OwlFlex Hand Printing and Assembly
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Printing Overview

Part	Filename	Material	Infill	Printer	Extruder Temp	Bed Temp	Print Speed
Gauntlet	Gauntlet-Long-correct-scale.stl	PLA	80%	Ultimaker 2	210C	60	50 mm/sec
Fingers (Typical Hand Set)	Regular Hinge Index Finger .stl, Regular Hinge Middle Finger .stl, Regular Hinge Pinky.stl, Regular Hinge Ring Finger.stl, Regular Hinge Thumb.stl	Semiflex	35%	M2 or Prusa	235C on M2/ 230C on Prusa	50C on Prusa/ 40C on M2	16.67 on M2 / 30% speed manual override on Prusa
Fingers (Alternate Hand Set)	thickhingejointsindex.stl, thickhingejointsmiddleflat.stl, thickhingejointspinky.stl, thickhingejointsring.stl , thickhingejointsthumb.stl	Ninjaflex	35%	M2 or Prusa	235C on M2/ 230C on Prusa	50C on Prusa/ 40C on M2	16.67 on M2 / 30% speed manual override on Prusa
Palm	OwlFlexRightHand.stl or OwlFlexPalm.stl (left hand)	Ninjaflex	35%	M2 or Prusa	235C on M2/ 230C on Prusa	50C on Prusa/ 40C on M2	16.67 on M2 / **50%** speed manual override on Prusa
Hinges	FFX_-_Flexy-Hinge_Wrist.stl	Ninjaflex	35%	M2 or Prusa	235C on M2/ 230C on Prusa	50C on Prusa/ 40C on M2	16.67 on M2 / 50% speed manual override on Prusa

Pins	Tensioner-correct-scale.stl	PLA	80%	Ultimaker 2	210C	60	50 mm/sec

Parts:

Please download the following files from MillerLabFTW/eNABLE_OwlFlexHands/Owl Flex Final Design 1.0 Scale on Github

