

Making a Faraday Flashlight

Executive Summary: This project demonstrates the principle that a magnet passing through a coil of wire induces a current, which in this case lights an LED. Two LED's are used, one that lights when the magnet moves in one direction and the other lights when the magnet goes back the other way. In a real flashlight, an additional circuit would be used to cause the light to stay on; this is just a demo and is intended to keep costs down.



Materials needed (per flashlight)

Part	Number	Part number	Unit price (June 2011)	Description
Wire	150 ft	Wire-MW-24-1/4	\$8.60*	Magnet wire, 24 gauge
		http://www.bulkwire.com/wire-cable/magnet-wire.html		
Magnet	1	ND035	\$1.29**	Neodymium (rare earth_ magnet, disk, 1/2 in. diameter, 1/2" thick
		http://www.magnet4less.com/product_info.php?products_id=123		
LED	2	160-1665-ND	\$0.36	LED 3MM 632NM ALINGAP RED CLEAR
		http://search.digikey.com/scripts/DkSearch/dksus.dll?lang=en&site=US&KeyWords=160-1665-ND&x=0&y=0		
Tube	4 in	49035K23	\$7.77 for 4 ft length)	Clear PVC pipe, 1/2 "
		http://www.mcmaster.com/#clear-pvc-pipe/=cre6rr		
Rubber bands	2			
Tape, scissors, paper, and a match or lighter				

*For multiple projects, this wire can be bought in larger spools for much less, e.g. http://www.magnet4less.com/product_info.php?products_id=195 is approximately 8,700 feet for \$107. This wire is about 790 lb/foot.

**About \$1 each in quantity

Principle of operation

Faraday's Law

The flashlight works on the principle of Faraday's law, which says that a changing magnetic field induces an electromotive force, producing a current in a wire. In our case, the magnet is moving (when you shake the flashlight), which causes a changing magnetic field. A coil of wire is wrapped around the outside, and the moving magnet induces a field.

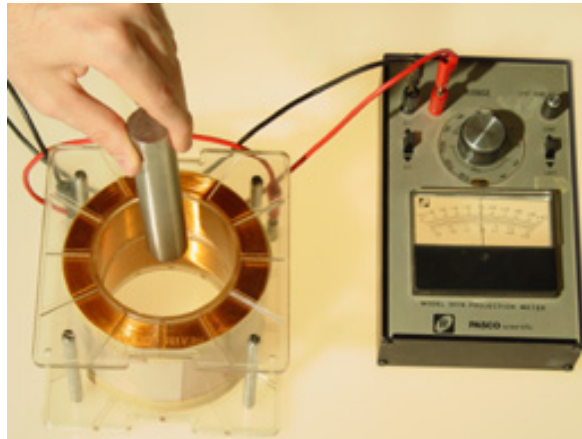


Figure 1. Faraday's law. http://sirius.ucsc.edu/demoweb/cgi-bin/?e_m-electmag-faraday

A neat simulation can be found at <http://phet.colorado.edu/en/simulation/faradays-law>.

LED

In our case, we will use the current to light up a light-emitting diode (LED). The circuit symbol for a diode is shown in Figure 2. A diode is a device in which current flows in only one direction (the direction the arrow is pointing). The bar across the arrow tip reminds us that current cannot flow in that direction.

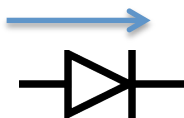


Figure 2. Current can flow only one direction in a diode.

When we shake the flashlight, the magnet moves back and forth, resulting in a current that reverses direction back and forth. Therefore, we will connect two diodes across the wire coil, in "anti-parallel" configuration, Figure 3.

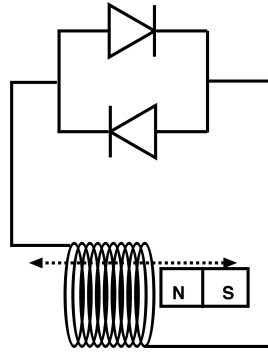


Figure 3. The LED's are connected anti-parallel.

The LED lamps look physically as shown in Figure 4. One lead is designated the anode, and the other is the cathode. There are two ways to tell them apart on the LED package. The first is to notice which lead is longer. The longer lead is the anode. If someone has cut the leads or you can't see them, the backup plan is to look for the flat side of the flange on the lamp body. The flat indicates the cathode.

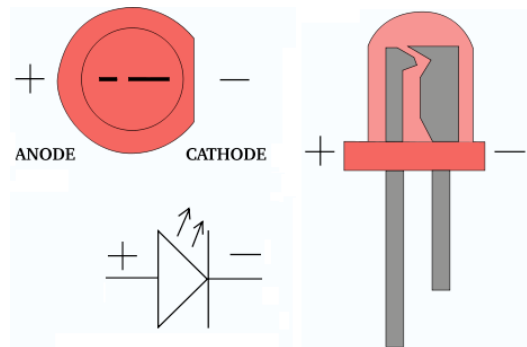


Figure 4. The anode and cathode of an LED lamp, and how to tell them apart.
http://www.societyofrobots.com/electronics_led_tutorial.shtml

Construction

1. Wind the coil.

Leaving about 6" of wire free at the beginning, tape the wire to the side of the tube. Wrap the wire around the tube until about 6" are left, and tape the wire to the tube.

- The tape is just to keep the wire from unwinding.
- Overlap the wire as much as possible
- Neatness doesn't count.
- It is not necessary or even desirable to cover the entire length of the tube. You want a short, dense coil to maximize the interaction of the magnet and the coil. You also want the ends of the tube to remain uncovered so you can see the magnet in there.

2. Burn off the insulation

The magnet wire has a coating of insulating material painted onto it, to keep it from shorting to itself when wound into coils. To make electrical connections, you'll need to burn it off.

Holding the end of the wire away from flammable objects, use the lighter to burn off about 1" of the insulation. You may see the coating flare up instantaneously. It only takes a second or two. When the wire looks black, you have succeeded. Repeat for the other end.

- Children sometimes have trouble operating lighters with safety mechanisms.
- The insulation can be also removed with sandpaper, but it is harder to get all the insulation off, and is nowhere near as much fun.

3. Connect the LEDs

To connect the LEDs, twist together the anode of one LED and the cathode of the other. Repeat for the other leads, Figure 5. Make sure the two pairs of leads don't touch each other.

Twist one burned-off end of the coil wire to each pair of LED leads.

4. Insert magnet and cap tube

Insert the magnet into the tube. Cut two circles of paper, and rubber band them to the ends of the tube.



Figure 5. Connection of the LEDs.

CAUTION: Make sure you cover the ends of the tube with your thumb and finger to prevent the very heavy magnet from becoming a projectile.

5. Shake and observe

Comments

If you decide to scale this up or down, it is important that the tube inner diameter be only slightly larger than the magnet. If the magnet can rotate, the effect will be largely lost. Also the tube should be slippery enough that the magnet can slide freely (e.g., not rubber).