

Haplink 2.0 Assembly Instructions

Version 10.05.2017



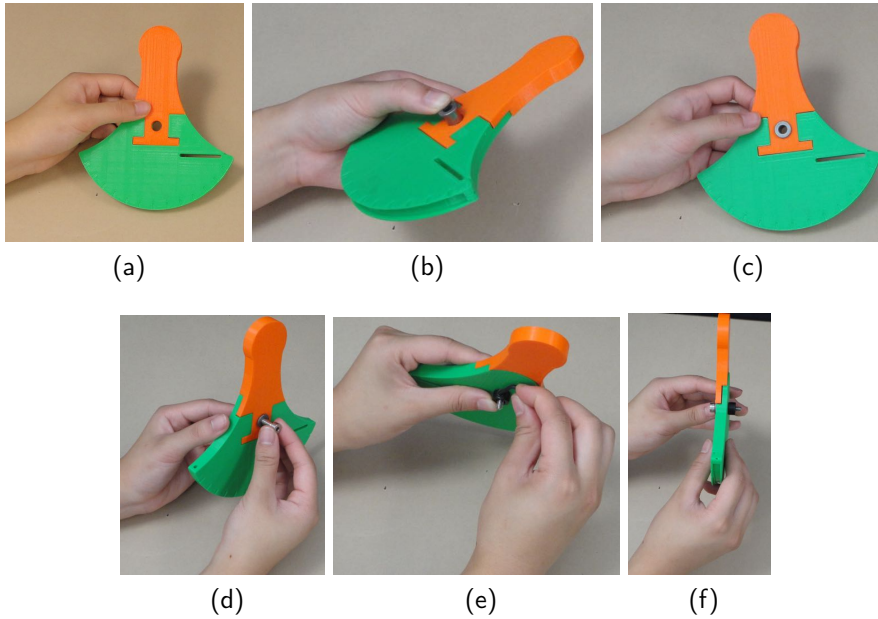
(a)

(b)

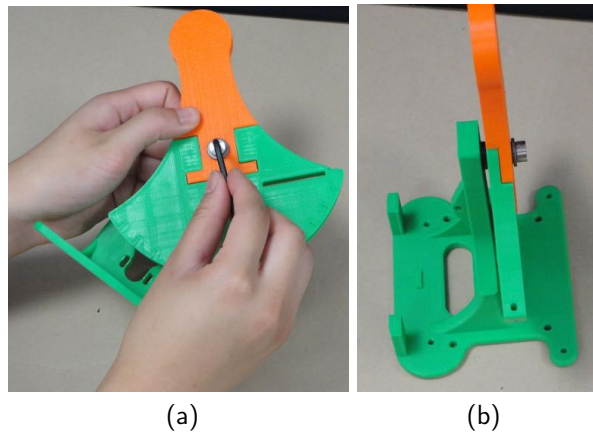
(c)

Haplink 2.0 is composed of one Hapkit (one-degree-of-freedom) with additional components attached to it to transform it into a two-degree-of-freedom device. In this assembly document, we will first assemble a Hapkit, and then we will transform it into a Haplink.