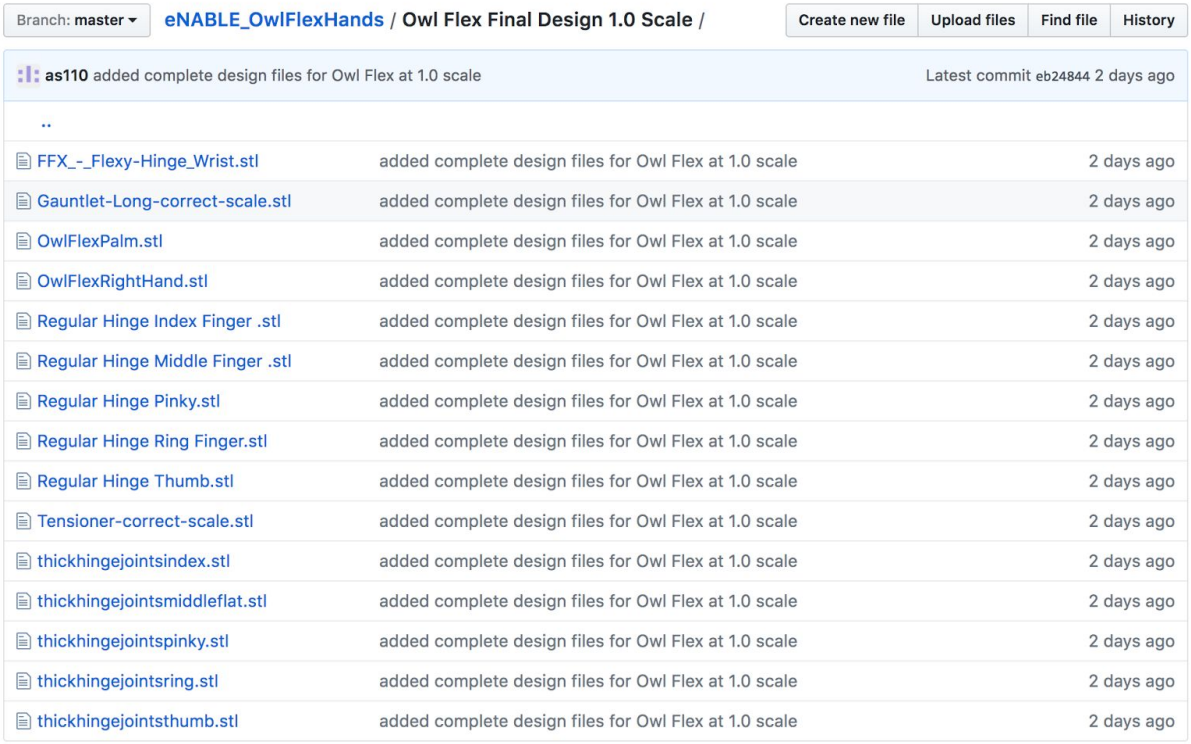


Fig.1: Github Folder with Design Files

- Palm: OwlFlexRightHand.stl or OwlFlexPalm.stl (left hand)
- Gauntlet: Gauntlet-Long-correct-scale.stl
- Fingers (please download either the Regular Hinge or Thick Hinge Fingers)
    - Regular Hinge Fingers:Regular Hinge Index Finger .stl, Regular Hinge Middle Finger .stl, Regular Hinge Pinky.stl, Regular Hinge Ring Finger.stl, Regular Hinge Thumb.stl
    - thickhingejointsindex.stl, thickhingejointsmiddleflat.stl, thickhingejointspinky.stl, thickhingejointsring.stl, thickhingejointsthumb.stl
- Wrist Hinges: FFX_-_Flexy-Hinge_Wrist.stl
- Tensioner Pin: Tensioner-correct-scale.stl

Scaling

Please scale the palm so that the patient's orthoplast socket is a snug fit inside of it. At 1.0 scale, the palm is 65mm across the wrist as seen in Fig.2 below.Please use one of the shoebox palms for reference.

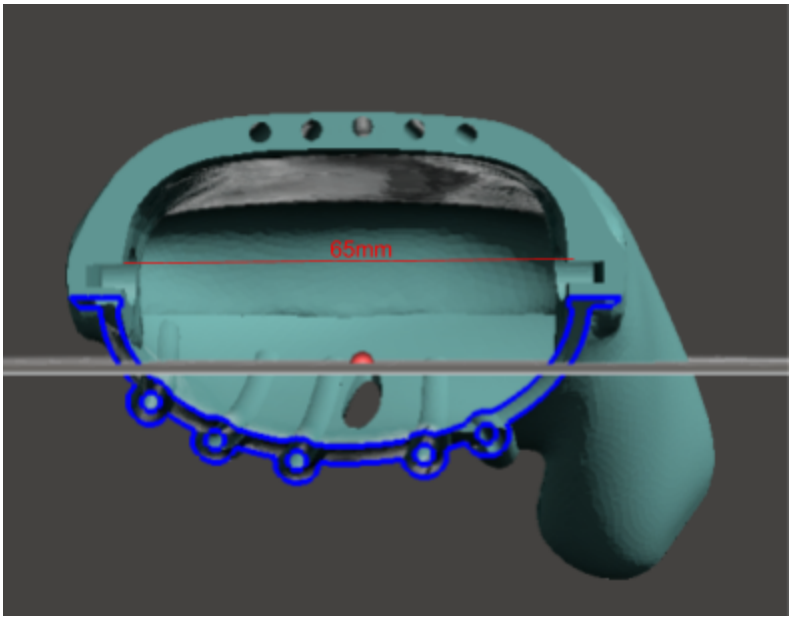


Fig.2: Width of Palm across Wrist

Please download the correct sized palm from the eNABLE_OwlFlexHands repository. For the other parts, please scale them to the same scale as the palm.

IN THE FUTURE: We want to be able to match the fingers scale so that they are the same size as the patient's biological fingers. Please update the protocol once we figure out how to do this.

Slicing

- Palm: Orient the hand as seen in the picture below (Fig.3) and please don't add any support. It is printed with 35% infill with Ninjaflex.

