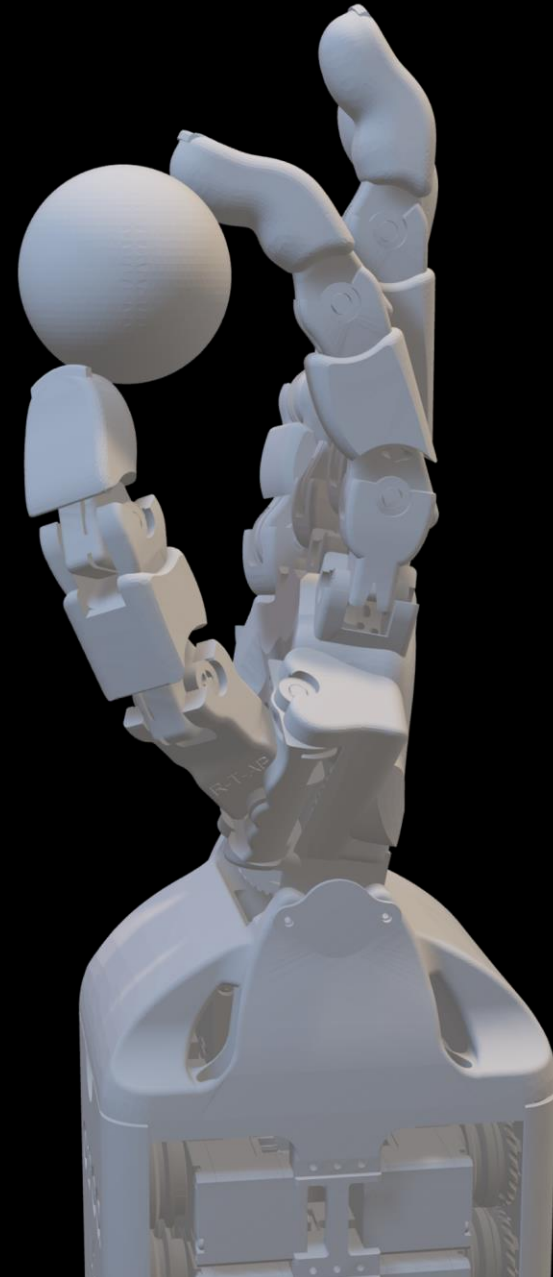




Assembling the ORCAv2 Hand

Vikash Jeyathevan



ORCA Hand Simulation



Overview | General Guidelines | Parts Preparation | Fingers & Thumb | Carpal & Wrist | Motors & Spooling | Final Checks

**orcaatlas.**

Anatomy of a robotic hand

THE COMPONENT LIBRARY

A hand. Every part.

Explore the pieces behind the movement.

v1 - Original

v2 - Base

Left hand

Right hand ✓

Components

Joint motion

Find a component...

SHOW

Complete

Frame

Skin

● Palm & wrist

2 >

🔍

● Thumb

6 >

🔍

● Index finger

5 >

🔍

● Middle finger

5 >

🔍

● Ring finger

5 >

🔍

● Little finger

5 >

🔍

● Forearm & electronics

6 >

🔍

34 of 34 pieces visible

Hide all

A little guidance?

Take a 5-step tour of the hand

→

ORCA HAND / RIGHT

Engineering,
under the skin.

Orbit. Discover. Understand.



Collision checks on

17 MOVABLE JOINTS · 5 DIGITS

Explode assembly

0 %

Assembled

Every piece

Reset

🔍

Drag to orbit

Scroll to zoom

Click to inspect

• v1 extended

3/4

F

S

B

🔄

▶

●

THE FIELD NOTES

FOK



FUNCTION

A CLOSER LOOK

Built to move.

Made to explore.

A tendon-driven robotic hand from ETH Zurich's Soft Robotics Lab. Get to know its structure, contact surfaces, and the joints that bring it to life.

34

17

05

modeled pieces

movable joints

finger chains

Follow your curiosity

01 Pick a piece

Click the hand or browse the library.

02 See how it fits

Isolate a part or open the assembly.

03 Put it in motion

Explore the range of each joint.

• Real geometry. Real connections.

Based on the open-source Orca Hand v1 extended description.

SoftRobotics
Laboratory

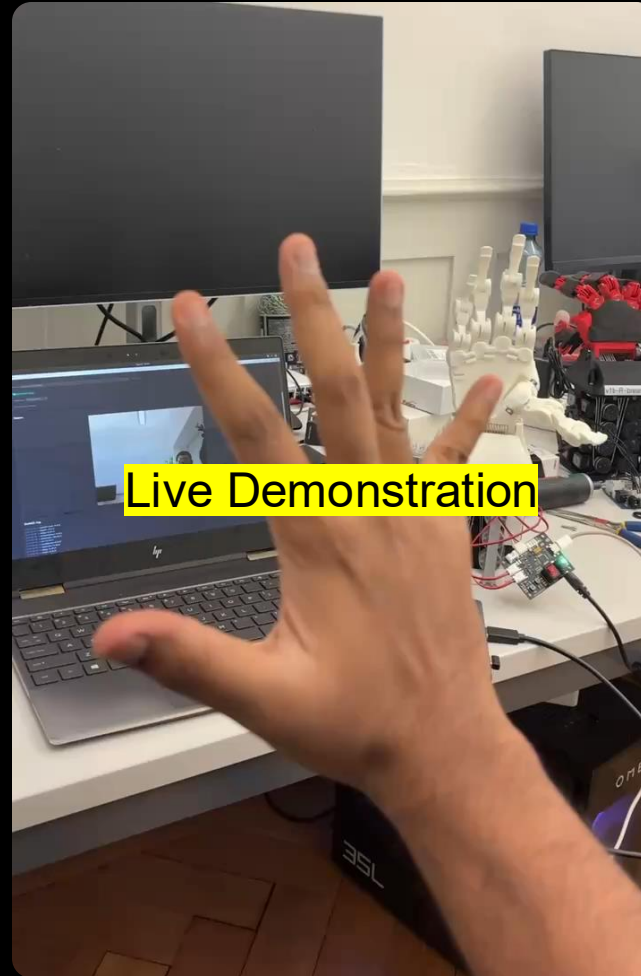
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2



Assembled Hand Demonstration

Overview | General Guidelines | Parts Preparation | Fingers & Thumb | Carpal & Wrist | Motors & Spooling | Final Checks



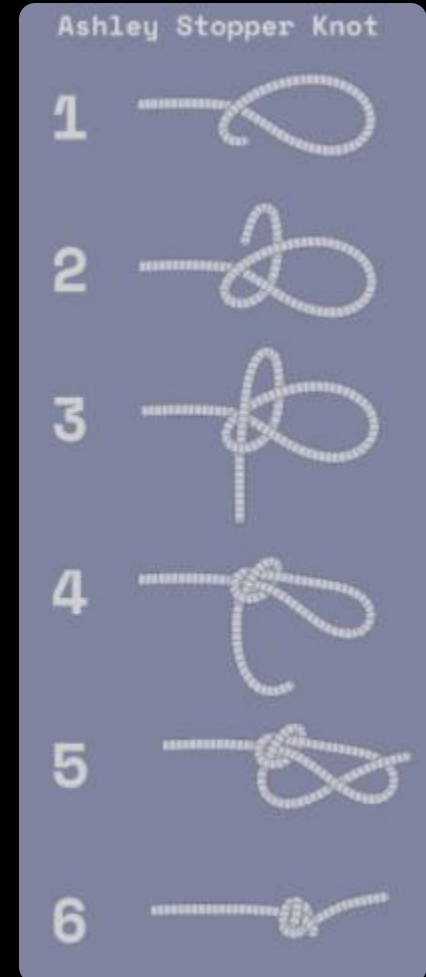
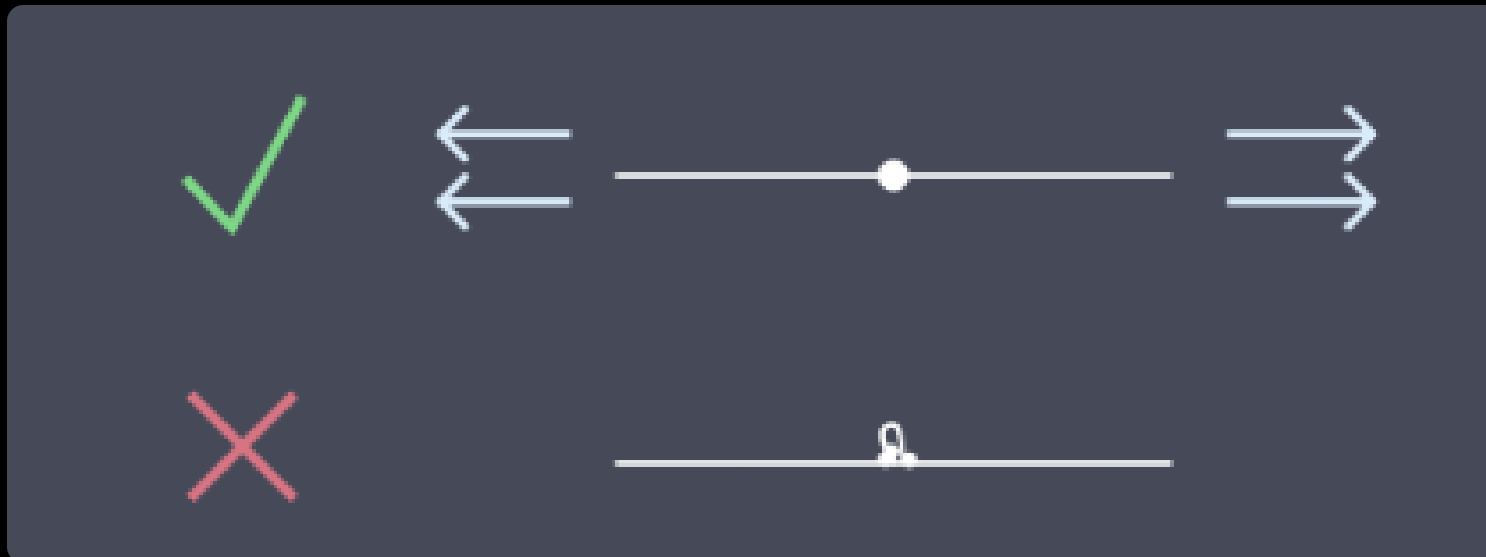


