# Hapkit Assembly Instructions
3-D printed, capstan drive version 11.11.15

1. **Obtain the Hapkit components.** Consult the parts list provided, and contact CAs for the parts you don't already have on hand. Tools will be provided in the lab space.

2. **Use a 3-D printer to create the 3-D printed parts.** The base, the sector pulley, the Drive Wheel and the Octagon. The STL files for the parts are available on the Hapkit website. The CAD files for these parts are also available in case you want to customize them. We recommend that you experiment and customize your handle.

3. **Attach the motor to the base.** (a) Place the motor in the base by pushing the motor shaft through the hole as shown below. (b) Use two 4-40 screws with length 3/8" (*not* the longer screws!) with washers on either side of the motor to secure the motor in place. The height of the motor/screws in the slots doesn't matter much; the slots just make it easier to place the screws. It is easiest to get the second screw in if you don't tighten the first screw all the way. Once both screws have purchase, then tighten them.

(a)   (b)
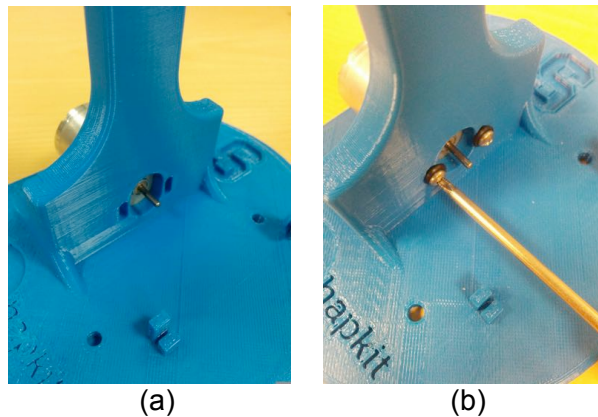
4. **Assemble the motor and drive wheel.** (a) Insert the 3D-printed drive wheel into the neoprene tube. If your drive wheel is loose within the neoprene, you can use superglue here. (This isn't necessary for most parts, but it may happen due to the tolerance of the 3D-printed parts.) (b) Then place superglue into the magnet holder end of the 3D-printed drive wheel, and insert the magnet. Let dry. When the motor shaft rotates, the cylinder-shaped magnet should rotate about an axis perpendicular to the cylindrical axis of the magnet (c) Apply a small amount of superglue on the motor shaft (d) and then slip the drive wheel over the motor shaft. (d) Let dry for a few minutes.

(a)   (b)   (c)   (d)   (e)
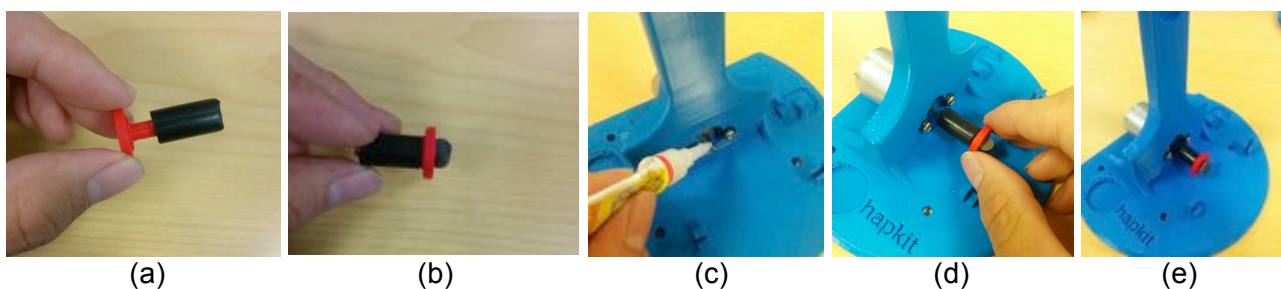
5. **Assemble the sector pulley.** (a) Press to fit your custom-designed handle into the sector pulley. Again, due to the tolerance of the 3D printer, it might be a little loose. You can apply some superglue in this case. (b) With the sector pulley laying flat on the table, insert the bearing into the hole. Press it in so the flange makes solid contact with the sector pulley surface.