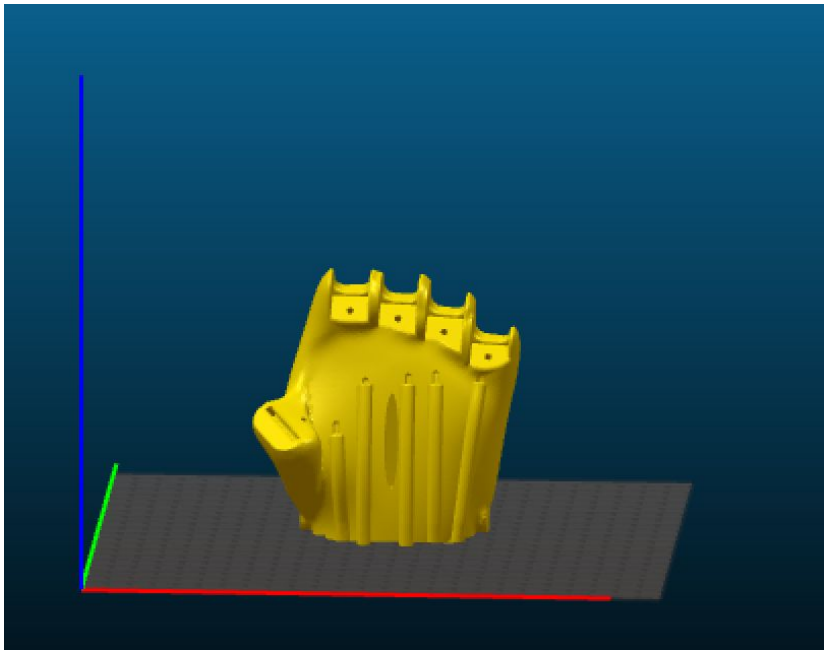


Fig.3 Palm Printing

When printing on M2, use the **M2** profile.
When printing on Prusa, please consult the “Printing Ninjaflex on Prusa i3.docx” file found on the server at People→ eNABLE→ Logistics and Overview. Use the **0.2mm Normal profile and change the infill to 35%** (Fig. 4)