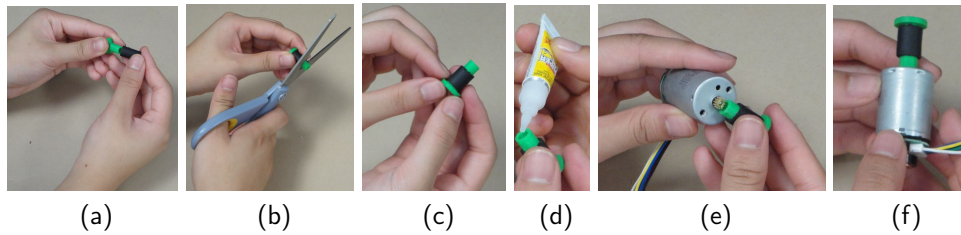
1. **Obtain the Haplink Components:** Consult the parts list provided on the website.
2. **Use a 3-D printer to create the 3-D printed parts.** The STL files for all the 3-D printed components you need to create Haplink are on the Hapkit website. The CAD files are also available. We recommend that you not modify the dimensions of the device in order to keep the kinematic and dynamic properties. But we encourage you to add your own design to the device. We especially encourage you to design your own handle for Hapkit.
3. **Assemble sector pulley.** (a) Press circle handle into a sector. Due to the tolerance of the 3-D printer it may be a little tight or loose. In the case that it is too loose, please use super glue to attach it. (b)-(c) With the sector pulley with the handle now press fitted into it laying flat on the table, insert the bearing into the through hole. Again here the fit may be a little tight or loose. In the case that it is tight you may use a light hammer to press it in. If it is too loose, you should add some glue to make a better attachment. It is important that the sector plus handle assembly not be able to move with respect to the bearing. (d) Insert the shoulder screw into the bearing. It should turn freely in the bearing. (e) Place the shaft collar over the shoulder screw and use the 3/32" hex key (allen wrench) to securely attach the shaft collar to the bolt part of the shoulder screw. (f) After assembly, you should be able to hold onto the screw part of the shoulder screw and freely swing the sector pulley around the bearing.



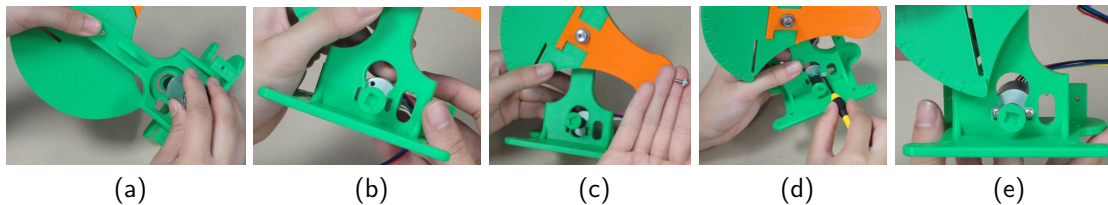
4. **Attach sector pulley to base.** (a)-(b) Place the shoulder screw (on the Sector Pulley assembly) into the hole on the base piece. Use the 1/8" hex key (allen wrench) to screw the shoulder screw into the hole. You will be tapping (creating threads in the plastic of the hole) as you screw it in, so be sure to make the screw go in as straight as possible. You need to screw it until a secure attachment is made. If this is the first time you are tapping threads, stop once the cross in the hole of the base is broken.



