



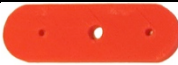





# Hapkit (3D Printed) Parts List









version 10.01.14







In order to make your Hapkit, you will need to gather (or make) all the parts shown in the table below and (as a group) in the picture at right.

The total cost of the Hapkit will likely range in price from \$50 to \$100, depending on where you get the parts, shipping costs, and what resources you have at hand. We provide online resources for purchasing most parts, although in many cases you can substitute with parts found at your local hardware store. (Many parts purchased online can only be found in bulk, but you may be able to buy parts individually at a local store.) If you are new to building mechatronic devices, we suggest that you purchase the specifically recommended items as much as possible.











Component	Photo (not to scale)	Quantity	How to get this part	Approximate cost per Hapkit
3D printed base		1	<p>These parts are 3D printed using the files available at <a href="http://hapkit.stanford.edu/build.html">http://hapkit.stanford.edu/build.html</a>. See the 3D printing tips in the Assembly document for more information.</p> <p>We have successfully built these parts using several commercially available consumer-type 3D printers, including the Makerbot Replicator 2, Printbot, and Up.</p>	<p>Cost of PLA (thermoplastic used in the Makerbot) to print all these parts is approximately \$10. The total weight of plastic used is about 100 grams.</p> <p>If you don't have direct access to a 3D printer, see the 3D printing tips document on the Hapkit website.</p>
3D printed sector pulley		1		
3D printed height adjustment bar		1		
3D printed drive wheel/magnet holder		1		
Wingnuts (for height adjustment) size 4-40 (size 4 bolt with 40 threads per inch)		2	<p>McMaster-Carr (<a href="http://www.mcmaster.com">http://www.mcmaster.com</a>) sells in packs of 100: part number 98143A005</p>	\$12.29 per pack of 100 (\$0.24 for two), not including shipping
Screws (for height adjustment) size 4-40, at least 3/4" length		2	<p>McMaster-Carr (<a href="http://www.mcmaster.com">http://www.mcmaster.com</a>) sells in packs of 100: part number 91781A113</p>	\$4.75 per pack of 100 (\$0.10 for two), not including shipping
Neoprene strip with thickness 1/8", width 1/4", and length approximately 6", ideally with adhesive backing.		1	<p>McMaster-Carr (<a href="http://www.mcmaster.com">http://www.mcmaster.com</a>) smallest size available is a 6"x6" sheet that can be cut into smaller pieces with a knife: part number 8463K22 to 8463K42</p>	\$9.79 for a 6"x6" piece with adhesive backing (about \$0.50 per strip), not including shipping
Neoprene tubing, 3/16" inner diameter, 3/8" outer diameter, cut to 3/4" length		1	<p>We purchased a very long tube from Small Parts via Amazon (<a href="http://www.amazon.com">http://www.amazon.com</a>): part number B008BWPM8Y</p> <p>Note: You can adjust the size of your 3D printed parts to accommodate a different size neoprene tube.</p>	<p>\$14.42 for a 50'-long tube (\$0.22 per piece), not including shipping</p> <p>We have also found this at a local hardware store for \$2.00 per foot.</p>