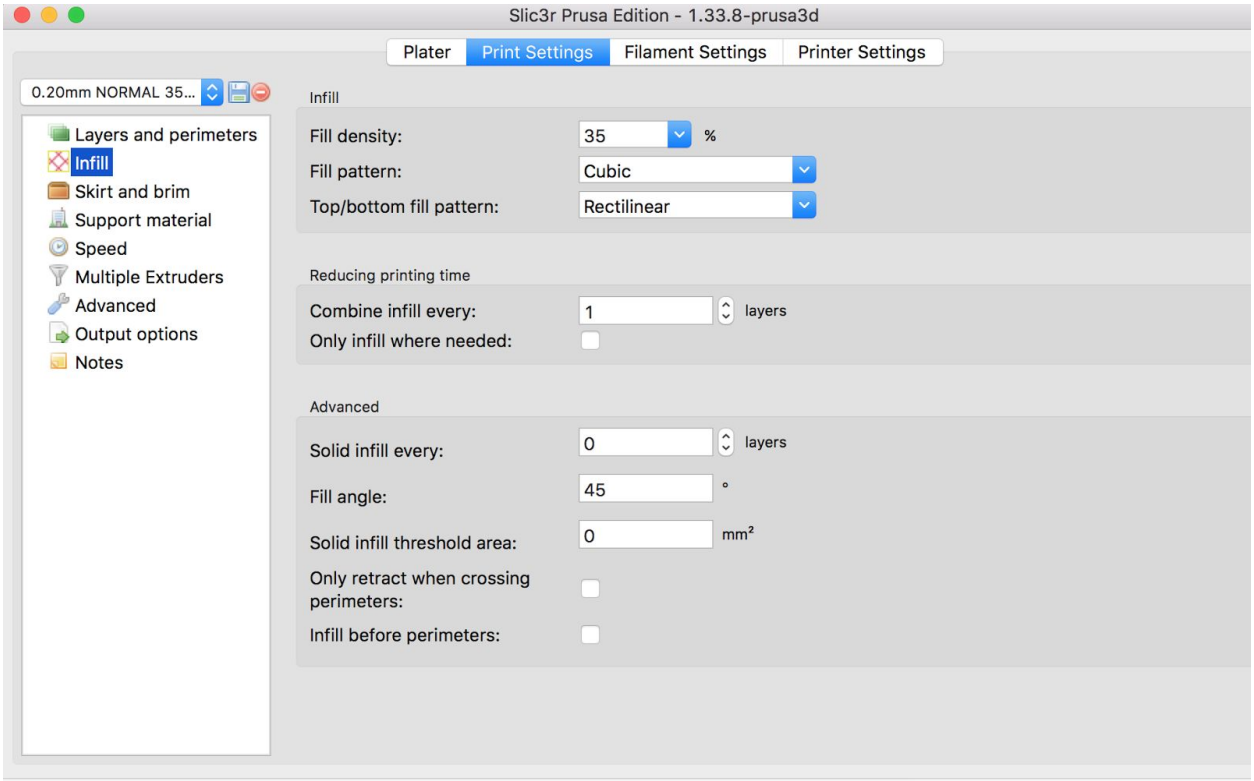


Fig. 4: Palm Infill Density on Prusa

- Fingers: printed with 35% infill
    - When printing Regular Hinge fingers, please insert **Semiflex Filament** into both the M2 and Prusa printers. Please use the **Semiflex** profile on the M2 and the **0.2mm Normal 35% Infill** profile on the Prusa that we have created for the palm.
    - When printing Thick Hinge fingers, please insert **Ninjaflex Filament** into both the M2 and Prusa printers. Please the **M2** profile on the M2 and **0.2mm Normal 35% Infill** profile on the Prusa
    - When printing fingers on the Prusa, make sure that the manual override speed is set to 30% and the Live Z offset is set to -0.675mm. For more info on where to find those settings, please consult the “Printing Ninjaflex on Prusa” protocol

Please orient the fingers so that the flat side is touching the print surface as seen below (Fig.5) and (Fig.6)