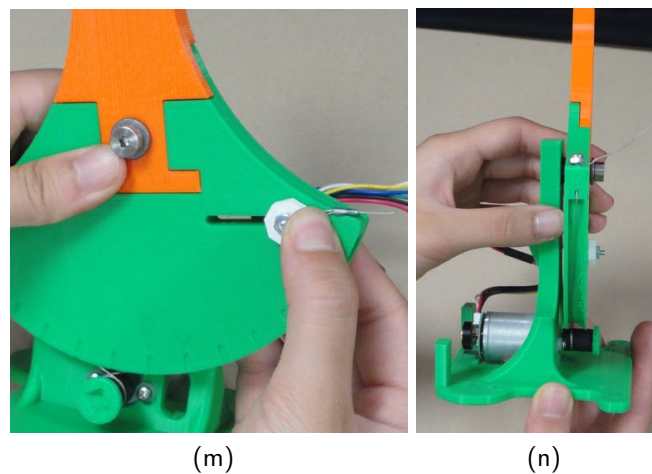
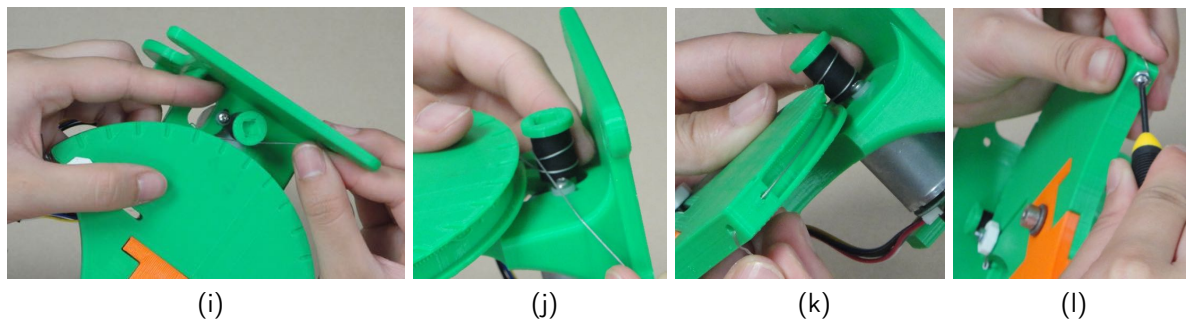
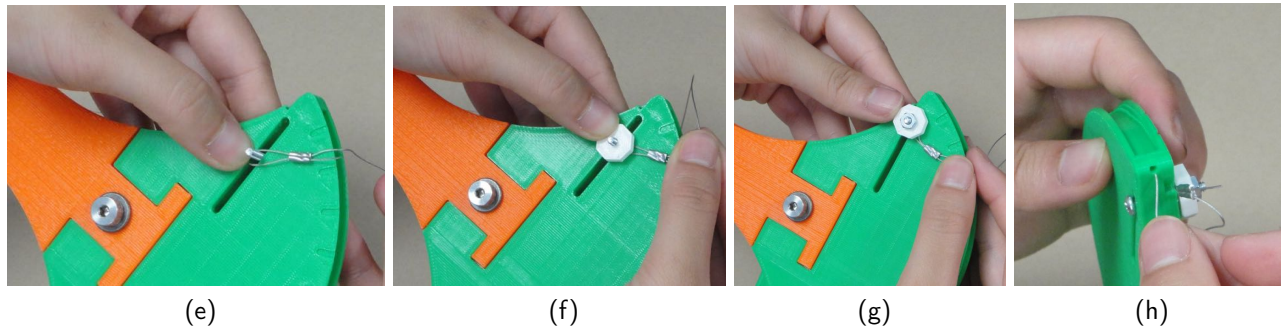
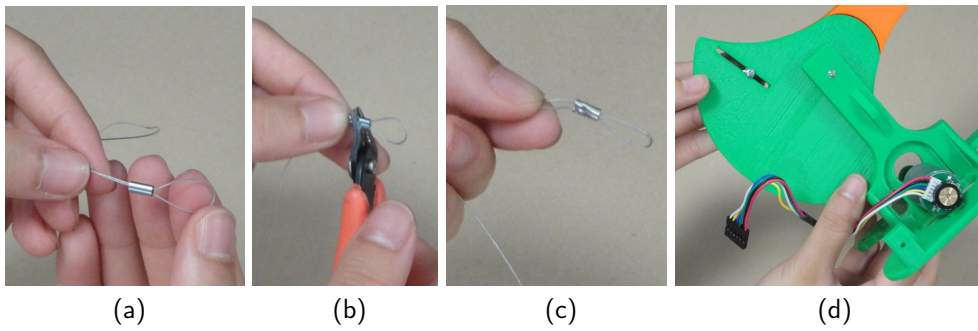
5. **Assemble your motor.** (a) Cut a piece of rubber tube and fit it on the drive wheel all the way to the end. (b)-(c) Make sure there is a portion of the driver wheel's plastic still showing. You only need about 1 cm of tube on the drive wheel, if you put on too much on, you can cut some off using scissors. (d) Put some super glue in the drive wheel (NOT TOO MUCH! A drop is enough!) and (e)-(f) attach it to the motor. After the glue dries, make sure you can rotate the drive wheel and that rotating the drive wheel rotates the rotor of the motor.