Component	Photo (not to scale)	Quantity	How to get this part	Approximate cost per Hapkit
Bearing: SAE 863 bronze flanged-sleeve bearing for 1/4" shaft diameter, with 3/8" outer diameter, 1/4" length, and 1/2" flange outer diameter		1	McMaster-Carr ( <a href="http://www.mcmaster.com">http://www.mcmaster.com</a> ): part number 2938T1	\$0.49 for one bearing, not including shipping
Self-locking shoulder screw: alloy steel thread-locking shoulder screw, 1/4" diameter x 1/2" long shoulder, 10-24 thread		1	McMaster-Carr ( <a href="http://www.mcmaster.com">http://www.mcmaster.com</a> ): part number 91264A242	\$1.81 for one shoulder screw, not including shipping
Shaft collar: set screw shaft collar for 1/4" diameter rod, black-oxide steel		1	McMaster-Carr ( <a href="http://www.mcmaster.com">http://www.mcmaster.com</a> ): part number 9414T6	\$0.92 for one shaft collar, not including shipping
4-40 screws with length 3/8" for mounting motor and Hapkit board to 3D printed base (18-8 Stainless Steel Flat Head Slotted Machine Screw, 4-40 Thread, 3/8" Length)		5 (2 are for motor, 3 are for Hapkit board)	McMaster-Carr ( <a href="http://www.mcmaster.com">http://www.mcmaster.com</a> ) sells in packs of 100: part number 91781A110	\$4.36 per pack of 100 (\$0.22 for five), not including shipping
4-40 nuts for mounting Hapkit board to 3D printed base (Zinc-Plated Steel Machine Screw Hex Nut, 4-40 Thread Size, 1/4" Width, 3/32" Height)		3	McMaster-Carr ( <a href="http://www.mcmaster.com">http://www.mcmaster.com</a> ) sells in packs of 100: part number 90480A005	\$0.81 per pack of 100 (\$0.03 for three), not including shipping
Motor: Mabuchi motor company, 12 Volt, 5600 RPM, shaft 0.78 diameter x 0.346 length (manufacturer's number RF370CA-15370)		1	Jameco ( <a href="http://www.jameco.com/">http://www.jameco.com/</a> ): part number 238473  Note: This motor cannot necessarily be replaced with any 12-Volt DC motor; this particular motor was selected for its balance of cost and suitability for Hapkit (size; relatively low friction, inertia, and cogging torque; reasonably high torque constant and maximum continuous torque)	\$3.49 for one motor, not including shipping
Magnet (Ultra-High-Temperature Alnico Disc Magnet, Grade 8, 1/4" Diameter, 1/4" Thick, 0.3 lbs. Maximum Pull)		1	McMaster-Carr ( <a href="http://www.mcmaster.com">http://www.mcmaster.com</a> ): part number 57295K73	\$1.87 for one magnet, not including shipping
Magnetoresistive sensor: NXP company, fully integrated single angular sensor, through-hole mounting type (manufacturer's number KMA210)		1	DigiKey ( <a href="http://digikey.com">http://digikey.com</a> ): part number 568-8399-1-ND  Note: This sensor needs to be soldered to the Hapkit board as described in the assembly instructions	\$5.18 for one sensor, not including shipping

Component	Photo (not to scale)	Quantity	How to get this part	Approximate cost per Hapkit
Hapkit board: Custom printed circuit board similar to the Arduino, but with additional circuitry for reading the magnetoresistive sensor and power amplifier for driving the motor		1	Seed Studio ( <a href="http://www.seeedstudio.com">http://www.seeedstudio.com</a> ): part number KIT04300M  Note: If you are very familiar with Arduino, sensor circuits, and motors, you can replace this board with an Arduino Uno and Ardumoto shield (with additional circuitry). However, the Hapkit board likely costs less than these items combined.	\$35.00 for one board, not including shipping  Note: As of this writing, Seeed is sold out of Hapkit boards. However, they are doing another manufacturing run, and the boards should be available in one week.
Power supply for Hapkit board: Should supply 12 V and 1 Amp. (Wall Power Adapter: 12VDC, 1A, 5.5x2.1mm Barrel Jack, Center-Positive)		1	Pololu ( <a href="http://www.pololu.com">http://www.pololu.com</a> ): part number 1466  Note: Similar items can be found from Digikey, Jameco, and other suppliers, but this is the least expensive one we have found.	\$5.95 for one power supply, not including shipping
USB cable for communication between Hapkit board and computer: (3ft USB 2.0 A Male to Micro 5pin Male 28/28AWG Cable)		1	Monoprice ( <a href="http://www.monoprice.com">http://www.monoprice.com</a> ): part number 4867  Note: Similar items can be found from other suppliers, but this is the least expensive one we have found. Also, we found that cables from some other sources did not fit as well into the female micro USB connector on the Hapkit board.	\$2.40 for one USB cable, not including shipping
Leads with alligator clips on both ends (can cut one in half to make the two cables for motor power, also keep one intact for testing circuits)		2	Mouser ( <a href="http://www.mouser.com">http://www.mouser.com</a> ): part number 835-501789  Note: These are available from many sources. You can also solder the leads to the motor instead of using alligator clips for a more permanent connection. If you solder, we suggest you use shrink tubing to protect the connection	\$4.00 for a pack of 10 leads, not including shipping
Resistor (390 Ω) used for testing Hapkit board with LED		1	Mouser ( <a href="http://www.mouser.com">http://www.mouser.com</a> ): part number 291-390-RC	\$0.10 per resistor, not including shipping
Light-emitting diode (LED) used for testing Hapkit board		1	Mouser ( <a href="http://www.mouser.com">http://www.mouser.com</a> ): part number 604-WP7113GD	\$0.14 per LED, not including shipping