Ashley-Stopper(A-S) Knot

Overview | General Guidelines | Parts Preparation | Fingers & Thumb | Carpal & Wrist | Motors & Spooling | Final Checks

- A solid stopper knot used at nearly every step of the assembly
- Video example: [ORCA Assembly Tutorial](#)
- Animated tutorial: <https://www.animatedknots.com/ashley-stopper-knot>

A correctly tightened knot

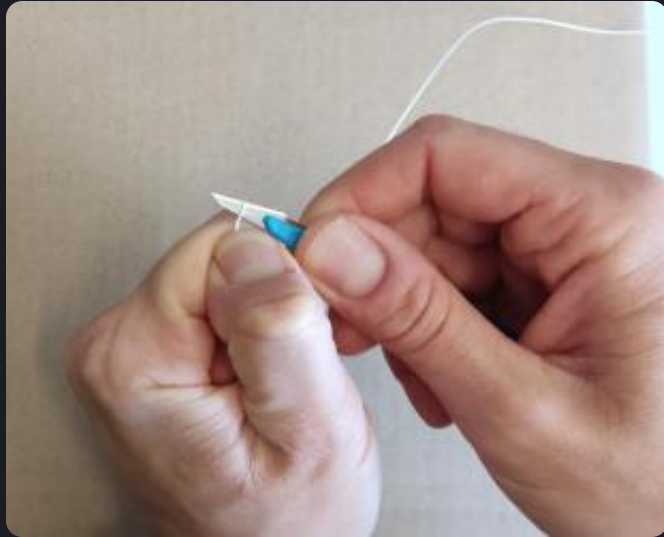




Cutting Tendons

Overview | General Guidelines | Parts Preparation | Fingers & Thumb | Carpal & Wrist | Motors & Spooling | Final Checks

Tendons need to be cut cleanly to be routed easily. Use the cutter, but be careful!



Clean cut



Make sure that the free tendon end remains intact during assembly. This ensures that the free end is firm and easy to route. Otherwise, it will get soft and will be difficult to route later.



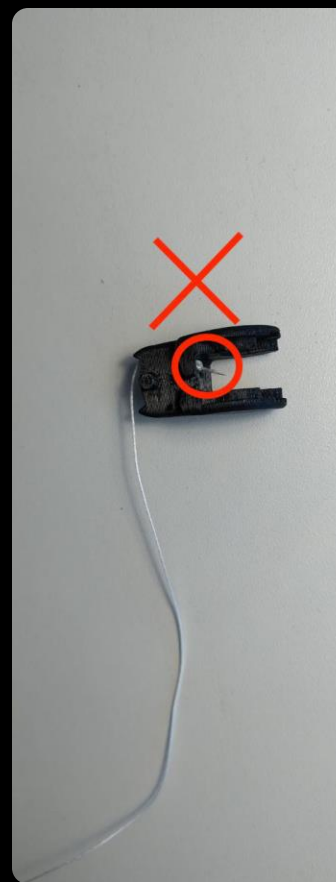
Frayed



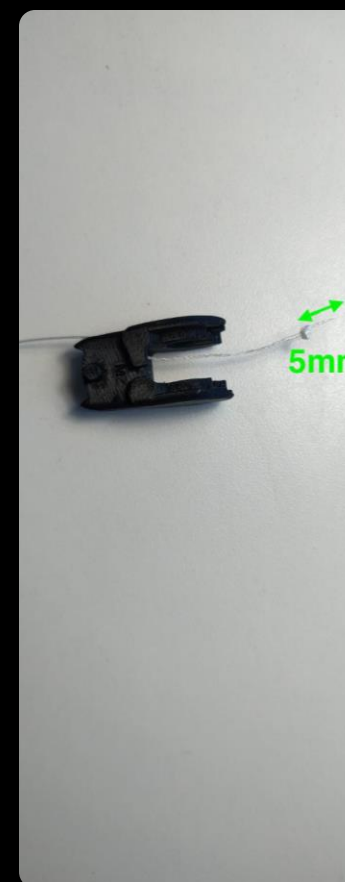
Trim and Stuff the Knot

Overview | General Guidelines | Parts Preparation | Fingers & Thumb | Carpal & Wrist | Motors & Spooling | Final Checks

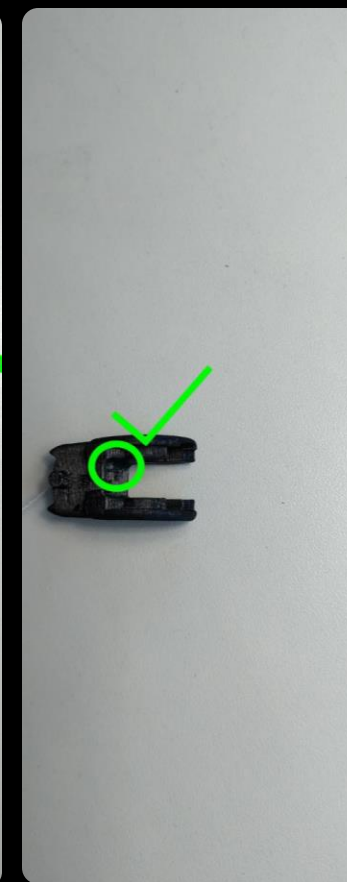
- Trim the tendon 5mm after the knot so it can't come loose
- Pull hard so the knot falls into its housing
- Stuff it fully in with a screw bit or Allen key



× Sticking out



5mm tail



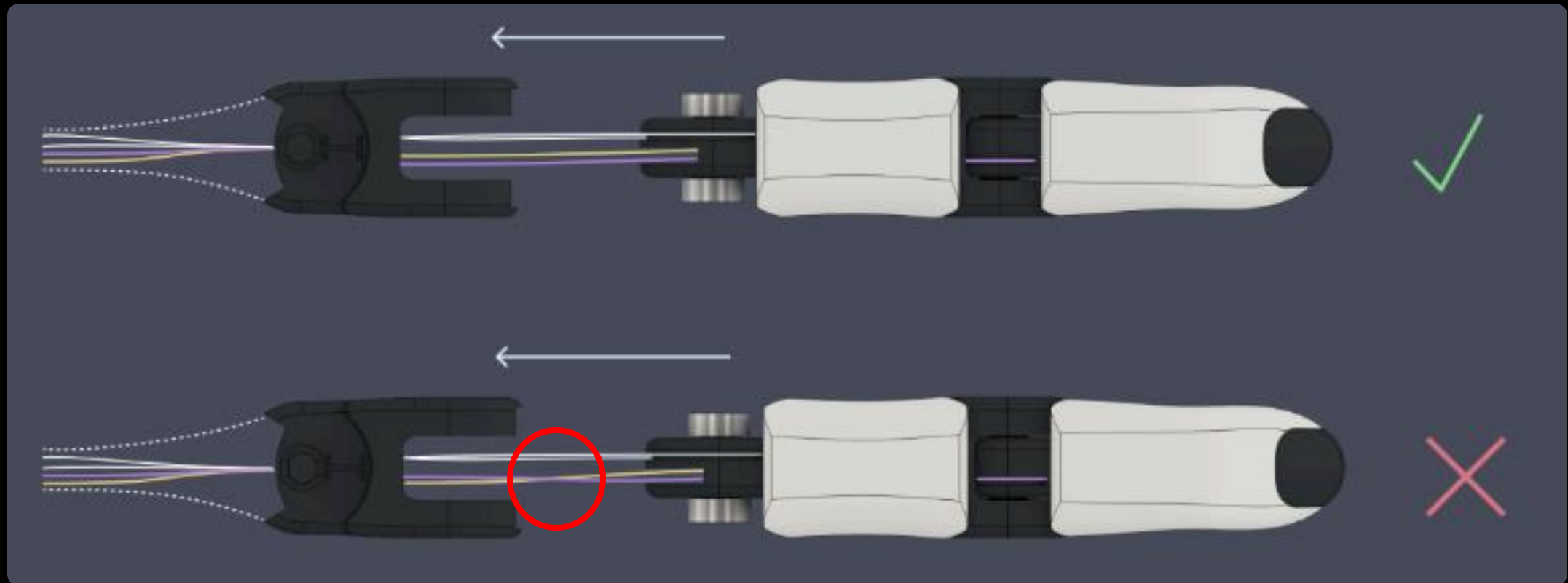
✓ Fully stuffed



Keep Tendons Straight and Aligned

Overview | General Guidelines | Parts Preparation | Fingers & Thumb | Carpal & Wrist | Motors & Spooling | Final Checks