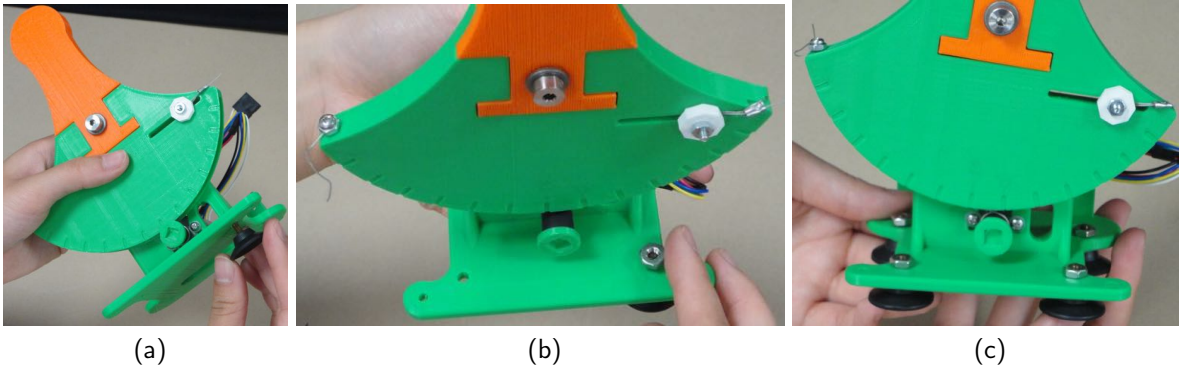
6. **Attach your motor to the base.** For this step you will need two 4-40 screws of length $3/8$ " and two washers. (a)-(e) Place motor at the bottom of the base and screw in place as pictured. If the sector is in the way, rotate the handle until you have easy access to the bottom of the base. Try to place the motor as far forward as possible on the slots (you may need to adjust a little later). Test the motor by gently turning the drive wheel with your fingers to ensure it's properly installed. If the wheel doesn't turn freely, make sure the washers are between the screw and the base, and that the neoprene is not rubbing against the washers and screws.



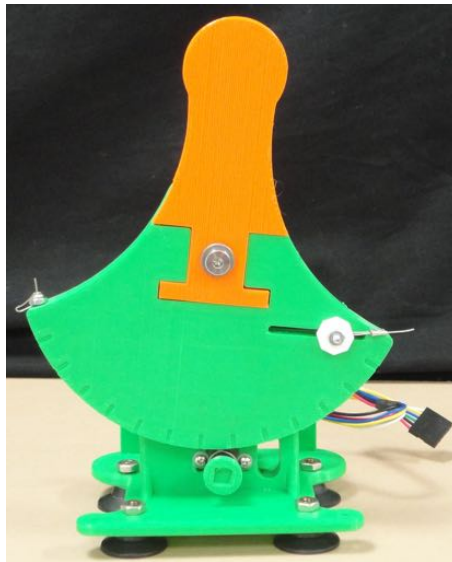
7. **Assemble cable driving system.** (a)-(c) Put one end of the cable through the compression sleeve and form a ring. Use the crimping tool to crimp the compression sleeve so that the cable can't move in the sleeve. (d)-(e) Place a 4-40 $3/4$ " screw from the back of the sector pulley through the long slot and the ring at the end of the cable. (f)-(g) Put the 3-D printed tightening washer and a 4-40 nut on top and tighten it. (h) Put the other end of the cable through the small hole on the bottom left corner of the sector pulley. (i)-(j) Pull the cable along the sector pulley and around the drive wheel for 2 to 3 loops. **Note that it is important to loop under the drive wheel and then around.** (k)-(l) Pull the end of the cable through the hole on the other end of the sector pulley. Screw the 4-40 $1/2$ " screw with a nut into the hole to fasten the cable. (m) Loosen the 3-D printed washer a little and push it as far forward on the slot as it will go. Tighten the washer again. This will tighten the cable drive. (n) Check your cable drive for any crossings of the cable, if there are, you can try to fix them with a screw driver. *Note: This step is quite difficult for novices. Please be patient and remember you can always reference Hapkit 3.0 assembly instructions for more tips.*



