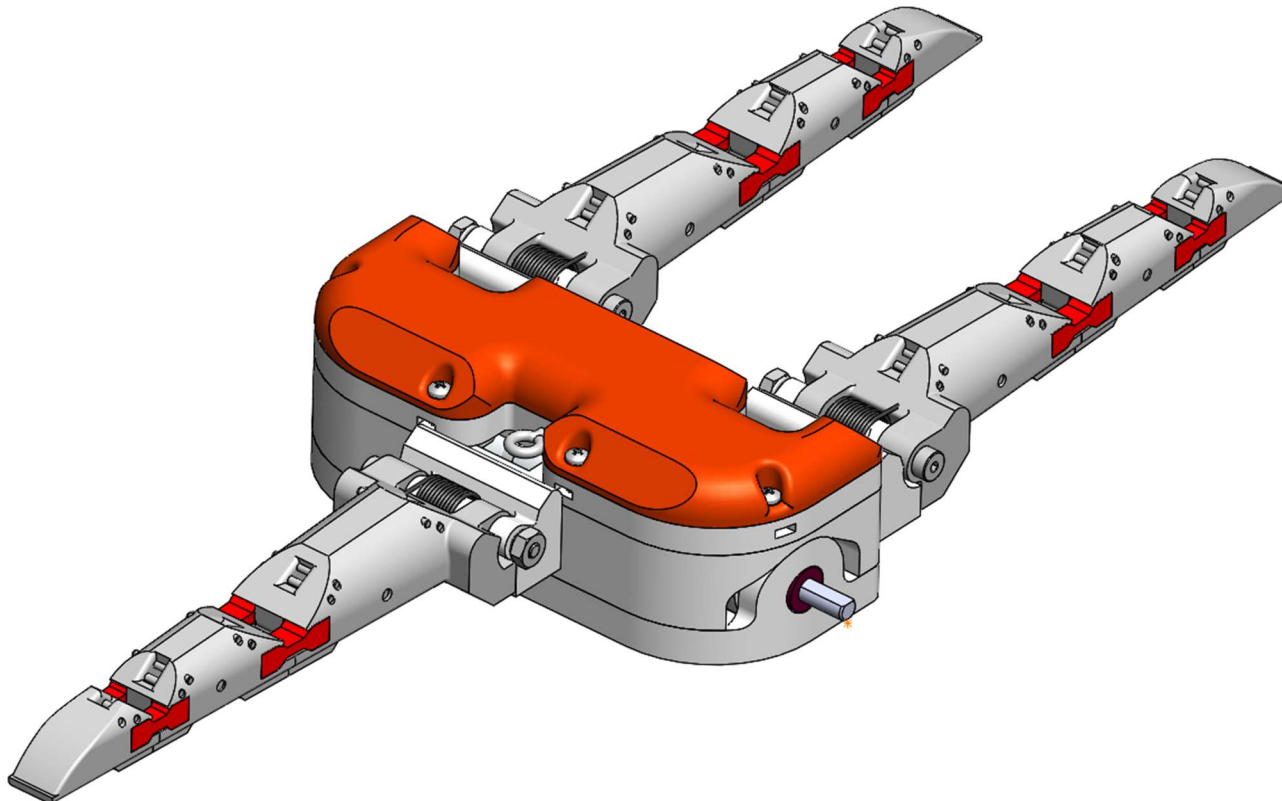
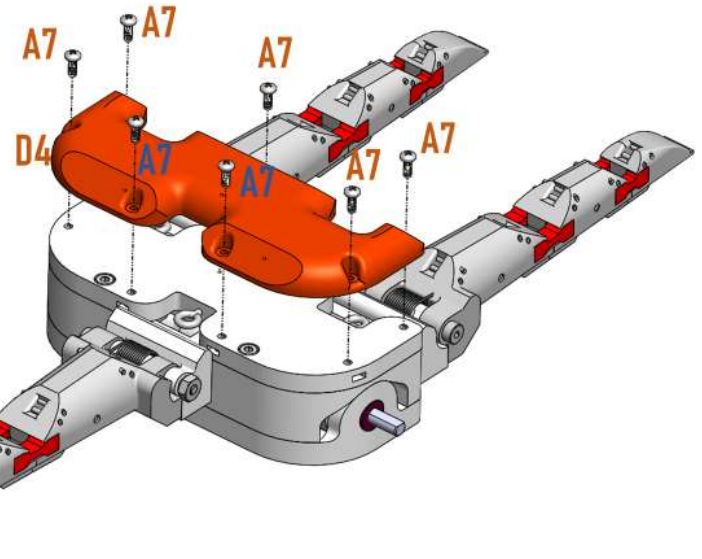
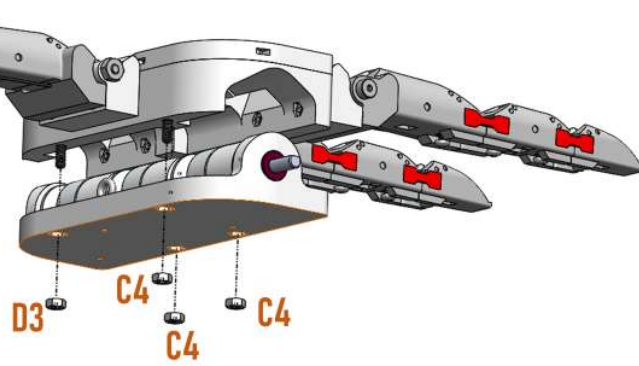


PULL THE TWO ENDS OF
STRING OUT TIGHTLY.

CLAMP THE TWO ENDS
TOGETHER USING B10 WHEN
THE HAND IS FULLY
ASSEMBLED



5



ASSEMBLY

FINAL ASSEMBLY

1. Use C4 bolts to join the eyehook plate and finger mounting plate together.
2. Thread B13 Braided Dyneema Fishing line through the dowel pin on the torsion spring unit and eyehook next to it. (The center point of the string should be on the dowel pin)
3. Thread the same string through the eyehook on the corresponding eyehook on the eyehook plate and then through the finger as shown in the illustration.
4. Repeat for the other fingers.
5. Pull the strings tight out of the slot at the end of the fingers and join the shaft support to the finger mounting plate by screwing the D3 nuts onto C4 bolts.
6. Clam the strings at the slots at the end of the fingers with crimps and cut of the rest of the strings.
7. Fix the palm plate onto the hand using A7 screws.

ACTUATION OF THE HAND

The hand can be actuated by using gears and servo attached to the D-shaft. The servo drives the gears which rotate the D-shaft and wind the tendons around the torsional spring units.

You are encouraged to design your own attachment for the servo and gears.

The original Ocean One hand was designed to be a grasping tool for an underwater robot. However, we are now open sourcing this design for you to discover its many possibilities. So, go explore.