- Each tendon travels in a straight, direct line from one part to the next
- Before joining two parts, tug the tendons straight and check that none cross

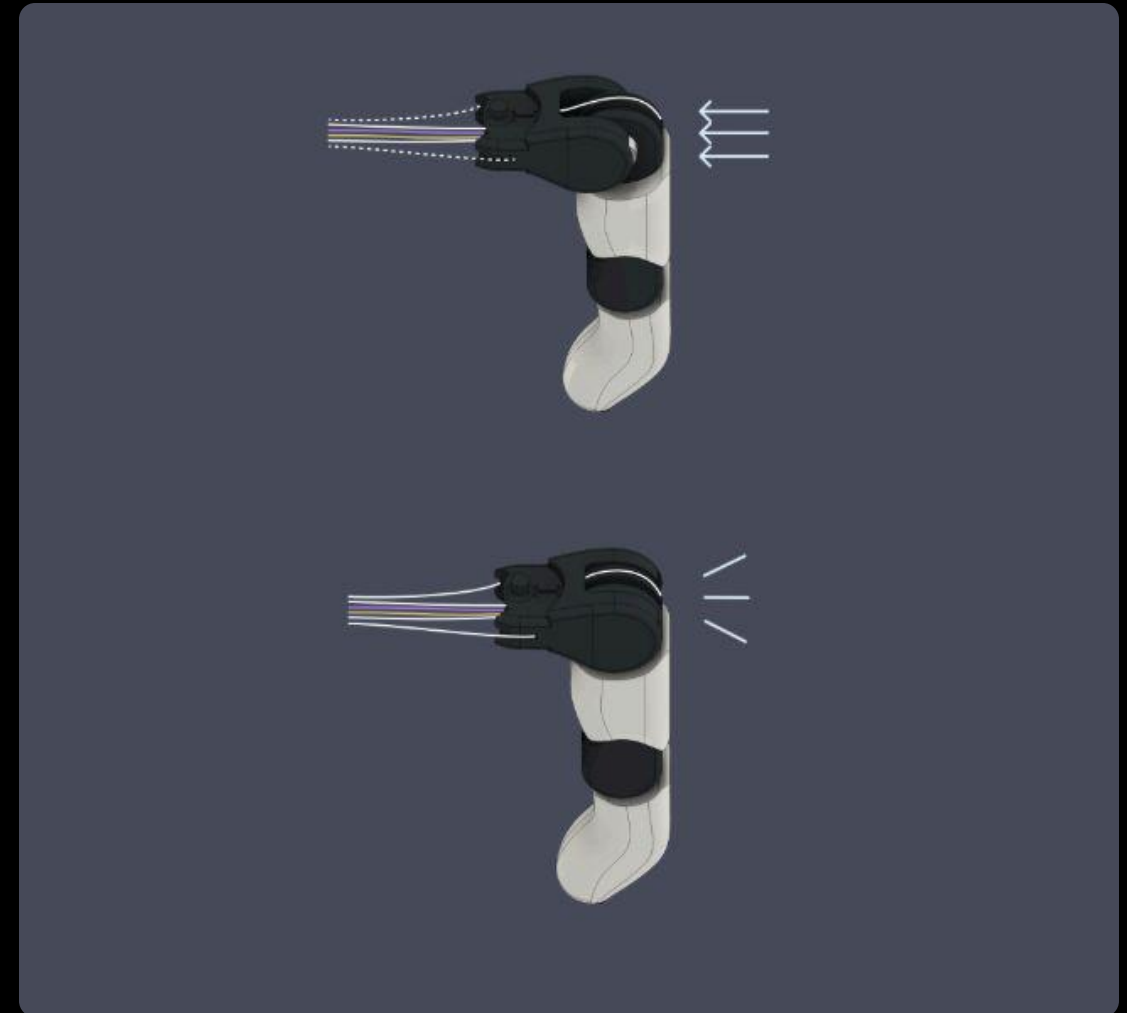




Fully Pop Each Joint In

Overview | General Guidelines | Parts Preparation | Fingers & Thumb | Carpal & Wrist | Motors & Spooling | Final Checks

- Push the joint hard into position until you feel or hear the bearing snap in
- A seated joint turns freely around the bearing and cannot move in any other direction





Check the Friction of Each Joint

Overview | General Guidelines | Parts Preparation | Fingers & Thumb | Carpal & Wrist | Motors & Spooling | Final Checks

TEST

Move and shake the joint through its whole range of motion

IF IT STICKS

Pop the joint out and fix it before moving on

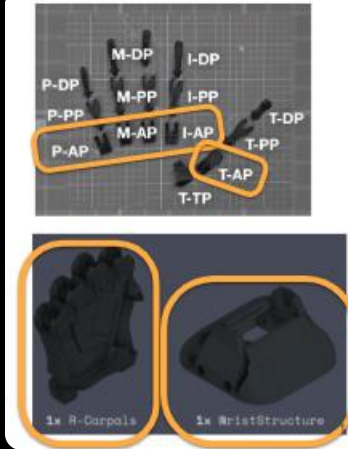
COMMON CAUSES

- Tendons caught in the joint
- A rough print surface (file or sand it smooth)

PTFE Tubes

Overview | General Guidelines | Parts Preparation | Fingers & Thumb | Carpal & Wrist | Motors & Spooling | Final Checks

- PTFE tubes reduce friction between tendon and plastic. Prepare them all at once
- Trim ~1mm out on both sides, uniform length



PTFE Tubes in the APs

- Insert the tubes into APs of Thumb, Index, Middle ×2, Pinky
- 2 tubes, one in each wide hole

PTFE Tubes in the Carpals and Wrist

- Screw in and out of all 32 channels to clean the bottom exits
- Insert a tube into each of the 32 channels
- Repeat with the wrist

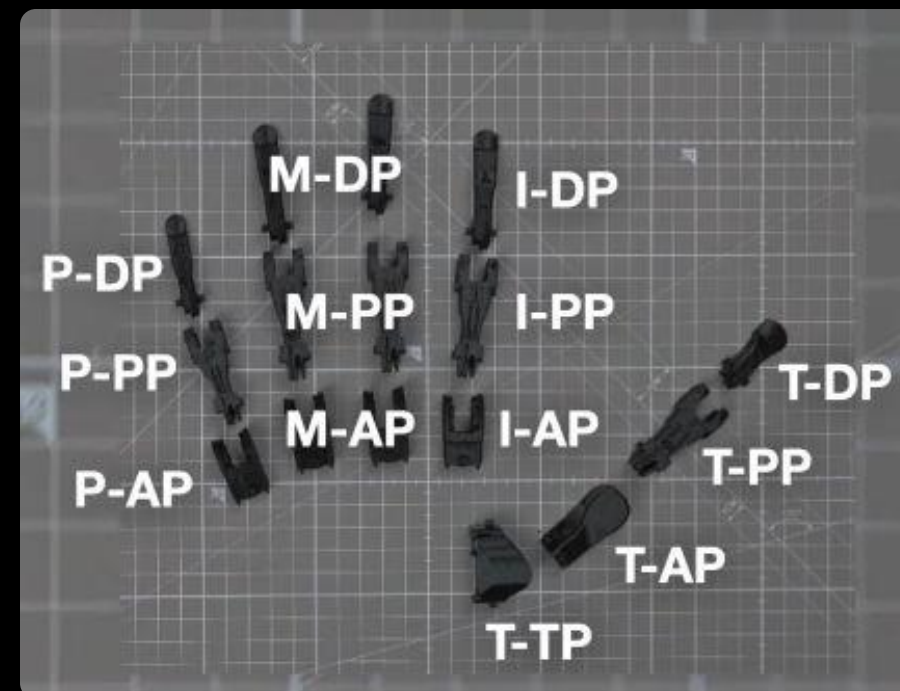




Sort the Printed Parts

Overview | General Guidelines | Parts Preparation | Fingers & Thumb | Carpal & Wrist | Motors & Spooling | Final Checks