## Tools

You may also find it necessary to purchase (or gain access to) the following tools to create your Hapkit. Some of these tools may already be available in your house, school, or workshop – or can be borrowed from friends!

Tool	Photo (not to scale)	How to get this tool	Approximate cost
Superglue (we suggest gel-type single use packs; you will probably only need to use it once)		Staples ( <a href="http://www.staples.com">http://www.staples.com</a> ): item 861702, model: AD119  This is available from many sources.	\$2.25 for a package of four single-use tubes, not including shipping
Utility knife (or heavy duty precision knife) for cutting Neoprene pieces		McMaster-Carr ( <a href="http://www.mcmaster.com">http://www.mcmaster.com</a> ): part number 4927A11 part number 38995A71	\$5.22 for one utility knife, \$4.41 for one precision knife, not including shipping
1/8" hex key (allen wrench) for shoulder screw		McMaster-Carr ( <a href="http://www.mcmaster.com">http://www.mcmaster.com</a> ): part number 7122A18	\$0.18 for one hex key, not including shipping
3/32" hex key (allen wrench) for shaft collar		McMaster-Carr ( <a href="http://www.mcmaster.com">http://www.mcmaster.com</a> ): part number 7122A16	\$0.17 for one hex key, not including shipping
Flathead screw driver for mounting screws (Miniature Metal-Handle Screwdriver, Nonmagnetic Precision Slotted Blade, 0.1" Wide Tip)		McMaster-Carr ( <a href="http://www.mcmaster.com">http://www.mcmaster.com</a> ): part number 7026A16	\$4.70 for one screw driver, not including shipping  Note: If you can spend a little more money, a magnetized screwdriver can be very handy to prevent losing small screws
Soldering station (for connecting magnetoresistive sensor to Hapkit Board and/or motor leads to motor)		Mouser ( <a href="http://www.mouser.com">http://www.mouser.com</a> ): part number 578-WES51  Soldering stations are available from a variety of sources at different costs. This one was selected for balance of performance and cost.	\$130 for one soldering station, not including shipping  You would also need to purchase solder.
Wire cutter/stripper (for cutting and stripping wires for electrical connections, particularly motor alligator clips)		Jameco ( <a href="http://www.jameco.com">http://www.jameco.com</a> ): part number 127862  Wire cutter/stripper tools are available from a variety of sources at different costs.	\$130 for one tool, not including shipping
3D printer: We used a Makerbot Replicator 2 (4 <sup>th</sup> generation) to make Hapkit parts		Home Depot ( <a href="http://www.homedepot.com">http://www.homedepot.com</a> ): model number MP04948  Many other sources for this printer exist, and other types of 3D printers can be used as well.	\$1,999* not including shipping

\* You would also need to purchase a spool of PLA filament (thermoplastic material, comes in a variety of colors), which costs approximately \$50 for a 2 lb. spool. (A spool this size should make about 9 Hapkits; smaller spools are available.) In addition, it is useful to have a scraper to help pry parts off the build platform tape, as well as replacement build platform tape.