Hapkit Parts List
3D-printed, capstan drive version 9.28.15
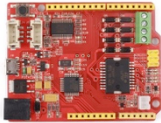
In order to make your Hapkit, you will need to gather (or make) all the parts shown in the table below and (as a group) in the picture at right.

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.
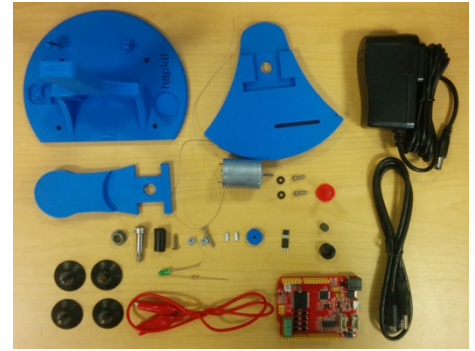
Component	Photo (not to scale)	Quantity	How to get this part	Approximate cost per Hapkit
3D printed base		1	These parts are 3D printed using the files available at the Hapkit website: http://hapkit.stanford.edu/build.html. See the 3D printing tips in the Assembly document for more information. We have successfully built these parts using a commercially available consumer-grade 3D printer, the Makerbot Replicator.	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. If you don't have direct access to a 3D printer, see the 3D printing tips document on the Hapkit website.
3D printed sector pulley		1		
3D printed handle		1		
3D printed tightening washer		1		
3D printed drive wheel/magnet holder		1		
Screws (for capstan adjustment) size 4-40, 3/4" length		1	McMaster-Carr (http://www.mcmaster.com) sells in packs of 100: part number 91781A113	$4.75 per pack of 100 ($0.10 for two), not including shipping
Neoprene tubing, 1/4" inner diameter, 3/8" outer diameter, cut to 3/4" length		1	McMaster-Carr (http://www.mcmaster.com) sells in packs of 10, 25 and 50 ft: part number 51075K27	$9.60 for a *10'-long* tube ($0.96 per foot), not including shipping. Can also find at hardware store for ~$2/foot.
Bearing: SAE 863 bronze flanged-sleeve bearing, 1/4" shaft dia., 3/8" outer dia., 1/2" length, 1/2" flange outer dia.		1	McMaster-Carr (http://www.mcmaster.com): part number 2938T3	$0.88 for one bearing, not including shipping
Stainless Steel Thread-Locking Shoulder Screw, 1/4" Diameter x 5/8" Long Shoulder, 10-24 Thread		1	McMaster-Carr (http://www.mcmaster.com): Part number 90311A144	$6.43 for one screw, not including shopping

Shaft collar: set screw shaft collar for 1/4" diameter rod, black-oxide steel		1	McMaster-Carr (http://www.mcmaster.com): part number 9414T6	$0.98 for one shaft collar, not including shipping
4-40 screws with length 1/2" (18-8 Stainless Steel Flat Head Slotted Machine Screw, 4-40 Thread, 1/2" Length)		1	McMaster-Carr (http://www.mcmaster.com) sells in packs of 100: part number 91781A110	$4.36 for pack of 100, not including shipping
Zinc-Plated Steel Machine Screw Hex Nut, 4-40 Thread Size, 1/4" Width, 3/32" Height		2	McMaster-Carr (http://www.mcmaster.com) sells in packs of 100: part number 90480A005	$0.87 for pack of 100, not including shipping
Screws for the Motor Type 316 Stainless Steel Pan Head Phillips Machine Screw, 4-40 Thread, 3/8" Length		2	McMaster-Carr (http://www.mcmaster.com) sells in packs of 100: part number 91735A104	$5.15 for pack of 50, not including shipping
Washers for motor: Mil. Spec. Flat Washer, Nylon, Number 2 Screw Size, NAS-1515-H02, 0.105" ID		2	McMaster-Carr (http://www.mcmaster.com) sells in packs of 100: part number 92150A101	$8.40 for pack of 100, not including shipping
Rubber Suction Cup: 1" diameter, 5/16" H, 8-32 machine screw, 3/8" screw projection, pack of 10		4	McMaster-Carr (http://www.mcmaster.com) sells in packs of 10: part number 53535A22	$9.40 for pack of 10, not including shipping
Type 316 Stainless Steel Hex Nut: 8-32 Thread Size, 11/32" Wide, 1/8" High, packs of 100		4	McMaster-Carr (http://www.mcmaster.com) part number 90257A009	$7.98 per pack of 100, not including shipping
Nylon Coated Stainless Steel Wire Rope Flexible 3X7, 0.014" Diameter, 2 lb Load Capacity. , Clear, 25 ft. length, (used max of 15.5 cm)		1	McMaster-Carr (http://www.mcmaster.com) part number 8930T16	$0.34 per foot $8.50 for 25 feet, not including shipping
Zinc-Plated Copper Oval Compression Sleeve for 1/32" Rope Diameter, 1/4" Sleeve Length		1	McMaster-Carr (http://www.mcmaster.com) sells in packs of 50: part number 3898T29	$2.32 for a pack of 50, 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 (http://www.jameco.com/): 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 max 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 (http://www.mcmaster.com): 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 number KMA210)		1	DigiKey (http://digikey.com): part number 568-8399-1-ND Note: This sensor needs to be soldered to the Hapkit board as described in the assembly instructions.	$6.73 for one sensor, not including shipping
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	Seeed Studio (http://www.seeedstudio.com): part number KIT04300M Note: If you are very familiar with Ardiuno, 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
Power supply for Hapkit board: Should supply 12 V and 1 Amp. (Wall Power Adapter: 12VDC, 1A, 5.5×2.1mm Barrel Jack, Center-Positive)		1	Pololu (http://www.pololu.com): 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 (http://www.monoprice.com): part number 4867 Note: Similar items can be found from other suppliers. We found that cables from some other sources did not fit well into the female micro USB connector on the Hapkit board.	$0.79 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)		1	Mouser (http://www.mouser.com/): 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.	$4.00 for a pack of 10 leads, not including shipping
Resistor (390 Ω) used for testing Hapkit board with LED		1	Mouser (http://www.mouser.com/): part number 291-390-RC	$0.10 per resistor, not including shipping
Light-emitting diode (LED) used for testing Hapkit board		1	Mouser (http://www.mouser.com/): 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 (http://www.staples.com): 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 piece		McMaster-Carr (http://www.mcmaster.com): 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 (http://www.mcmaster.com): part number 7122A18	$0.18 for one hex key, not including shipping
3/32" hex key (allen wrench) for shaft collar		McMaster-Carr (http://www.mcmaster.com): part number 7122A16	$0.16 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 (http://www.mcmaster.com): part number 7026A16	$4.86 for one screw driver, not including shipping. Note: For more money, a magnetized screwdriver can be very handy to prevent losing screws.
Soldering station (for connecting magnetoresistive sensor to Hapkit Board and/or motor leads to motor)		Mouser (http://www.mouser.com/): 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.	$129 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, e.g. motor alligator clips and crimping the wire sleeve to make a loop)		Jameco (http://www.jameco.com/): part number 127862. Wire cutter/stripper tools are available from a variety of sources at different costs.	$5.95 for one tool, not including shipping
Nicopress® No. 17-BA Swaging Tools (for crimping the wire sleeve, can also just use the wire cutter/stripper)		Rigging Warehouse (http://www.riggingwarehouse.com/) Item Code: 323-17-BA	$48.65 for one tool, Not including shipping
3D printer: We used a Makerbot Replicator to make Hapkit parts		Makerbot.com Many other sources for this printer exist, and other types of 3D printers can be used as well.	~$3,000* 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.