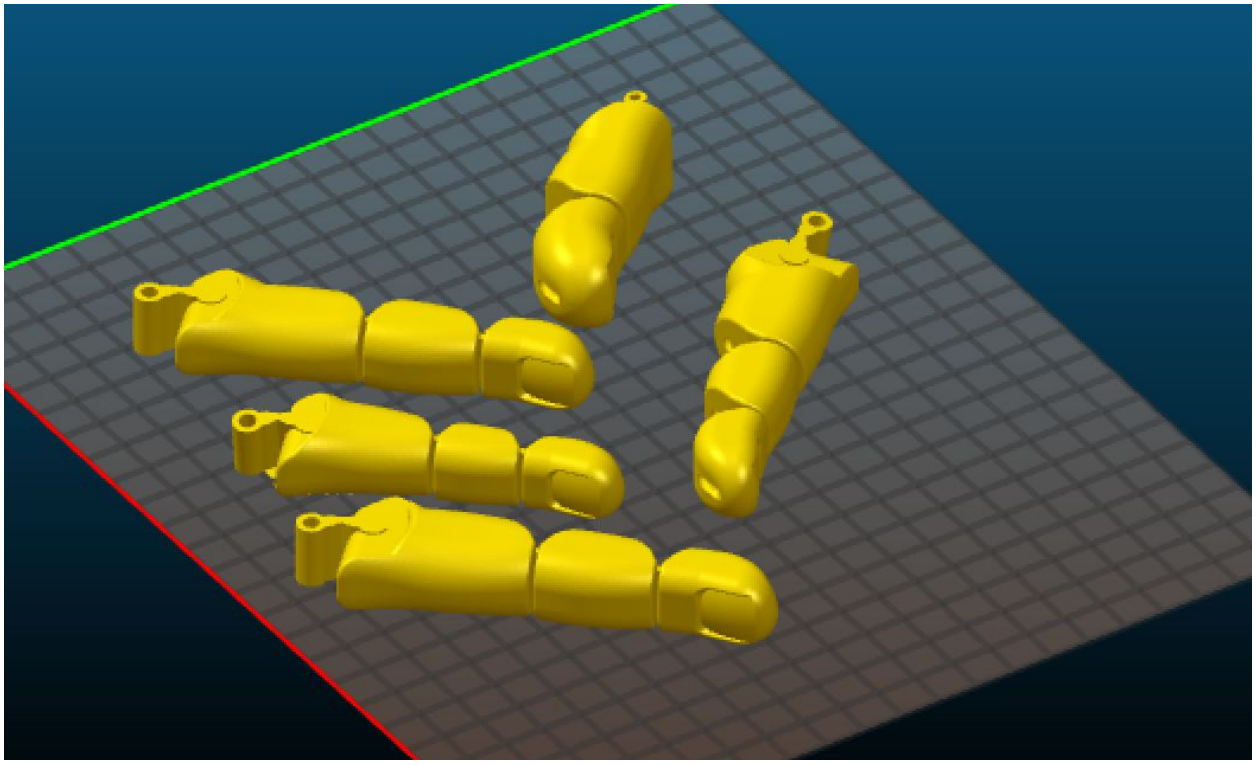


Fig.5: Finger Orientation

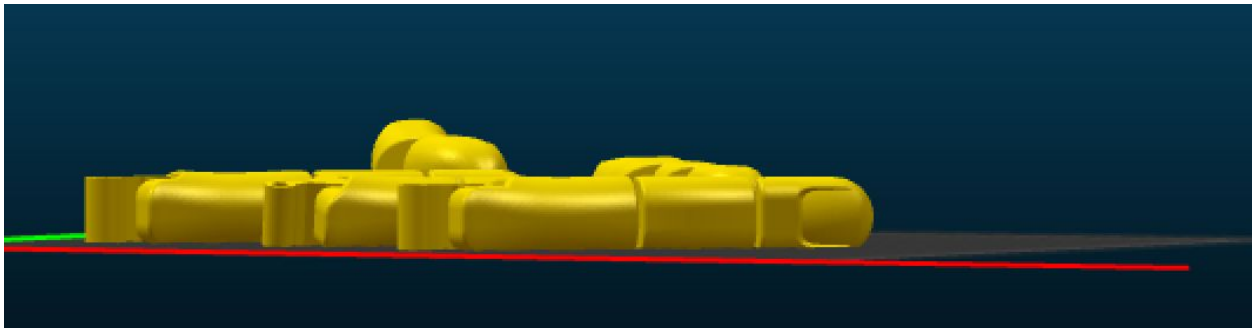


Fig. 6: Finger Orientation

- Hinges: You need to print 2 hinges for each hand. These are printed at 35% infill with Ninjaflex. Please use the **M2** profile on the M2 and the **0.2mm Normal 35% Infill** profile on the Prusa. Orient the hinges on the platform as seen below (Fig.7).

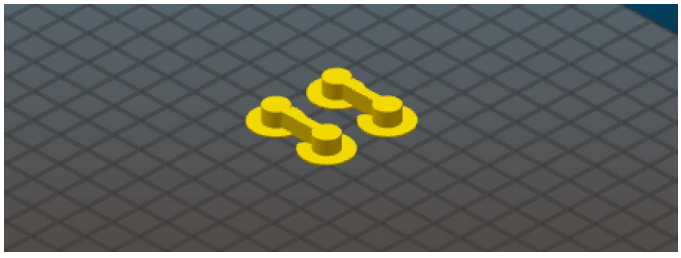


Fig. 7: Orientation of Hinges

- Gauntlet: Please print the Gauntlet at 80% infill and use a Brim when printing it. The gauntlet is printed on Ultimaker with PLA filament, so please use Cura to slice the file. The key print settings can be seen in the figure below (Fig.8).

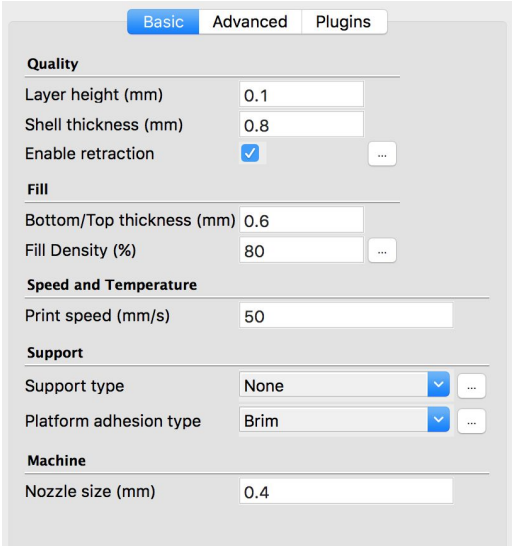


Fig.8: Gauntlet Printing Profile

The orientation of the gauntlet on the platform can be seen in the figure below (Fig.9).