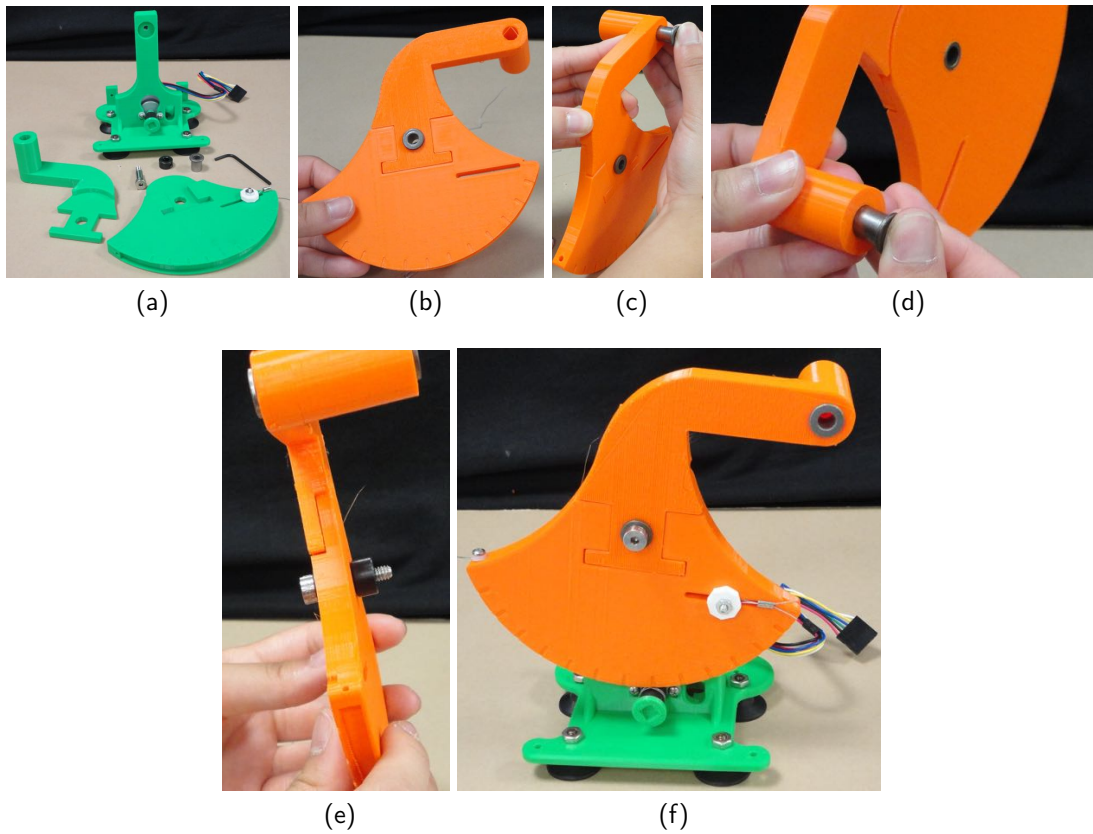
8. **Attach the suction cups to the base** (a) Put the suction cups through the 4 holes at the feet of the base. (b) Use 11/32" nuts on the threads of the suction cups to fasten them. (c)-(e) check that you placed them in the correct orientation.



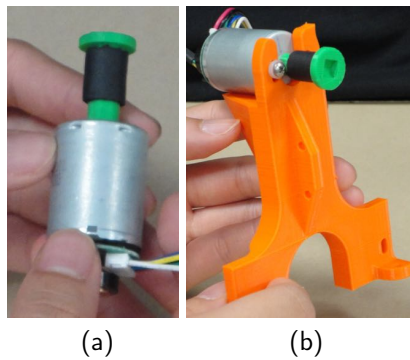
The mechanical assembly of your Hapkit (one-degree-of-freedom) is now complete. You should render different 1-DOF virtual environments and then move on to assemble a Haplink!



