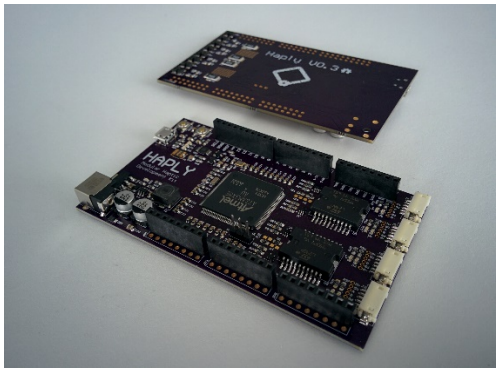
HAPLY PANTOGRAPH DEVICE ASSEMBLY INSTRUCTIONS

This manual provides the instructions needed to construct the Haply 2-D Pantograph device. The manual is divided into two parts: 1) The Pantograph kit contents for component indexing, 2) Step by step assembly instructions.

PANTOGRAPH KIT CONTENTS

The Haply 2-degree-of-freedom kinesthetic (force feedback) haptic development kit is comprised of the following component items:

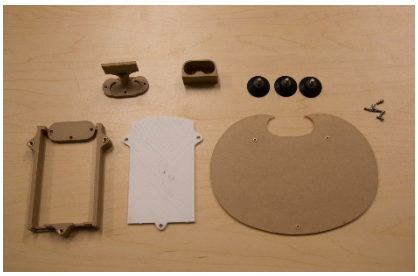
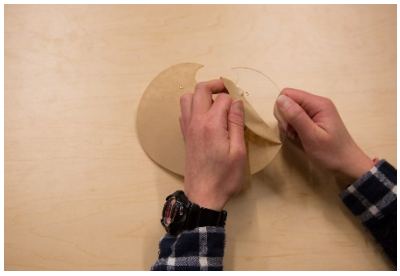
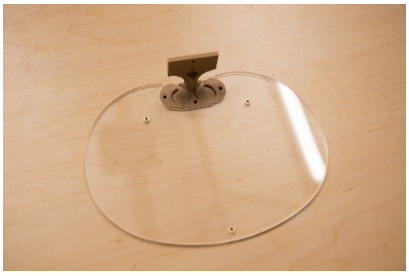
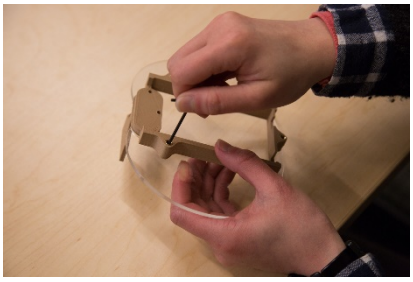
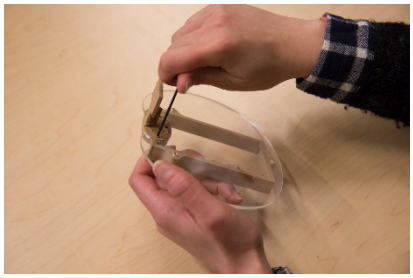
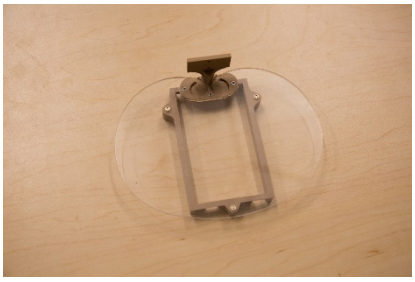


1.	1x Acrylic top plate	10.	1x Haply development board
2.	1x 3D printed motor stand	11.	2x plastic joints and 1x end-effector handle
3.	1x 3D printed motor housing	12.	2x Dev board extension wiring
4.	1x 3D printed development board housing	13.	11 x 2-56x ¼ Inch screws and 6x #2 washers
5.	1x Acrylic bottom plate	14.	4x M2/ 5 mm screws
6.	2x Motors	15.	1x Wire adapter board
7.	4x Acrylic motor linkages	16.	1x micro USB cable
8.	4x Suction cup feet	17.	1x Power supply
9.	2x Aluminum motor hubs		