- Identify and sort the parts before threading the tendons

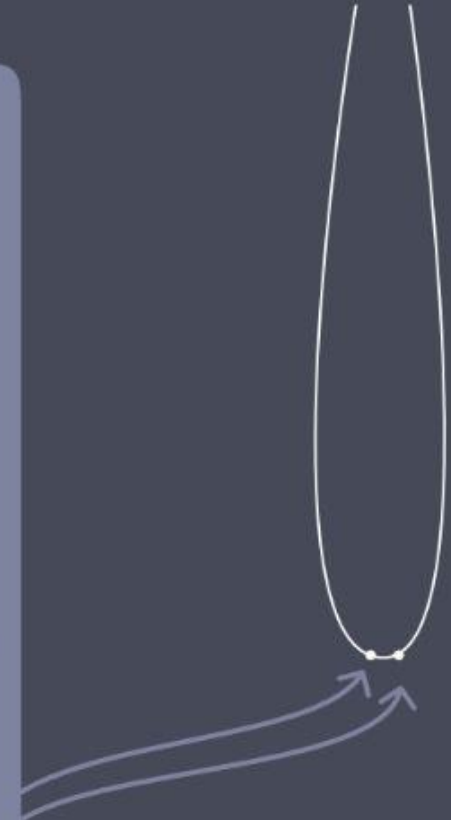
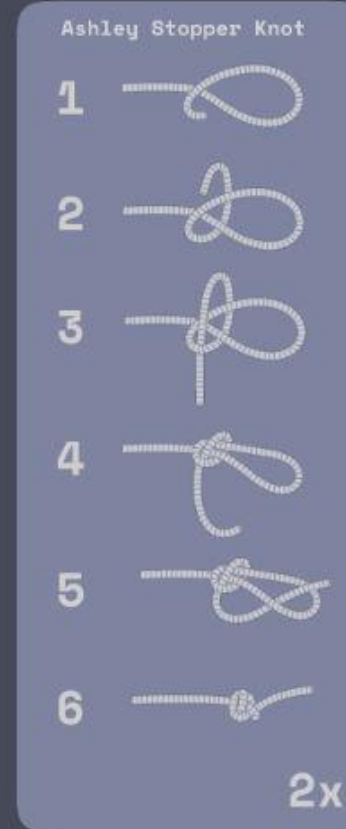
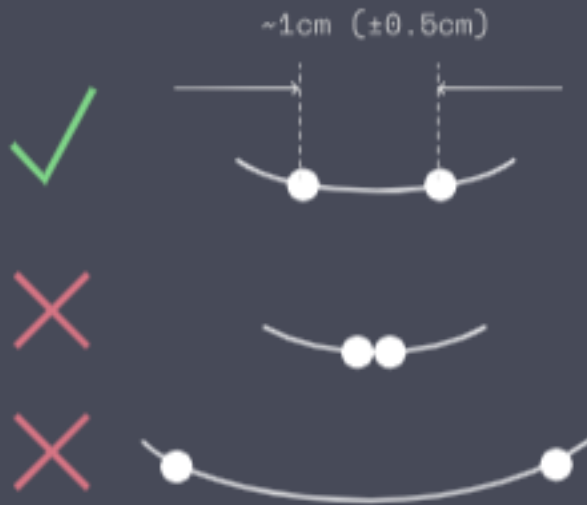




Prepare a Double-Knot Tendon

Overview | General Guidelines | Parts Preparation | Fingers & Thumb | Carpal & Wrist | Motors & Spooling | Final Checks

- Measure 1.5m of tendon
- Tie 2 A-S knots in the middle, 10mm apart

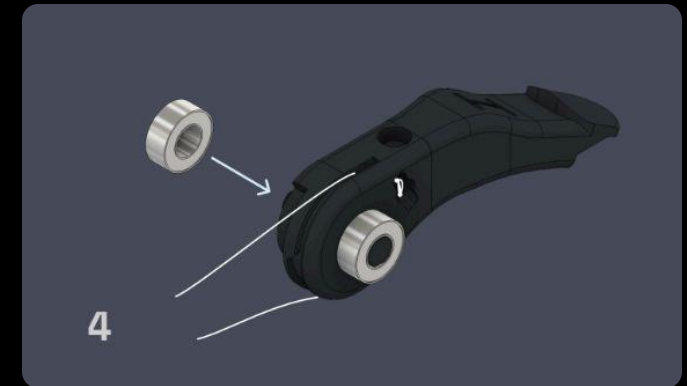
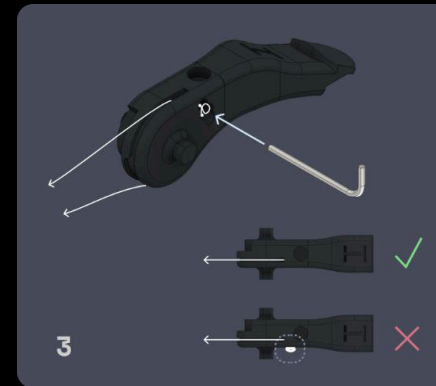
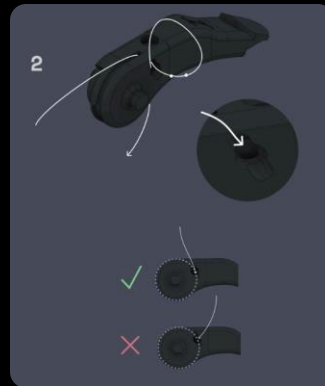




Prepare the DP

Overview | General Guidelines | Parts Preparation | Fingers & Thumb | Carpal & Wrist | Motors & Spooling | Final Checks

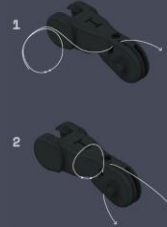
- Thread the double-knot tendon through the knot housing: both ends in from the middle, out to the sides
- Pull tight, stuff it in and add two 4mm bearings



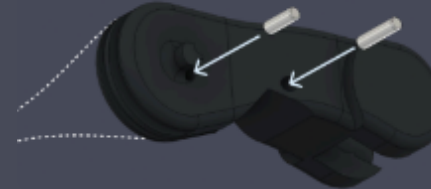


Add the PP

Overview | General Guidelines | Parts Preparation | Fingers & Thumb | Carpal & Wrist | Motors & Spooling | Final Checks



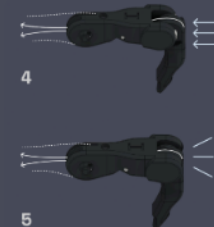
Thread a double-knot tendon through the PP knot housing, stuff it in



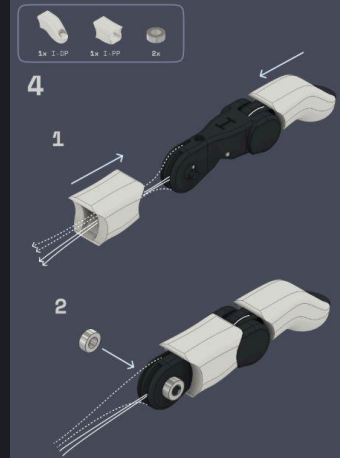
Insert the pins into the respective slots



DP top tendon into the PP top hole



Tug to check no crossing, then pop the joint in

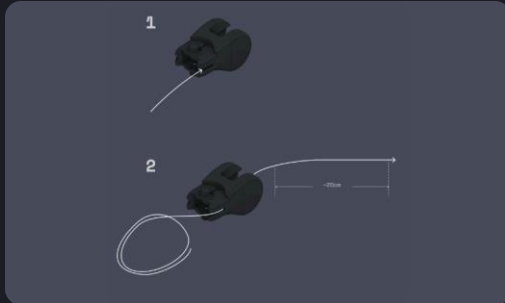


Add the I-DP and I-PP skins and two 4mm bearings



Prepare the AP

Overview | General Guidelines | Parts Preparation | Fingers & Thumb | Carpal & Wrist | Motors & Spooling | Final Checks



Cut two 75cm tendons, pass them through the side holes (outside → inside)