(a)   (b)
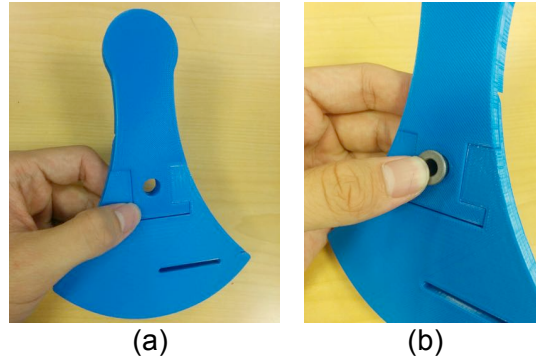
(c) Insert the shoulder screw into the bearing. It should turn freely in the bearing. (d) Place the shaft collar over the shoulder screw and (e) use the 3/32" hex key (allen wrench) to securely attach the shaft collar to the bolt (not screw) part of the shoulder screw. (f) After assembly, you should be able to hold onto the screw part of the shoulder screw and freely swing the sector pulley around the bearing.


(c)   (d)   (e)   (f)
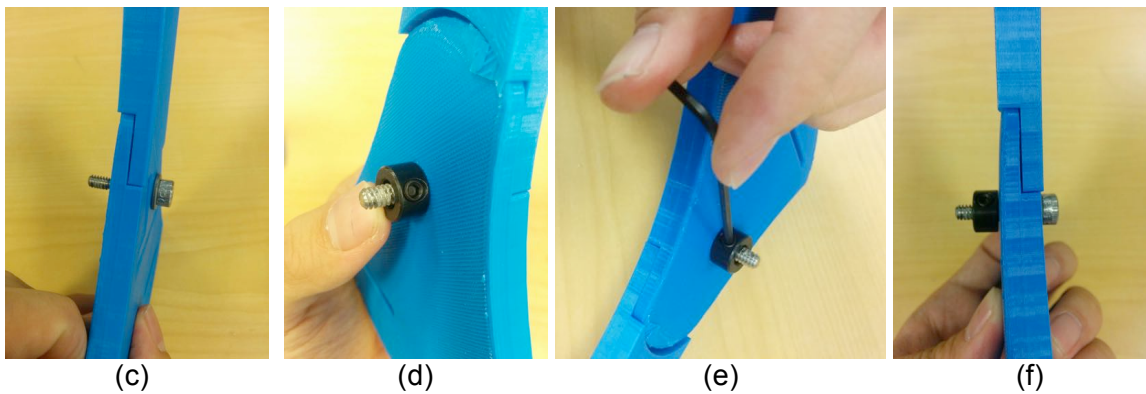
6. **Attach the sector pulley to the base.** (a) Place the shoulder screw (on the sector pulley assembly) into the hole on the base piece. Use the 1/8" hex key (allen wrench) to screw the shoulder screw into the hole on the height adjustment bar. You will be tapping (creating threads in the plastic of the hole) as you screw it in, so be sure to make the screw go in as straight as possible. (b) You need to screw it until a secure attachment is made. As the shoulder screw is screwed in, it will break the little plastic cross on the back of the base.


(a)   (b)
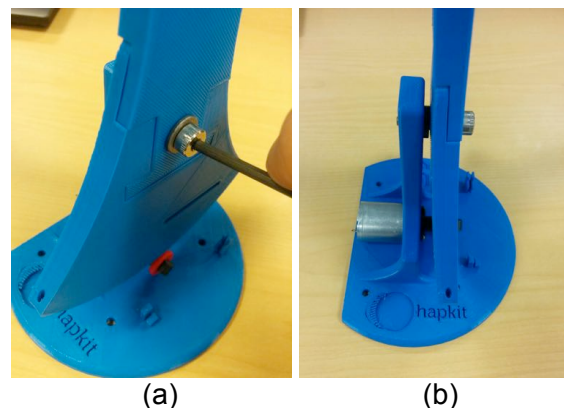
7. **Assemble the cable driving system.** (a) Put one end of the cable through the compression sleeve and form a ring. (b) Use the crimping tool to crimp the compression sleeve so that the cable can't move

in the sleeve. (c) Put the other end of the cable through the small hole on the bottom right corner of the sector pulley (when the front side of the sector pulley is facing you). (d) Place the 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. (e) Put the 3D printed tightening washer and a 4-40 nut on top and tighten it.