DEVICE ASSEMBLY

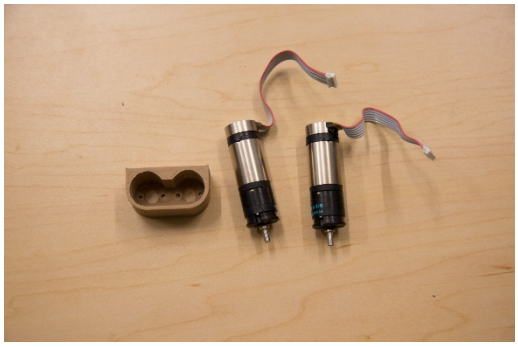
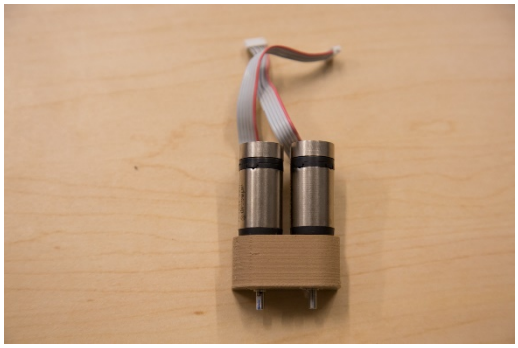
This section provides a step by step guide on how to assemble the Haply 2-D device

PART A: BASE ASSEMBLY

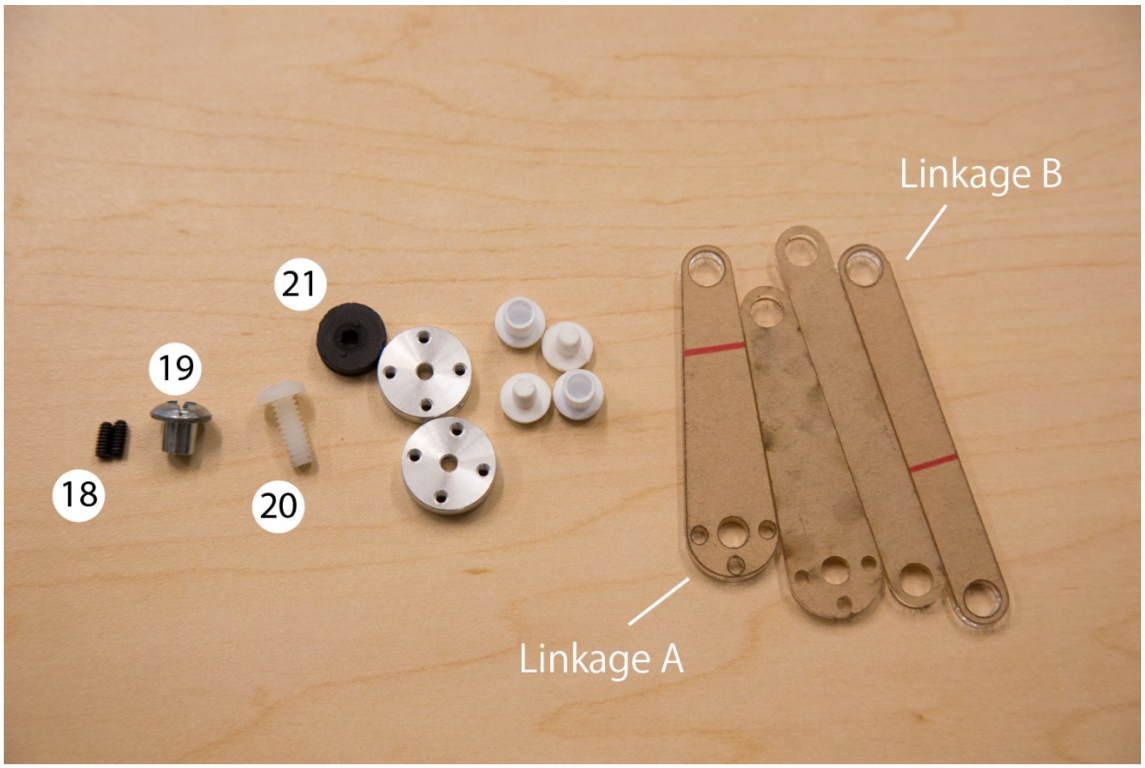







1. Peel off the protective wrapping paper from the acrylic top plate (item 1)
2. Fix the motor stand (item 2) onto the top plate. No screws are requited yet.
3. Screw the bottom board housing (item 4) to the plate.
4. Screw the top stand to the bottom board housing.

