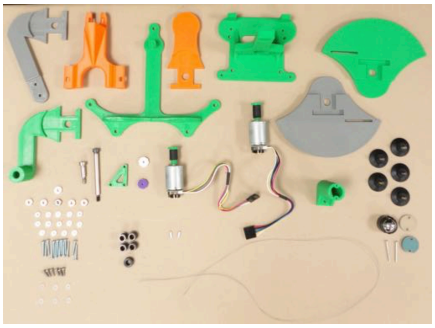
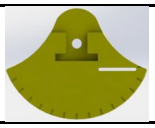
Haplink Parts List
3D-printed, capstan drive version 9.19.17

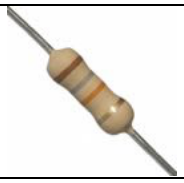
In order to make your Haplink, you will need to gather (or make) all the parts shown in the table below and (as a group) in the picture at right.

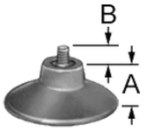


The total cost of the Haplink will likely range in price from $100 to $200, depending on where you get the parts, shipping costs, and what resources you have at hand. We provide online resources for purchasing most parts, although in many cases you can substitute with parts found at your local hardware 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 Parts					
Hapkit base		1	1	These parts are 3D printed using the files available on the Hapkit website: http://hapkit.stanford.edu/2-DOF.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 $20. The total weight of plastic used is about 200 grams. If you don't have direct access to a 3D printer, see the 3D printing tips document on the Hapkit website.
Hapkit Handle		1	0		
Bottom base		0	1		
Motor holder for second motor		0	1		
Triangle support		0	1		
Sector handle 1		0	1		
Sector handle 2		0	1		
Handle post for sector handle 2		0	1		

Sector pulley		1	2		
Tightening washer		1	2		
Drive wheel		1	2		
Electronic Components					
Nucleo development board (NUCLEO-F446ZE)		1	1	Mouser, part number 511-NUCLEO-F446ZE	$19 each
MP 12V Motor with 48 CPR Encoder for 25D mm Metal Gearmotors (No Gearbox)		1	2	Pololu, part number 3236	$21.95 each
Logic Level Shifter, 4-Channel, Bidirectional		1	1	Pololu, part number 2595	$2.50 each
DC/Stepper Motor Driver breakout board, 1.2A (Adafruit TB6612)		1	1	Adafruit, part number 2448	$4.95 each
Wall power adapter, should supply 5V and 2A, 5.5x2.1mm center-positive plug		1	1	Amazon	$7.49 each
Wall power adapter, should supply 12V and 2A, 5.5x2.1mm center-positive plug		1	1	Amazon	$7.99 each
USB 2.0 A to Micro 5pin cable, 28/28 AWG, 3ft		1	1	Monoprice, part number 4867	$0.70 each
USB 2.0 A to Micro 5pin cable, 28/28 AWG, 6ft		1	1	Monoprice, part number 4868	$0.75 each

Large protoboard with power rails		1	1	Sparkfun, part number PRT-12699	$8.95 each
1.8kOhms through-hole resistors		2	4	Mouser, part number 291-1.8K-RC	$0.13 each
Break-away headers, right angle 2x40		2	2	Sparkfun, part number COM-12792	$1.95 each
Break-away headers, straight 1x40		1	1	Sparkfun, part number PRT-00116	$1.5 each
Screw-down terminal block, through-hole header, 3.5mm pitch, 2 positions		1	1	Jameco, part number 2094506	$0.35 each
Screw-down terminal block, through-hole header, 5mm pitch, 2 positions		2	2	Jameco, part number 2094485	$0.39 each
Male DC to jack screw terminal, 5.5x2.1mm barrel		2	2	Jameco, part number 2153908	$4.95 for a pack of 5
Male/female 6" jumper wires		1 pack	1 pack	Sparkfun, part number PRT-12794	$1.95 for a pack of 20
Female/female 6" jumper wires		1 pack	1 pack	Sparkfun, part number PRT-12796	$1.95 for a pack of 20