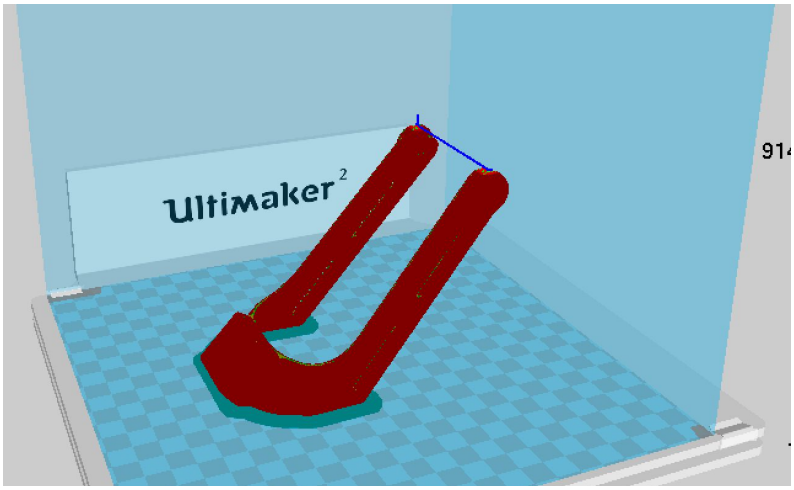


Fig.9: Gauntlet Printing Orientation

- Pins: You need 5 pins per hand. These are printed with the Ultimaker using PLA. Please use the same profile as you used for the Gauntlet. Orient the pins as seen below (Fig.10).

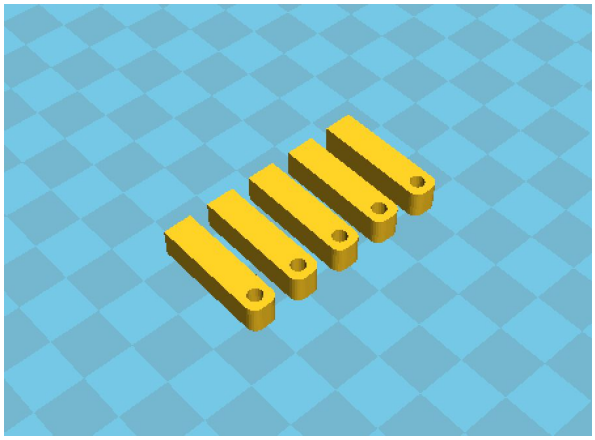


Fig.10: Orientation of Pins

Printing

- Printing on the M2:
    - First, heat up the extruder in the Machine control Panel to 230C. As this happens, clean out the bed with water and Isopropyl Alcohol (IPA)
    - Retract the filament out of the nozzle
    - Pull out the nozzle and push 1.75mm PLA into the nozzle to clean any possible clogs.
    - Put the nozzle back into the extruder and hit the Extrude button on Machine Control Panel as you feed in Ninjaflex or Semiflex. Please hold the filament at the top as it feeds into the extruder. Once all the PLA has been cleared out, hit Prepare to Print on Simplify 3D
    - Apply glue onto the bed using a glue stick before it starts printing. Stick around for the first few layers.
- Printing on Prusa: Please follow the instructions on the “Printing Ninjaflex on Prusa i3.docx”

After Printing, you should have all of the pieces seen below (Fig.11)