A-S



× Next to A-S



✓ Around A-S

Tie an A-S knot. Then, tie a simple knot around the A-S to make it larger



Trim 5mm after the knot, pull it into its housing



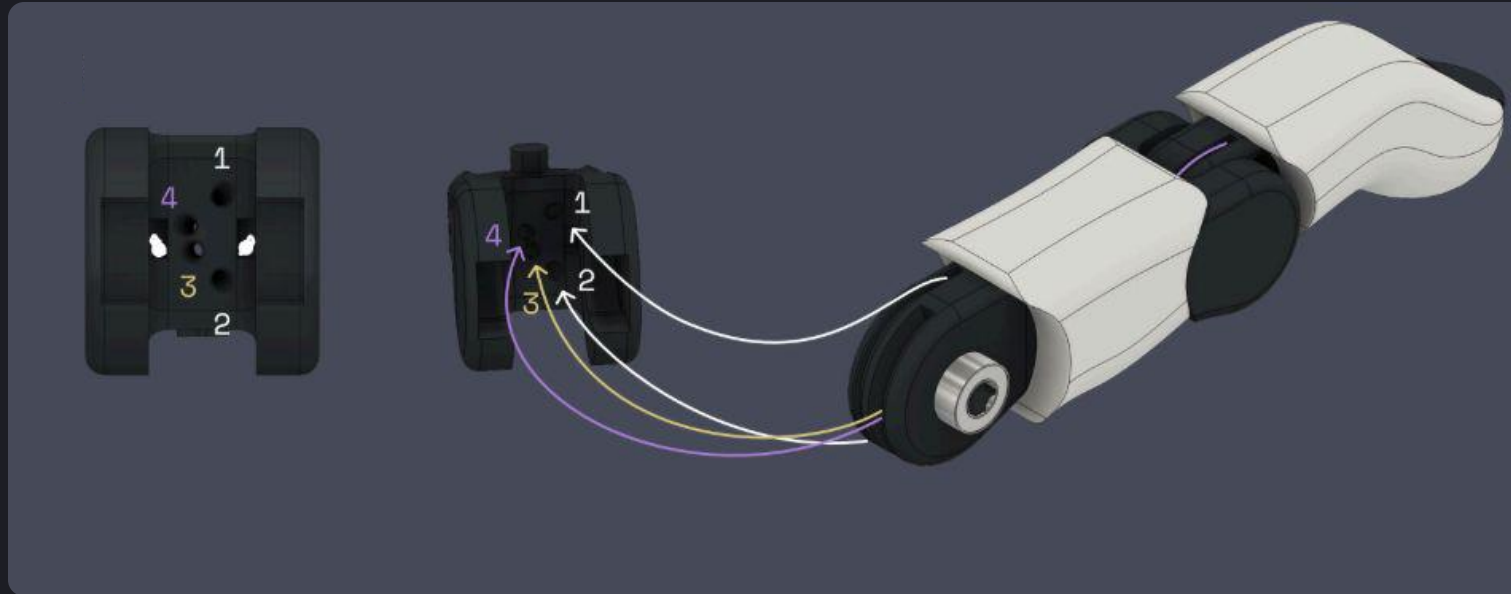
Stuff anything still loose into the knot-housing with a rod-like object



Assemble the Finger

Overview | General Guidelines | Parts Preparation | Fingers & Thumb | Carpal & Wrist | Motors & Spooling | Final Checks

- Thread DP and PP tendons into the AP, tug and pop the joint in
- Add two 2×8 pins with tendons seated between them, then two 4mm bearings. Shake test



1 · PP extension 2 · PP flexion 3 · DP flexion 4 · DP extension





Repeat for Middle and Pinky

Overview | General Guidelines | Parts Preparation | Fingers & Thumb | Carpal & Wrist | Motors & Spooling | Final Checks

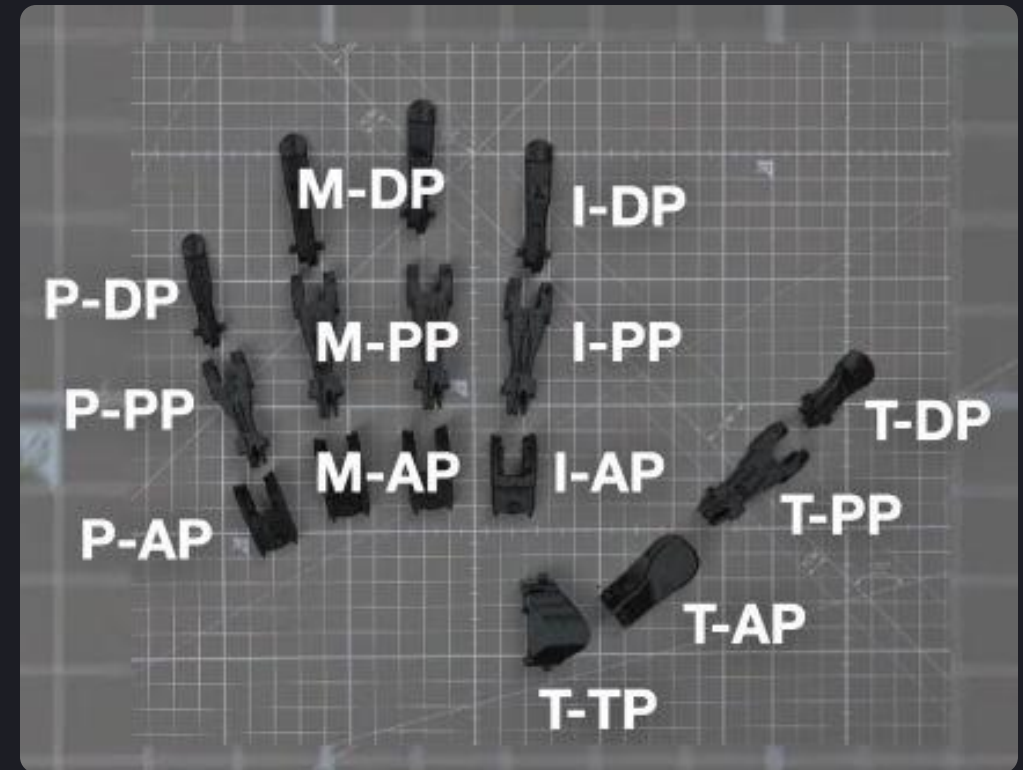
- Middle and Pinky are assembled exactly like the Index finger

2x

Middle

1x

Pinky

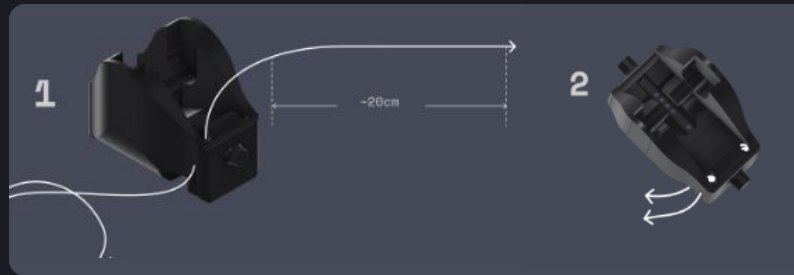




Route the Thumb Through the TP

Overview | General Guidelines | Parts Preparation | Fingers & Thumb | Carpal & Wrist | Motors & Spooling | Final Checks

- DP, PP and AP are built as for the index finger. Then route all six tendons into the TP in order.



Prepare the TP



Add two 4mm bearings and pop the joint in



Route the six tendons through the TP

- 1 Right TP adduction
- 2 PP extension
- 3 DP extension
- 4 DP flexion
- 5 PP flexion
- 6 Left TP adduction



Insert two 2×30 pins, tendons seated between them, order kept



Thread the Fingers into the Carpals

Overview | General Guidelines | Parts Preparation | Fingers & Thumb | Carpal & Wrist | Motors & Spooling | Final Checks

- Thread, tug, then pop each finger in until its bearings snap into the housing.



Tug to verify that no tendons are crossing

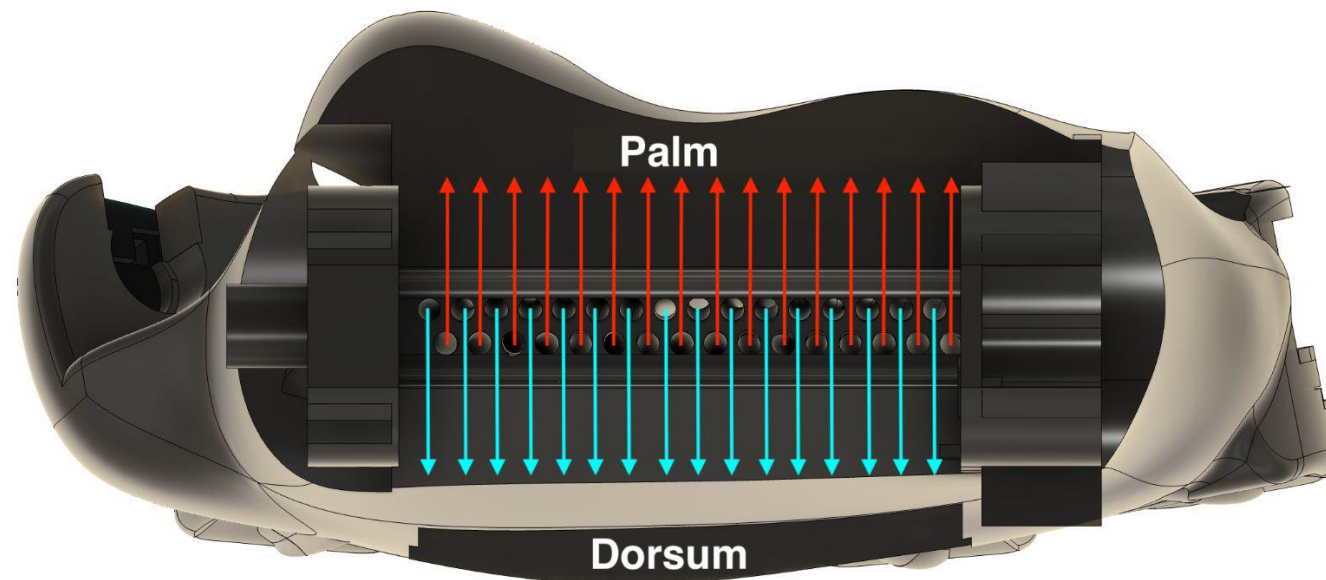
- 1 Right AP adduction
- 2 PP extension
- 3 DP extension
- 4 DP flexion
- 5 PP flexion
- 6 Left AP adduction



Separate Palm and Dorsum Tendons

Overview | General Guidelines | Parts Preparation | Fingers & Thumb | Carpal & Wrist | Motors & Spooling | Final Checks

Tendons leave the carpal in two lines, alternating side to side. Bundle every other tendon with tape now, before the pins block the view.