Male/male 6" jumper wires		1 pack	1 pack	Sparkfun, part number PRT-12795	$1.95 for a pack of 20
140-piece jumper wire kit, 22 AWG, contains jumper wires of various lengths, analogous product sold on SparkFun		1	1	Digikey, part number BKWK-2-ND	$6.2 each
Hardware Components					
Philips screws , 4-40 thread size, 3/4" length		1	13	McMaster-Carr, part number 90272A113	$2.32 for a pack of 100
Philips screws, 4-40 thread size, 3/8" length		3	6	McMaster-Carr, part number 90272A108	$4.30 for a pack of 100
Rubber feet, 8-32 thread size, 1" diameter, 5/16" high base with 3/8" long threading		4	5	McMaster-Carr, part number 53535A22	$9.67 for a pack of 10
Shaft collar with set screw for 1/4" diameter, black-oxide 1215 carbon steel		1	1	McMaster-Carr, part number 9414T6	$1.02 each
Shoulder screw, thread-locking for 1/4" diameter, 5/8" long shoulder, 10-24 thread size, 316 stainless steel		1	1	McMaster-Carr, part number 90311A144	$5.47 each
Shoulder screw, thread-locking for 1/4" diameter, 2-1/4" long shoulder, 10-24 thread size		0	1	McMaster-Carr, part number 91259A104	$1.57 each
Flanged sleeve bearing, for 1/4" shaft diameter, 1/2" length, SAE 863 iron-copper bronze		1	4	McMaster-Carr, part number 2938T3	$0.88 each
Hex nuts, 4-40 thread size, low-strength zinc-plated steel		2	14	McMaster-Carr, part number 90480A005	$0.87 for a pack of 100

Hex nuts, 8-32 thread size, 316 stainless steel		4	5	McMaster-Carr, part number 90257A009	$6.65 for a pack of 100
Hex nut, 10-24 thread size, low-strength zinc-plated steel		0	1	McMaster-Carr, part number 90480A011	$1.84 for a pack of 100
Plastic washers for motor, Mil. Spec, Nylon, for Number 2 Screws, NAS 1515-H02		2	4	McMaster-Carr, part number 92150A101	$8.4 for a pack of 100
Rubber tubing, 1/4" inner diameter, 3/8" outer diameter, long-life tygon rubber		1 2” piece	2 2" pieces	McMaster-Carr, part number 51075K27	$9.8 for10 ft.
Ball caster with 3/4" metal ball		0	1	Pololu, part number 955	$2.69 each
Oval compression sleeve for 1/32" rope diameter, zinc-plated copper		1	2	McMaster-Carr, part number 3898T29	$2.32 for a pack of 50
Coated stainless steel braided wire, 0.009" diameter		2 ft.	4 ft.	McMaster-Carr, part number 8930T16	$9.00 for 25 ft

Vendors

This is the list of vendors and their websites that we have used to obtain all the parts.

Adafruit: www.adafruit.com
Amazon: www.amazon.com
Digikey: www.digikey.com
Jameco: www.jameco.com/
McMaster-Carr: www.mcmaster.com
Makerbot: www.makerbot.com
Monoprice: www.monoprice.com
Mouser: www.mouser.com
Newark: www.newark.com
Pololu: www.pololu.com
Sparkfun: www.sparkfun.com
Staples: staples.com

Tools

You may also find it necessary to purchase (or gain access to) the following tools to create your Haplink. 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
Scissors		Staples, part number 569577 Note: this is available from many sources.	$14.79 per pack of 2
Super glue (we suggest gel-type single use packs; you will probably only need to use it once)		Staples, part number 861702 Note: this is available from many sources.	$5.49 per pack of 4
Philips screwdriver, number 1		McMaster-Carr, part number 7026A19	$7.24 each
3/32" hex key/allen wrench		McMaster-Carr, part number 7122A16	$0.16 each
1/8" hex key/allen wrench		McMaster-Carr, part number 7122A18	$0.18 each
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
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.