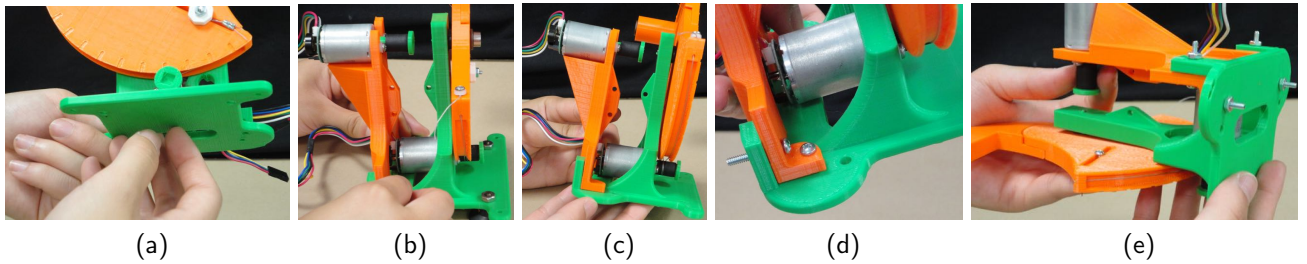
9. **Disassemble the Hapkit Sector and reassemble it using Handle A.** (a) Unwind the cable driving system, keeping the washer/tightening side intact for later use. Remove the sector pulley from the base. Disassemble the sector pulley completely, as pictured. (*You will eventually also remove the suction cups from the bottom of the base, but we will keep them on for now as they aid a little during the assembly process*). For Haplink, you will need to replace the circle handle with handle A. (b) Assemble the sector pulley with handle A instead of the circle handle (you can refer to Step 3, if you need more help). (c)-(d) Attach bearings to both ends of handle A. (e) Attach the shoulder screw and shaft collar as seen on Step 3. (f) Attach the new Sector Pulley assembly to the base as seen on Step 4 and rewind the cable drive system. (*All steps are identical as before except we are now using handle A*)



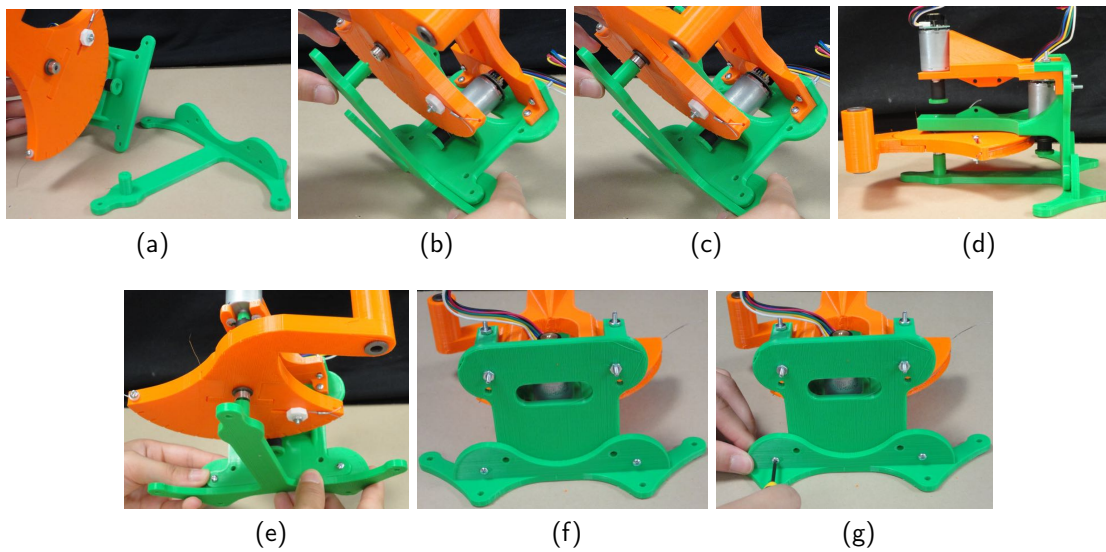
10. **Assemble second motor and attach to motor holding base.** (a) Refer to Step 5 to attach a second drive wheel to the second motor. (b) Attach the motor to the motor holding base by placing the motor at the top of it and securing it into place as in Step 6.