Completing the Carpal Assembly

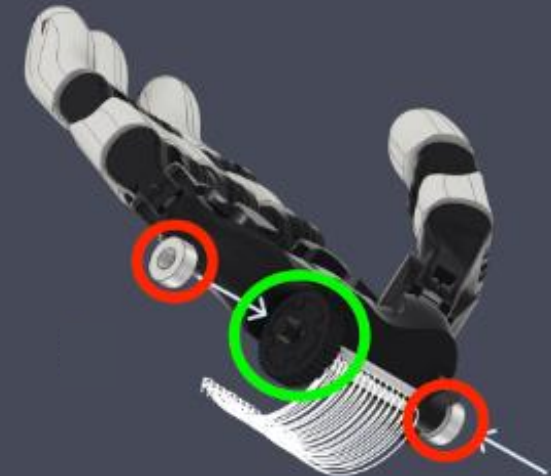
Overview | General Guidelines | Parts Preparation | Fingers & Thumb | Carpal & Wrist | Motors & Spooling | Final Checks



Add the silicone skin



Add two pins through the shaft holes



Mount the carpal pulley and add two bearings on the shaft



Thread the Tendons into the Wrist

Overview | General Guidelines | Parts Preparation | Fingers & Thumb | Carpal & Wrist | Motors & Spooling | Final Checks

- 1 Left-most palm tendon into the left-most dorsum-side channel
- 2 Continue in sequence for all palm tendons; keep them free of tangles
- 3 Repeat with all dorsum tendons into the palm-side channels



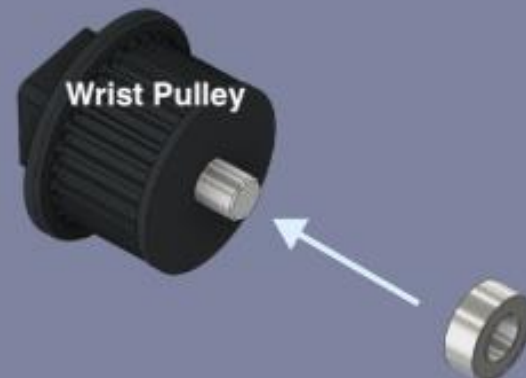
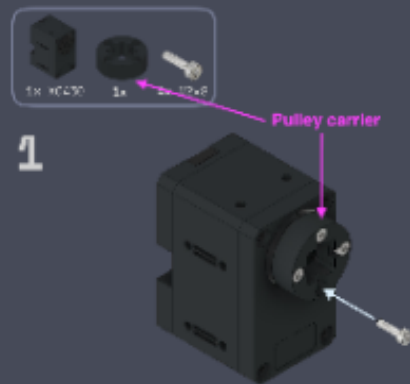


Complete the Wrist

Overview | General Guidelines | Parts Preparation | Fingers & Thumb | Carpal & Wrist | Motors & Spooling | Final Checks



Add two screws, nuts and PTFE tubes



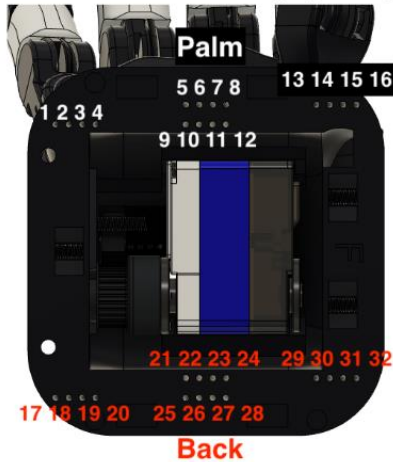
Assemble the wrist motor into the wrist



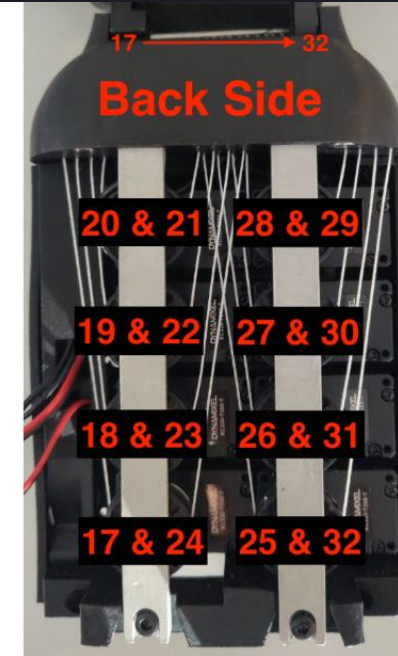
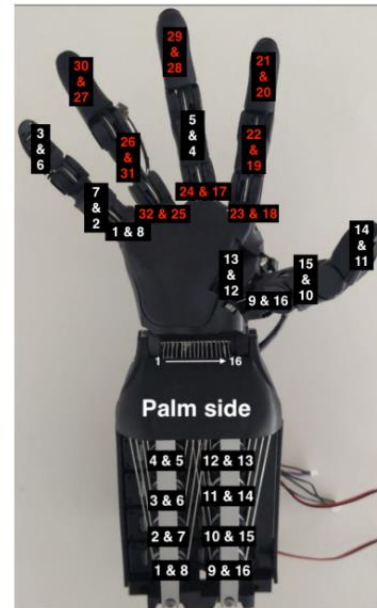
Tendon Mapping

Overview | General Guidelines | Parts Preparation | Fingers & Thumb | Carpal & Wrist | Motors & Spooling | Final Checks

Tendon mapping



1) P-AP-L	17) M-AP-R
2) P-PP-flex	18) I-AP-R
3) P-DP-ext	19) I-PP-flex
4) M-PP-flex	20) I-DP-flex
5) M-PP-ext	21) I-DP-ext
6) P-DP-flex	22) I-PP-ext
7) P-PP-ext	23) I-AP-L
8) P-AP-R	24) M-AP-L
9) T-AP-L	25) R-AP-R
10) T-PP-flex	26) R-PP-ext
11) T-DP-flex	27) R-DP-flex
12) T-TP-flex	28) M-DP-flex
13) T-TP-ext	29) M-DP-ext
14) T-DP-ext	30) R-DP-ext
15) T-PP-ext	31) R-PP-flex
16) T-AP-R	32) R-AP-L



The numbers are superposed over the joints they actuate (central image). The number above is the extensor and below is the flexor. For the AP the number to the left moves the joint to the left and vice-versa.

First letter stands for Thumb, Index, Middle, Ring or Pinky, while the two following letters indicate the joint.

In last position, ext means extension (finger opens/moves away from the palm) and flex

means flexion (finger closes / moves in towards the palm).

For the APs, in last position L means moving to the left (when looking at the palm side) and R means moving to the right.

So R-DP-flex means : Ring finger - DP - flexion

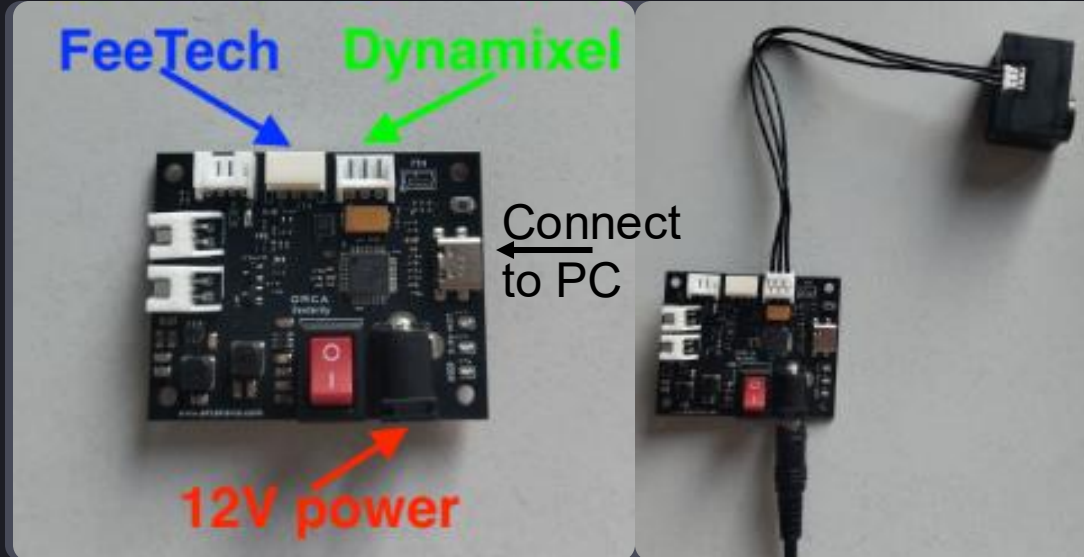


FeeTech Motor Assembly

Overview | General Guidelines | Parts Preparation | Fingers & Thumb | Carpal & Wrist | Motors & Spooling | Final Checks



Prepare the motors



Connect the motors



Assemble the motors onto the tower

**Check servo wiring polarity and align the connector notch before inserting.
It should slide in easily. Never force it.**



Motor Wiring Warning

Overview | General Guidelines | Parts Preparation | Fingers & Thumb | Carpal & Wrist | Motors & Spooling | Final Checks



**Wrong wiring can permanently
damage the servo**

**Check servo wiring polarity and align the connector notch
before inserting.**

It should slide in easily. Never force it.