PART B: MOTORS AND LINKAGES ASSEMBLY

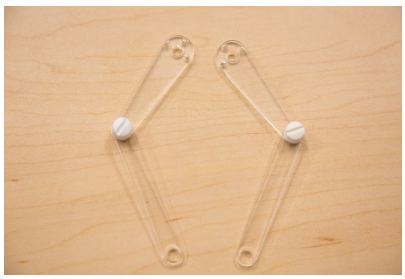
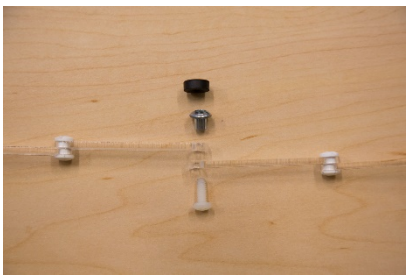
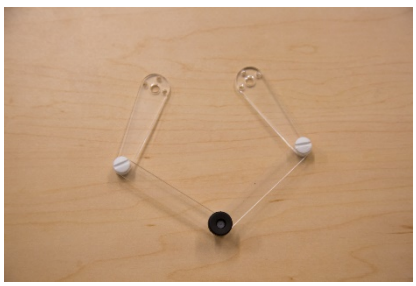
1. Insert the motors (item 6) into the motor housing (item 3). Make sure the motors are pushed all the way to the bottom.
2. Align the holes from the motor housing with the screw holes on the motors and use four M2/5mm (item 14) screws to fix the motors to the motor housing.



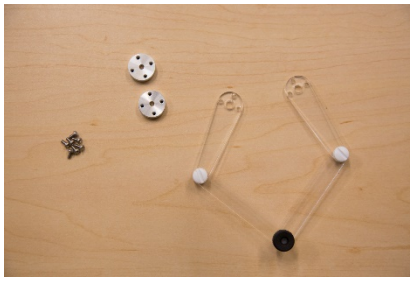
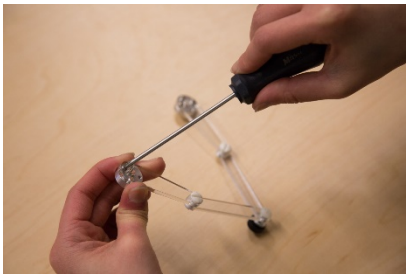
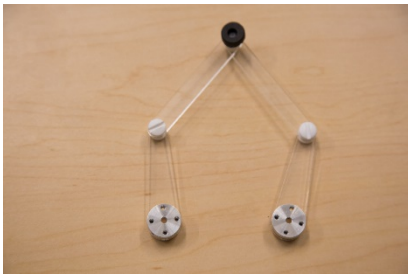


3. Peel off the protective wrapping paper from the motor linkages (item 7).
4. Connect linkage A with linkage B using the white linkage joints (item 11). The smaller side of linkage A are aligned to joint.

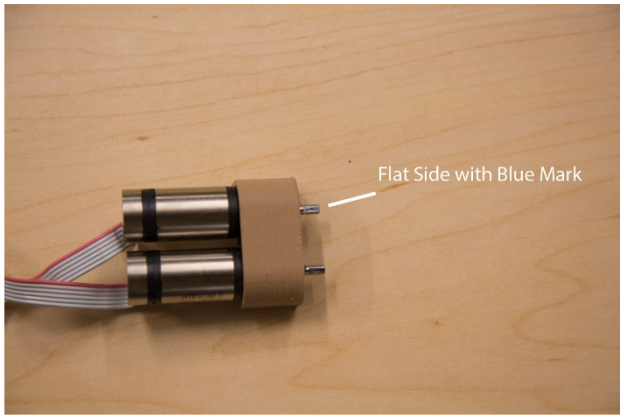
   ***Caution**: test the size of the hole on linkage B using the ¼ inch threaded metal insert (item 19), if the hole fits the metal screw cap, then use the other side to joint.