(a)   (b)   (c)   (d)   (e)
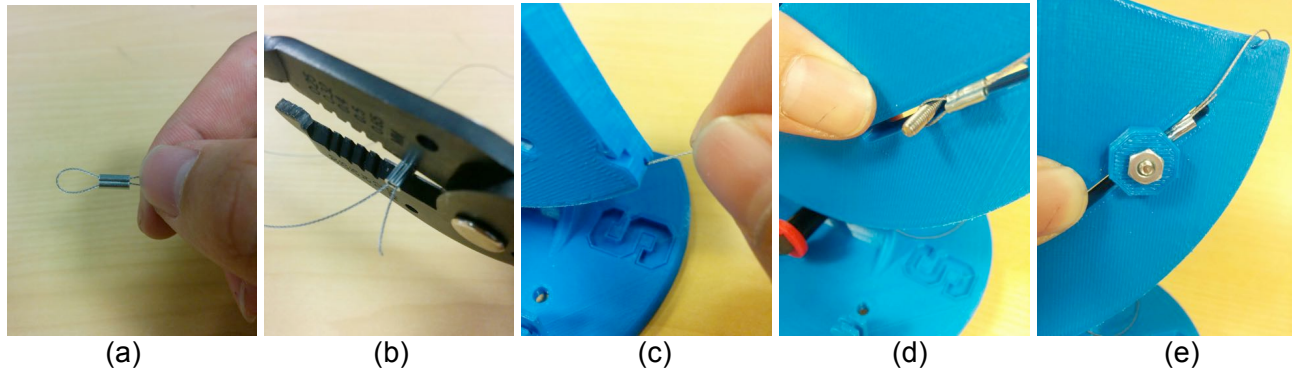
(f) Put a 4-40 nut on the 4-40 1/2'' screw. (g) Pull the cable along the sector pulley and around the drive wheel for **3 loops**. Note that it is important to loop **counterclockwise** rather than clockwise around the drive wheel. (This step could be very hard for people with no experience with cable driven systems, be patient and ask for others' help). (h) Pull the end of the cable through the hole on the other end of the sector pulley. (i) Screw the 4-40 1/2'' screw with nut in to the hole to fasten the cable.