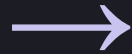
Motor Arrangement

Overview | General Guidelines | Parts Preparation | Fingers & Thumb | Carpal & Wrist | Motors & Spooling | Final Checks

- The configuration script automatically assigns IDs from 17 down to 1. Connect motors in descending order
- Only install the next motor after the current one has been found using the script

17

Top right, palm side



1

Wrist





Tendons in the Bottom Spools

Overview | General Guidelines | Parts Preparation | Fingers & Thumb | Carpal & Wrist | Motors & Spooling | Final Checks

- Connect the wrist and tower
- Left inner-row tendon goes into the spool of the highest motor
- Thread bottom → top, measure ~8cm (a palm's width), tie an A-S knot and trim 5mm after it
- Turn counterclockwise 3–5 revolutions; it must wind on the spool
- Repeat for next tendon to the left, next spool down; 16 tendons in total

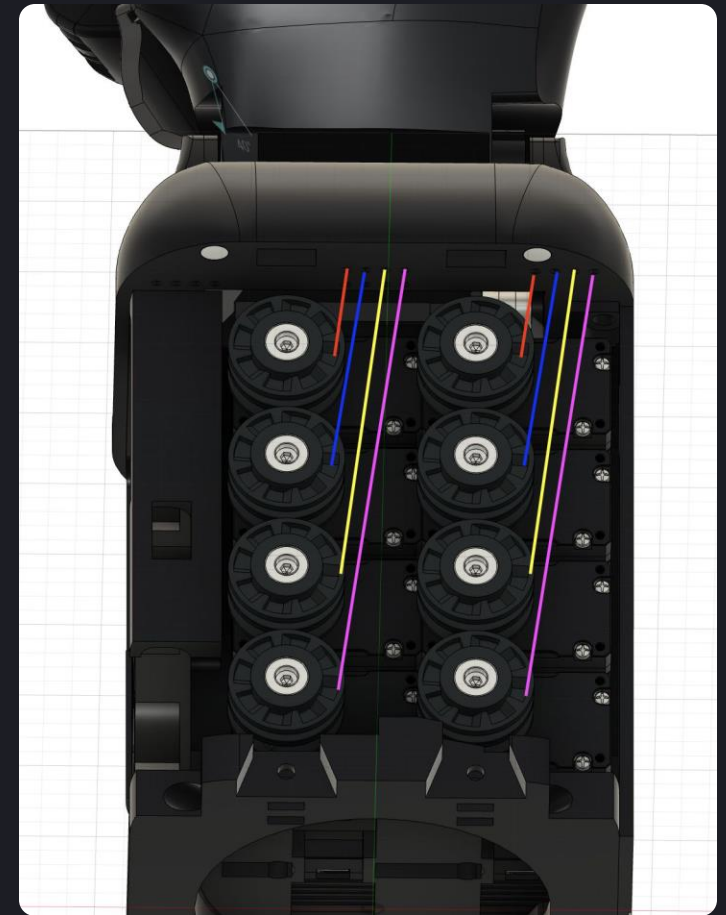




Tendons in the Top Spools

Overview | General Guidelines | Parts Preparation | Fingers & Thumb | Carpal & Wrist | Motors & Spooling | Final Checks

- Thread the closest right outer-row tendon, measure ~8cm, tie an A-S knot and trim 5mm after the knot
- Wind to the max (3–5 turns), seat it so the ratchet teeth engage
- Add a 4mm bearing to the top spool and fix with a screw

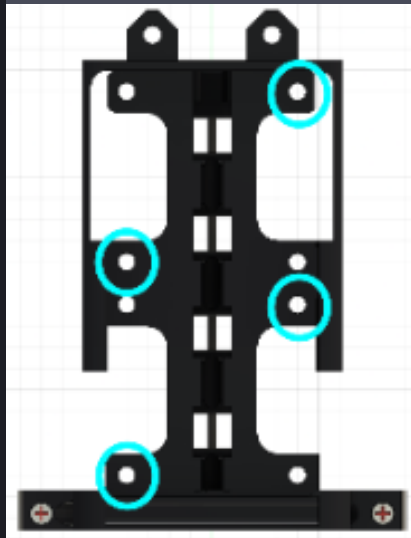




Final Assembly Steps

Overview | General Guidelines | Parts Preparation | Fingers & Thumb | Carpal & Wrist | Motors & Spooling | Final Checks

Refer to the guide for detailed instructions on these steps



Fans



Spoolholders



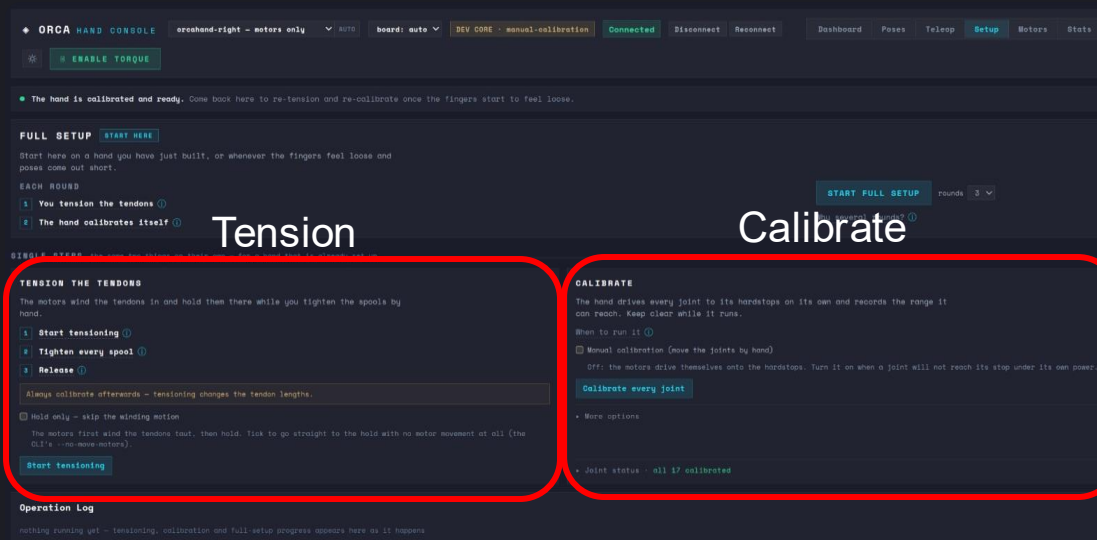
Hull Plates



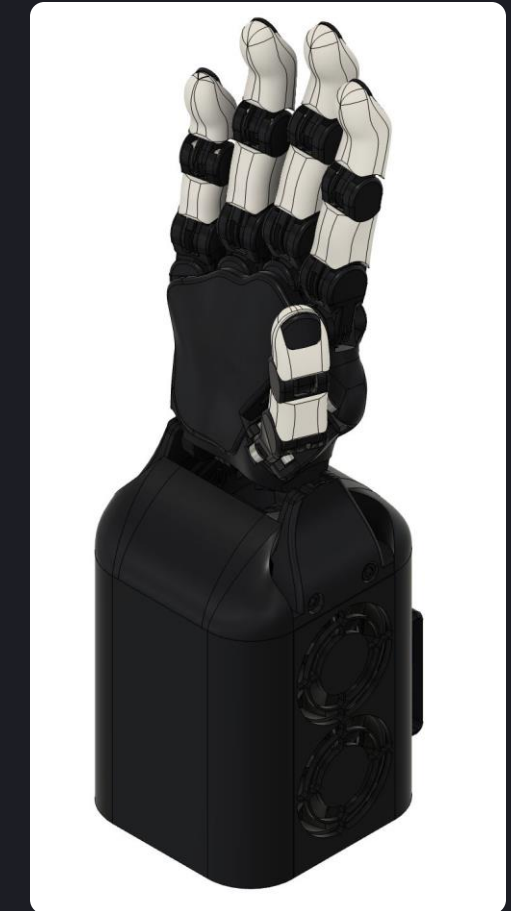
Final Checklist

Overview | General Guidelines | Parts Preparation | Fingers & Thumb | Carpal & Wrist | Motors & Spooling | Final Checks

- Go through the checklist of crucial points and common mistakes
- Run the tensioning procedure to make the hand ready for use
- Calibrate the hand and test its movements



ORCA UI





Takeaways

Overview | General Guidelines | Parts Preparation | Fingers & Thumb | Carpal & Wrist | Motors & Spooling | Final Checks

01

Simulate the hand

Explore every component and joint in the interactive model.

orcaatlas.netlify.app

02

Play with the hand

Move each finger and feel how a correctly assembled joint runs without friction.