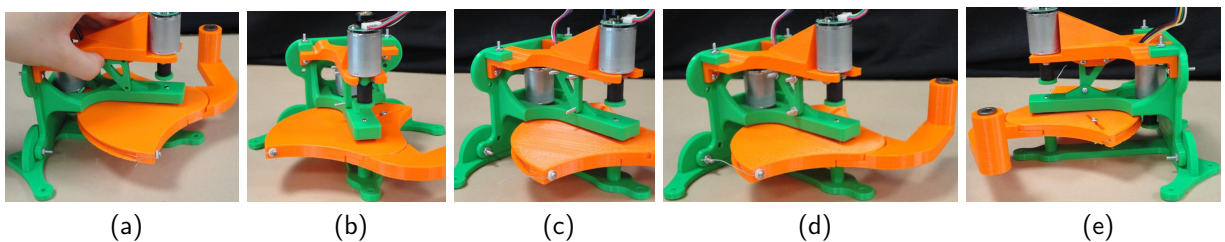
11. **Attach motor holder to the Hapkit Base.** (a) Remove the suction cups from the Hapkit Base (b)-(c) Line up the motor holder with the Hapkit Base as pictured. (d) Insert screws such that the ends are accessible from the outside of the base. (e) Attach 4-40 hex nuts to the end of the screws.



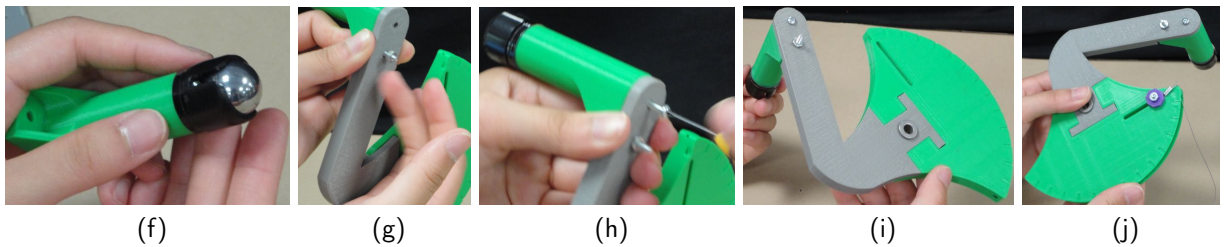
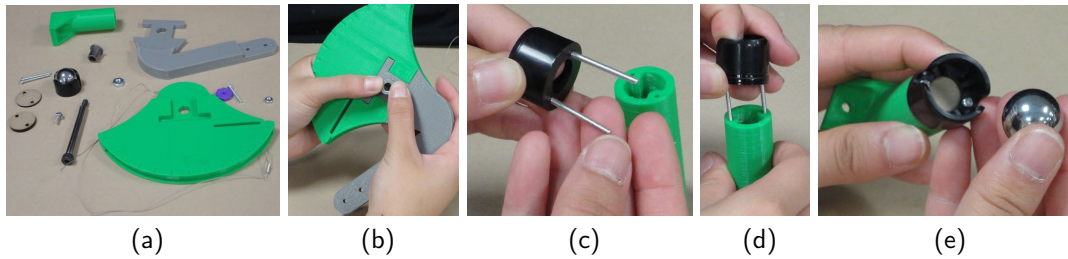
12. **Attach assembly to bottom base.** (a) Turn the Hapkit assembly on its side, such that the longer side of the Hapkit base is on the bottom. (b) Place the assembly on the bottom base. (c)-(d) Be sure to align the middle post with the bearings of the first sector pulley assembly. (d)-(g) Screw into place with 4-40 screws.