5. Connect two linkages to create the handle or end-effector using the threaded metal insert (item 19), the acrylic linkages (item 20) and the rubber ring (item 21). The rubber ring will be a bit of a tight fit so we recommend holding the rubber just above the thread metal insert and screw in the nylon bolt into the hole on the black rubber ring. You can use locktite, or some other form of thread glue to prevent loosening of the joints.

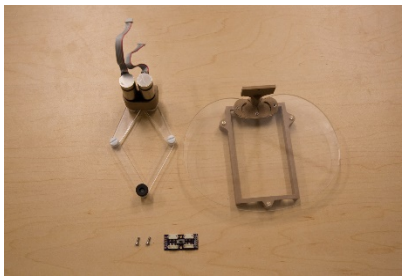
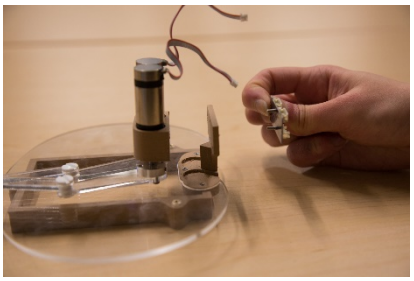
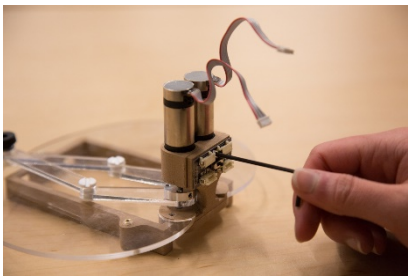




6. Screw the motor hubs (item 9) to the linkages using the 2-56 ¼" screws (item 13)



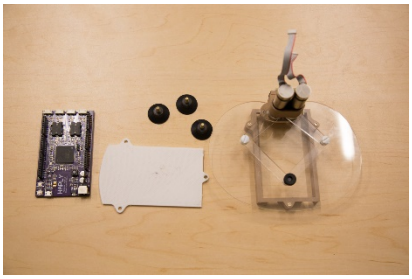
7. Align the set screw hole of the motor hub to the flat portion on the motor shaft before attaching the motor hub onto the motors.
8. Leave a certain space between the motor and the hub, adjust the spacing so that all end points of the linkage arms lightly touches the base plate and align both hubs to be at the same height.
9. Insert and screw the black set screws (item 18) into the motor hubs to attach the motor hubs to the motor shaft. You can use locktite, or other thread glue to prevent loosening of the joints.

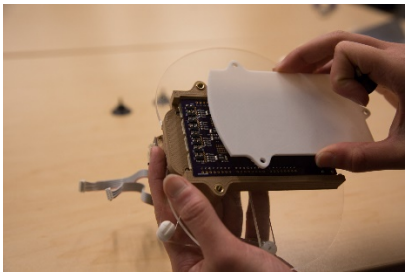
   ***Warning**: sometimes this screw can become loose with usage. This is an incredibly annoying bug to solve as the motor will freely rotate inside of the motor hub. One of the arms will appear to stop working as movement of the device will not cause the encoder to pick up any movement. Make sure these set screws are tightened properly.