03

Build your own hand with the guide

Follow the assembly instructions alongside the video tutorial.

[Assembly guide](#)

[Video tutorial \(YouTube\)](#)



Materials in the box

- *3D Printed Parts:* Fingertips, Carpal, Plates&Halls, Bottom Tower, Top Tower
- *Mechenics:* 2x MR138ZZ bearings, 50x MR84ZZ bearings
- *Electronics:* 2x Fans, 16x HLS2915M servos, 1x HLS3930M servo, USB-C cable, power adapter
- *Tools:* pliers (set of 3), 2x tweezers, red marker, cutter, screwdriver, superglue



Materials arriving soon

- *3D Printed Parts:* Spools&Small Parts
- *Mechenics:* sililcon skins
- *Electronics:* servo cables

Public tools



- 2 Bosch Electric screwdrivers
- Box of screws, nuts, washers, etc.



3D Printing

Yucheng Xia

Slides adapted from materials by Dr. Ronan Hinchet and Thomas Buchner.



Why 3D Printing

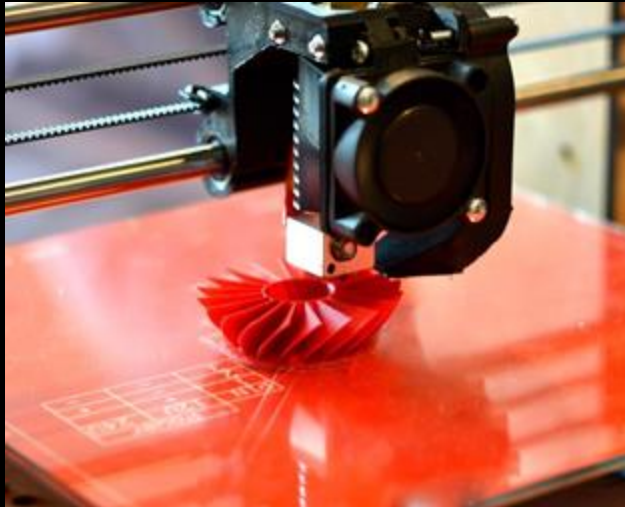


- Alternative to machining and injection molding
- Cost-effective
- Rapid prototyping

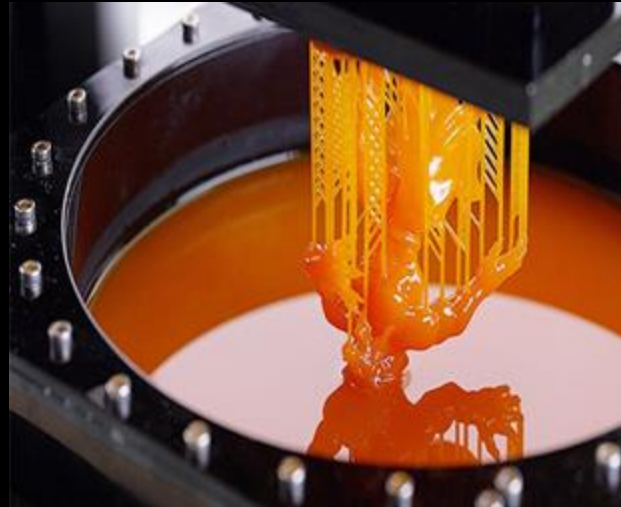
Common Types of 3D Printing



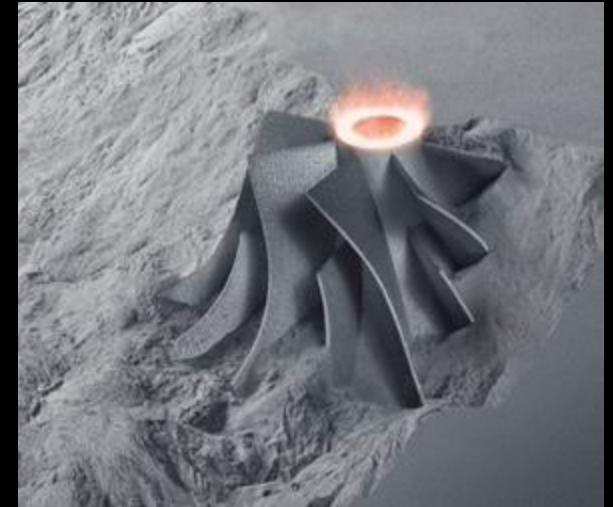
Fused Deposition
Modeling
(FDM)



Stereolithography
Apparatus
(SLA, DLP, LCD)



Selective laser sintering
(SLS, DMLS, EBM)

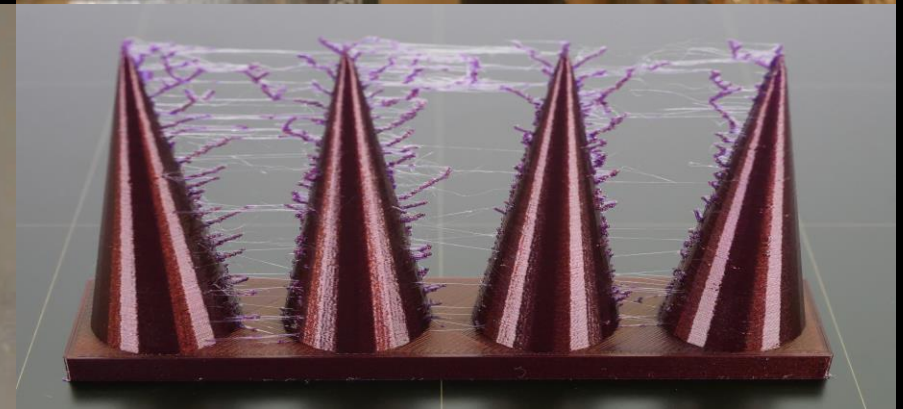
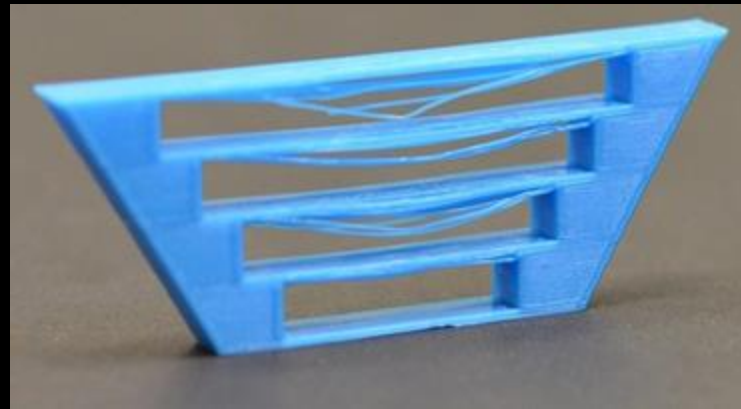
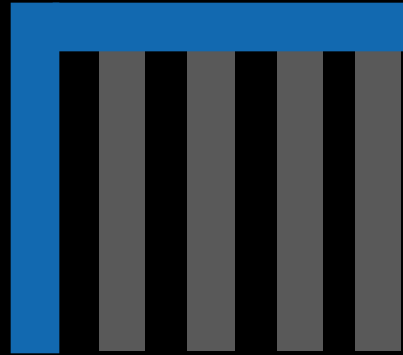


Fused Deposition Modeling (FDM)



- **Materials:** Thermoplastics (PLA, PET, TPU), composites (CF, GF, BP), and specialized filaments (PVA, PVB, Wax)
- **Advantages:** Easy to use, Wide range of materials, Cost-effective for prototyping, Suitable for functional parts
- **Limitations:** Layer lines visible on finished product, Support structures often required, Slower than some other 3D printing methods

FDM: Bridges and Overhangs





FDM: Strength of Printed Parts

Material choice

Stiff/hard/strong/[tough](#)

Check the technical datasheet values ([cf](#))

Orientation

Parts are a lot weaker in the z-direction, perpendicular to the layers

Mind the print orientation of your part (Bambu auto orient)

You can split your model into several parts (Prusaslicer cut)

Infill

Isotropic (gyroid), not isotropic ([honeycomb](#))

Layer height ([0.15 is good](#))

Wall thickness

3 is the optimal [strength/weight](#)

Ext. width, Temp, color ...