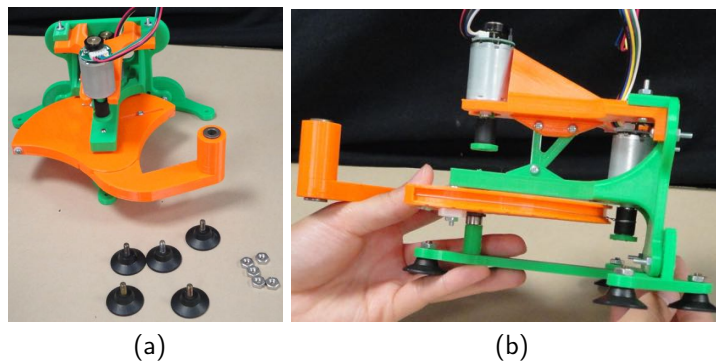
13. **Attach triangular support.** (a) Be sure to align the triangular support on the **LEFT** side of the contacts when looking down on the assembly. **This will be crucial to the device's functioning.** (b)-(c) Insert three 4-40 screws as pictured. Again, the direction in which you insert the screws is crucial. Remember that anything that sticks out on the device should be in the opposite side to Handle A. (d)-(e) Attach hex nuts to the end of each screw and tighten.



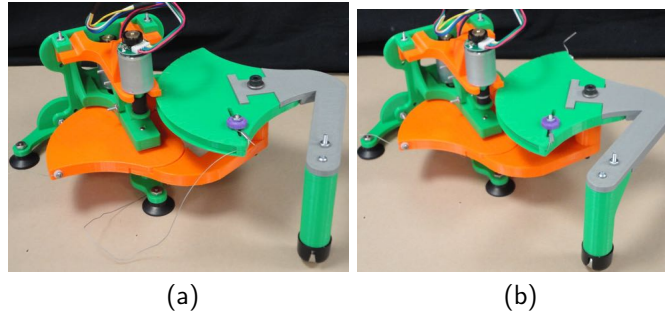
14. **Assemble sector pulley B.** (a)-(b) Assemble the sector pulley in the same way as you did previously, this time with the handle B in the place of handle A. (c)-(d) Assemble the handle post by first attaching the ball caster without the metal ball using the longer screws included with it. You may need to include 1 or 2 of the spacers included with the ball caster kit depending on the assembly of your Haplink. (e)-(f) insert the metal ball into the ball caster. (g)-(i) Attach the handle post to handle B using the two screw holes. Make sure to attach a nut to the screw that sticks out of the assembly. (j) Attach the cable drive wire and nut and have it ready for assembling the drive.



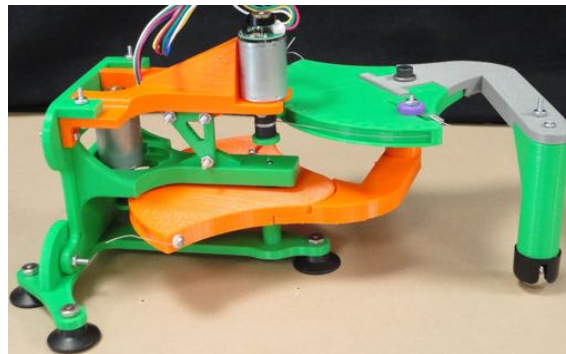
15. **Attach suction cups to bottom base.** Attach five suction cups to the bottom base, as pictured.



16. **Attach second sector pulley and assemble second cable driving system.** (a) Place sector pulley B on top of the end of handle A as pictured. Note that the handle post should be pointing towards the bottom, not the top, of the assembly. (b) Place the long shoulder screw through the aligned holes. (c) Attach the largest hex nut to the bottom of the shoulder screw.



17. **Final Adjustments.** Depending on the construction of your device, you may need to adjust the number of spacers on your handle post. (a) Check to make sure that all sectors are as parallel as possible to the table. Measure on your own device how many spacers are necessary for the handle to rest parallel as well. If necessary, remove the handle post and ball bearing, adjust the number of spacers so everything is as parallel as possible, and re-attach it to your device.



Congrats! The mechanical assembly of your Haplink is complete. You should download different 2-D virtual environments and see how it feels!