(f)   (g)   (h)   (i)
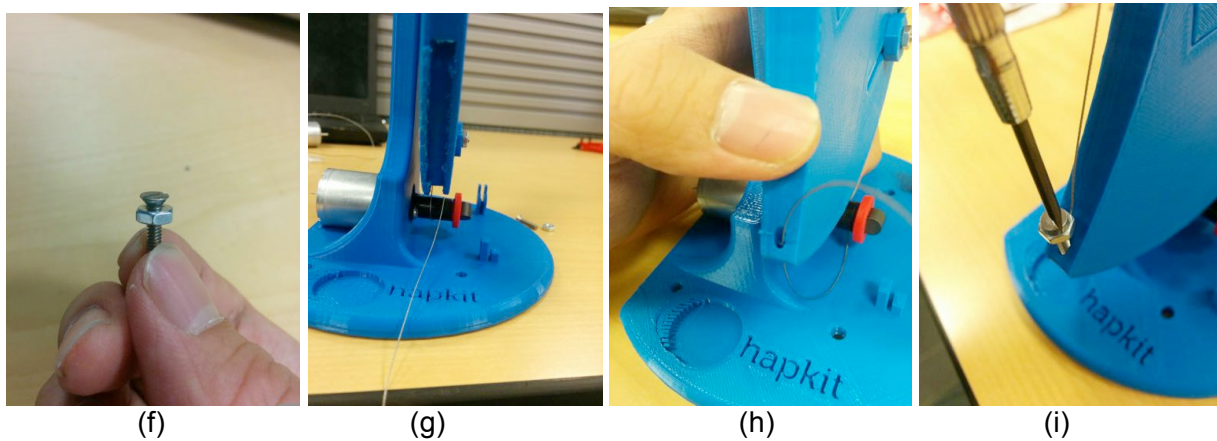
(j) Tightening the cable by adjusting the position of the 3D printed tightening washer along the slot. (k) Adjust the position of the cable around the drive wheel so that the 3 loops won't cross over each other when rotating. (l) Adjust the position of the tightening washer again to make sure the cable is tight enough and the sector pulley can rotate smoothly.
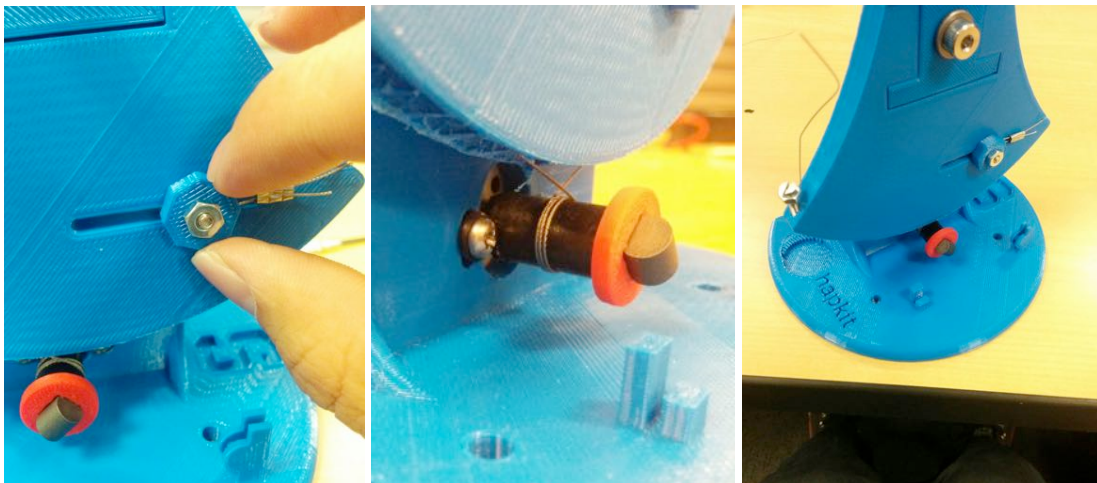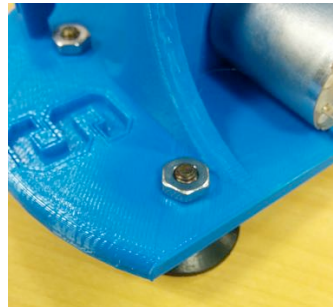
8. **Assemble the suction cups**. (a) Put the suction cups through the holes on the bottom of hapkit. (b) Put 11/32'' nuts on the threads of the suction cups to fasten them.


(a)   (b)

9. **Solder the magnetoresistive (MR) sensor to the Hapkit board.** (a) There is an outline for where the MR sensor should be placed on the Hapkit board. Place the sensor over the outline, such that the side of the sensor with the writing faces outward. Then tilt the sensor up 90 degrees and place the leads all the way into the holes on the Hapkit board. Fold the sensor down to bend the leads and lay the sensor flat against the board (over the outline). Do this only once, or the leads may fatigue and break. (b) Solder each of the 3 leads of the sensor to the board. (You can find soldering tutorials, such as: http://www.instructables.com/id/How-to-solder/step4/Soldering-components-onto-a-circuit-board/.)
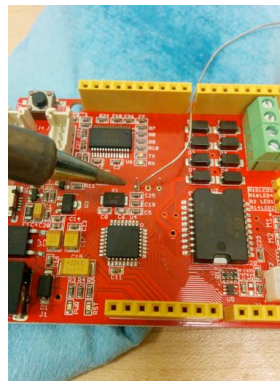

(a)   (b)