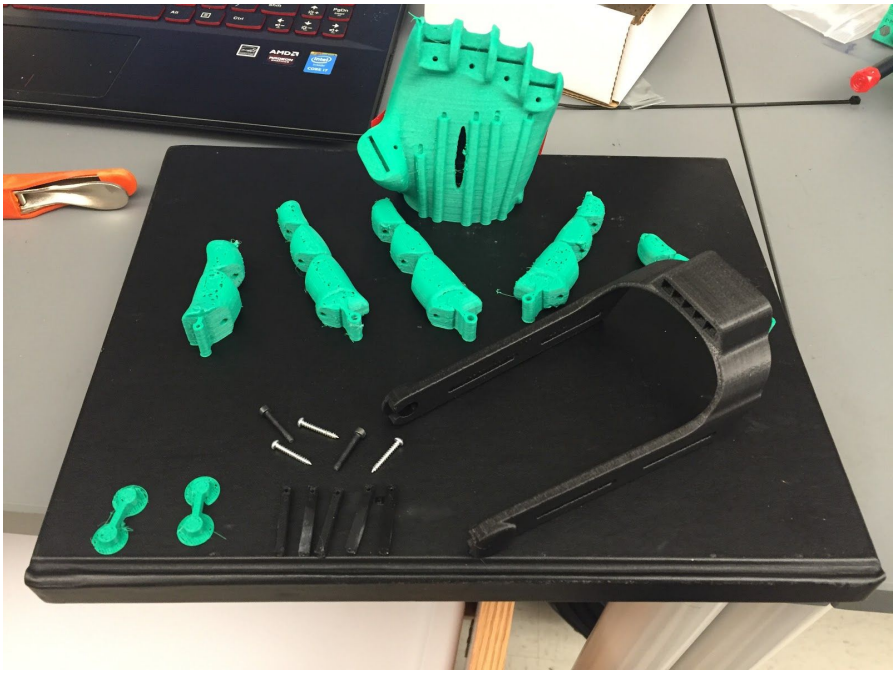
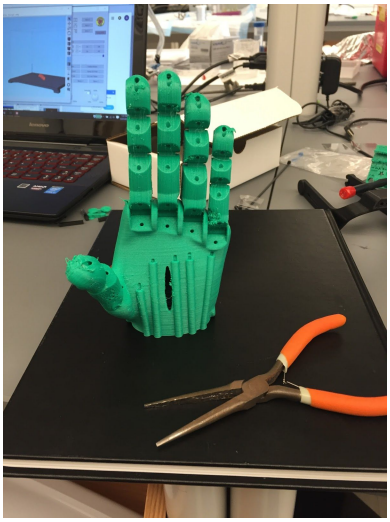


Fig.11: Printed Parts

Assembly

- Using a pair of pliers, attach the fingers to their respective locations on the palm.



- Strip 5 1 inch segments of 22 AWG wire and keep the external casing. This prevents the filament of each wire from cutting through the top of the phalanx over time. Using super glue, attach each segment into the proximal phalanx of each finger (Fig.12)

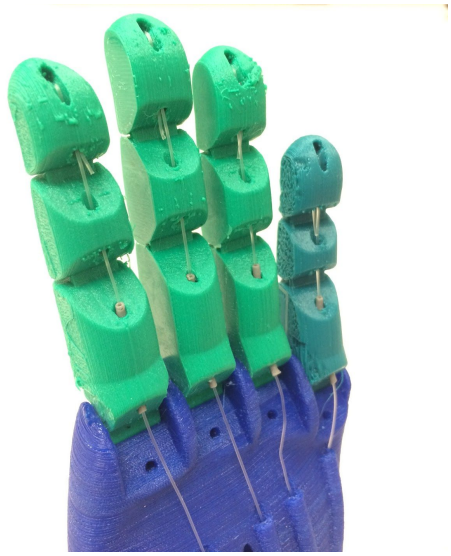


Fig.12: AWG Wire Tubing

- Super glue the two hinges into the sockets at the bottom of the hand, and after they have set, glue the other side of each hinge into the gauntlet
- Insert the tensioner pins into the slots on the gauntlet and secure with a bolt.
  A picture of the above two steps can be seen in Fig. 14
- Stringing the hands
    - Tie a non-slip knot onto the top of the finger following this tutorial: https://www.youtube.com/watch?v=hxQ3IsNwNx4
    - The following picture (Fig.13) is a good graphic for how to tie the non-slip knot.