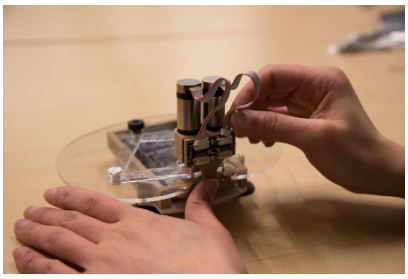
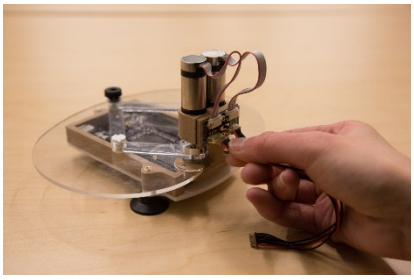
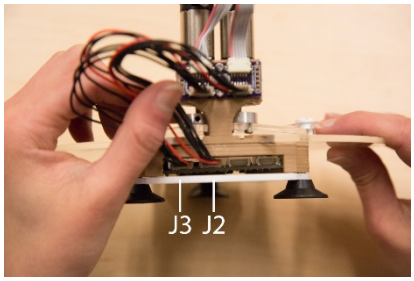
10. Make sure the round part of the motor housing is facing forward as seen above.
11. Make sure the orientation of the Wire Adapter Board (item 15) is correct. The two side mounted ports are facing the upward direction (The “M+” label on the edge of the board should be on top).
12. Screw the adapter board and the motor housing together onto the stand.

PART C: HAPLY DEVELOPMENT BOARD FITTING



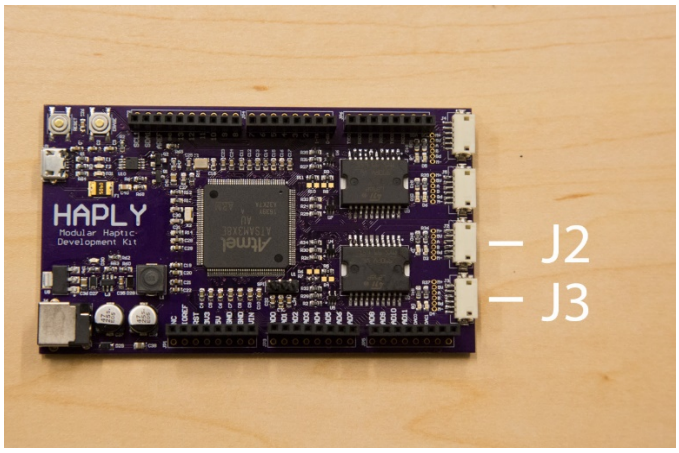


1. Place the Haply Development Board (item 10) in the board housing. Make sure that all sides are aligned with their respective openings, motor port for motor port opening, USB and Power ports to their respective openings.
2. Screw the bottom plate (item 5) to the board housing using the suction cut feet (item 8).

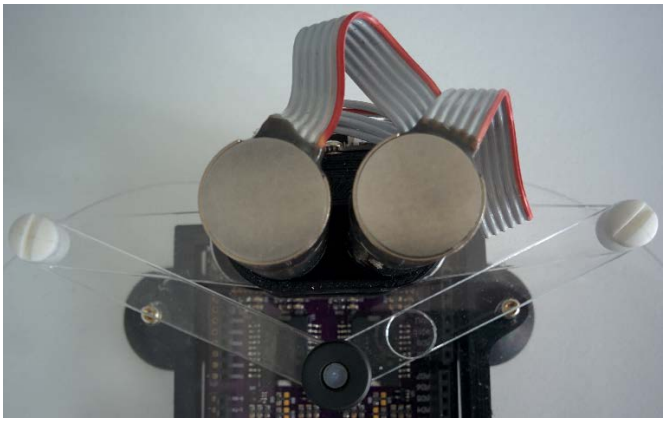




3. Connect the wires of the motor to the top two ports on the wire adaptor board. Gently wiggle the connectors into the adapter board if they are tough to connect. If you plan on using the encoders that are built into the motor, ensure that the slide switch on the adapter board is positioned on the side labeled “en” for encoders.

   ***Caution**: The adapter board wire ports can be a bit delicate.



4. Connect the two dev board extension wiring (item 12) from the bottom two ports of the wire adapter board to J2, J3 ports on the Haply development board.
5. Using super-glue, glue the circular cutout onto the lower height arm ~1.5cm from the end-effector know. This will prevent the device from moving into undesirable configurations called singularities.



Now your device is ready to be plugged in for use!