10. **Attach the Hapkit board to the 3D-printed base and connect to motor.** (a) There are two fixtures on the 3D printed base to fit the Hapkit board. Place the board on the fixtures as shown below. (b) Cut the wire with alligator clips in half, using wire stripper to strip the end of wires. (c) Use the screwdriver to unscrew the top two terminals on the right side of the Hapkit board. This will open up holes on the right side of the terminal block so you can insert the stripped wire end of the motor leads. Insert a lead into each hole. Twist the leads to get them into the holes, then tighten the terminals. (d) Attach the alligator clips on the other ends of the leads to the motor. The lead that is attached to the *top* terminal screw (labeled M+ on the other side of the Hapkit board) should connect to the lead on the motor with the red dot near it.
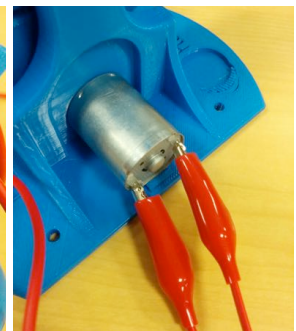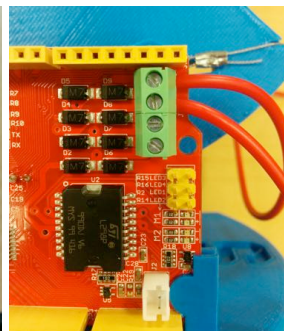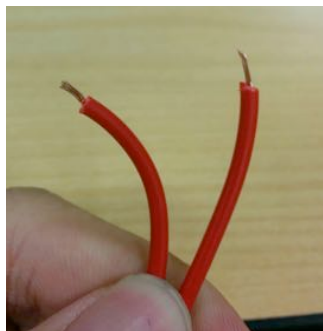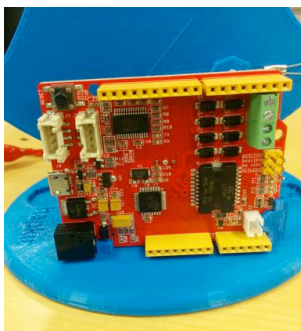
(a)   (b)   (c)   (d)

11. **Final electronic connections.** (a) Insert the "micro" end of the USB cable to the connector on the Hapkit board. Hold on to the board with your other hand while you do this. Be very careful during insertion and removal of the USB cable, since (depending on where you get your USB cable), it can be a very tight fit. Warning: It is possible to yank the USB connector off the Hapkit board! (b) Insert the power supply cable (coaxial connector) into the corresponding connector on the Hapkit board.
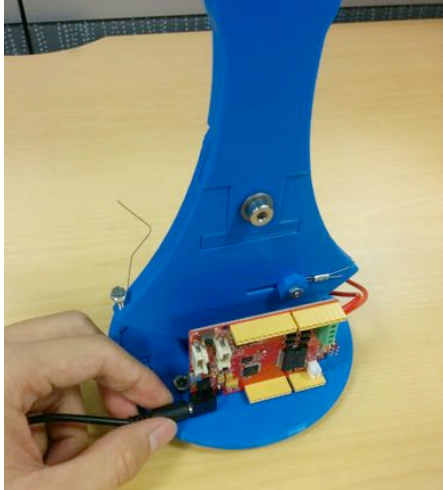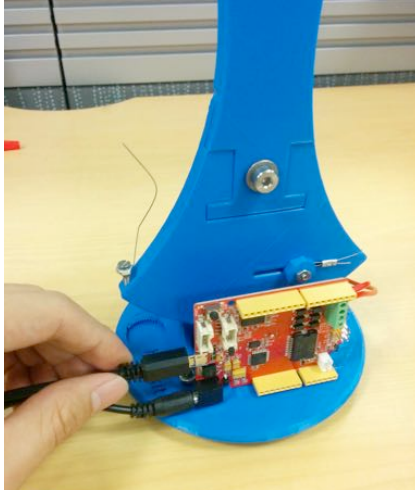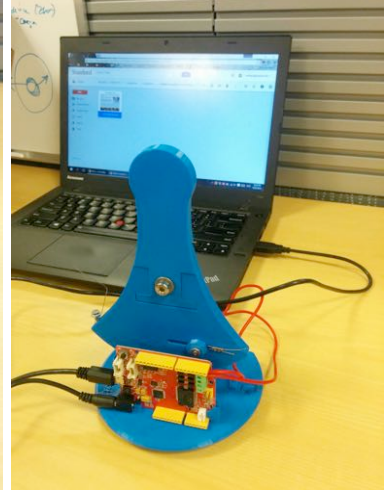
(a)   (b)   (c)

(c) When you plug the other end of the USB connector into your computer, you should see a green light on your Hapkit board. This tells you that the basic power functions of the Hapkit board are working. (You do not need to plug the power supply into the wall until you want to use the motor, so to avoid unintended motor commands, we suggest you wait to power the motor until you are ready to test it.)

Congratulations – you have successfully assembled your Hapkit. Now you can start programming!