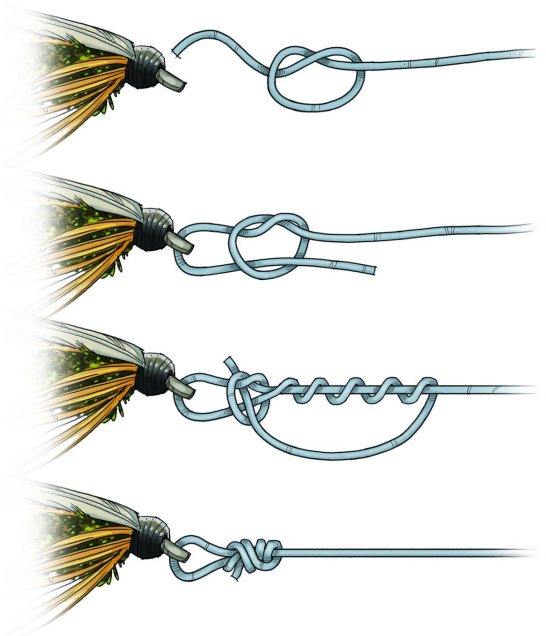


Fig.13: Non-Slip knot

- When stringing a hand for patients, we will tension the hand once the patient has put it on.
- When stringing a hand for testing a demonstration purposes, follow the steps below.
- Push the string through the channels at the base of the palm and tie knots at the gauntlet as seen below.

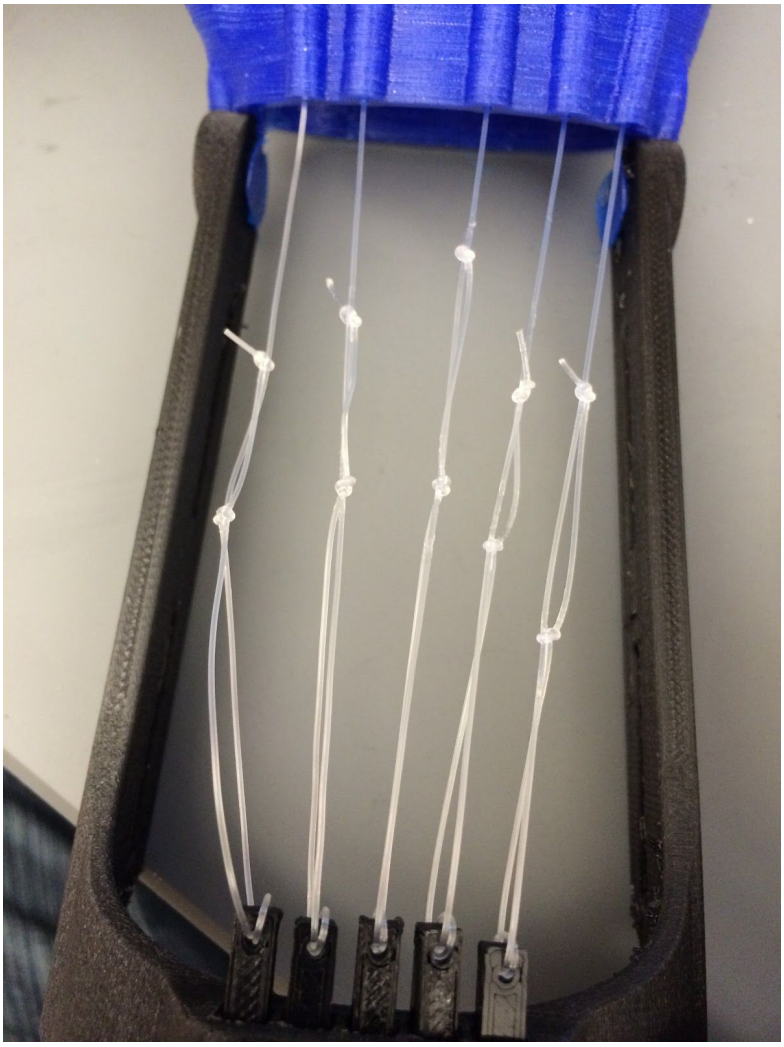


Fig.14: Hinges, Pins, and depiction of knots at Gauntlet level

- Tie them so that the fingers close at 20 degrees of wrist extension
- Use Table 1 for reference for the length of the tensioning strings so that the fingers close at 20 degrees of wrist extension. This applies when each finger is printed at 0.77 scale, but this can be a rough guide for other sizes as well.

Finger	**Length (cm)**
Thumb	13.25

Forefinger	13.5
Middle Finger	13.5
Ring Finger	13.6
Pinky Finger	15.1

Table 1: Proper lengths of tensioning for each finger

- Once the hands are assembled, disinfect the entire hand with 70% ethanol and move them into the student offices.