

Simon says “Build an Electromagnet” !

Permanent magnets are the kind that hang on a refrigerator. But did you know that there are other magnets, that can be turned on and off? When turned on, these electromagnets act just like permanent magnets, but if you turn them off, their magnetic properties disappear. This is very useful. Small electromagnets can be used in electrical circuits as tiny switches, called relays, and really huge strong ones are used in scrap-yards to lift heavy loads of scrap iron, then drop it into a truck. The strength of an electromagnet’s magnetic field depends upon the core of the magnet, the number of times you wind a suitable wire around the core, how much current is coming from the battery in the circuit.

You can make a simple electromagnet at home using a few materials. You may have some of the items that are listed in the Parts List below already. Ask your family! Otherwise buy them at any hardware or electrical store or order them online. I found lantern batteries, nails, electrical tape and wire cutters at the hardware store. At home we already had sandpaper, paper clips, rubber bands and card to make labels. I had to order magnet wire and test leads online and found them at American Science and Surplus, who have a couple of stores in the Chicago area and also sell online at <https://www.sciplus.com> Please shop around, as there are many suppliers and prices and minimum quantities vary from place to place.

Parts list.

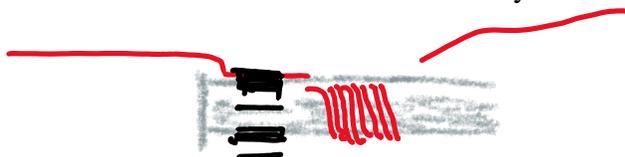
- **Iron rod:** Choose a large nail or spike for the electro-magnet core. Common iron nails up to 6 inches long or large spikes will create a strong magnetic field and can be purchased at a hardware store. Buy as many nails as you want to make magnets. A large screw or bolt could also be used. Be sure that the core is made of iron (check by seeing that it is attracted to a magnet). Spikes are often coated in zinc to prevent them rusting, so they are silver and shiny, but are actually made of iron.
- **Battery:** Direct current from a battery is needed for your electromagnet. A 6-Volt lantern battery is the largest one that you should use. Shop around – they cost from \$5 - \$10. This voltage is safe to use. Use it for only short periods of less than 5 minutes, then disconnect it so it does not get hot, or it will not last for very long.
- **Wire:** Hardware stores usually sell insulated copper wire, such as bell wire – two strands of wire twisted together. Any size (thickness) of wire from about 16-AWGauge to 30-AWGauge insulated copper wire could be used. It should be thin enough for you to wrap it around the nail easily. Make sure the wire has just one solid strand of copper

inside the insulation, rather than a lot of very thin strands. Magnet wire (or enameled magnet wire) is easiest to work with and enables you to put more turns on the nail. This looks like bare copper wire but is coated with a clear material for insulation. It is not usually carried in stock at regular hardware stores but is readily available online. You would have to buy a spool of perhaps 100 ft. of wire. I bought magnet wire with a gauge (or thickness) of 26 AWG. A bit thicker (24 or 22) or thinner (28 – 30) is OK.

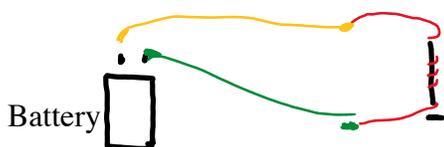
- **Test leads:** Connectors are needed to attach your finished electro-magnet to the terminals of the lantern battery. These are short pieces of wire with an alligator-clip at each end. You will need two. They are easily obtainable online or can be made using a couple of 18-inch-long pieces of insulated wire from the hardware store, with an alligator clip attached at each end (also available at the hardware store).
- **Electrical tape:** Not essential, but handy to tape down wires. A roll costs about \$1
- **Wire cutters:** to be used for cutting off the wire after you have wound the magnet. Don't use good scissors for wire! Some wire-cutters also have a gadget for stripping insulation from the ends of the wire in order to make connections. Otherwise, (**under adult supervision!**) you can use a **lighter or match** to melt the insulation from the end $\frac{1}{2}$ inch of wire, then wipe it off with a clean rag. The insulation on Magnet wire can be removed simply by rubbing with a small piece of sandpaper.
- **Sandpaper:** A small piece to remove insulation from ends of Magnet wire.
- **Paperclips - small:** about one small package containing 100 clips.
- **Rubber bands:** Two for each magnet.
- **Small tie-on labels:** One for each magnet – write on it how many turns of wire you have made around the core.

Directions for making an electromagnet.

1. If using bell-wire, cut a piece about 6 feet long, enough for 50 or so turns around the nail. For magnet wire, thread a pencil through the center of the wire-spool and ask someone to hold each end of the pencil so that you can gently pull the wire off the spool. This makes sure that the wire does not get tangled and the insulation is not damaged.
2. For magnet wire, leave about 6 inches of wire free, place the wire along the first ½” of the nail and then press over it a small strip of insulating tape so as to hold the wire down. The size of the piece of tape should be such that it leaves a ‘stripe’ of nail uncovered and that stripe should run parallel to the length of the nail. For bell wire, just start winding it around the nail and count the turns when you have finished.



3. Start winding the wire about ½” from the head of the nail and count the windings as you go, counting each time the ‘stripe’ on the nail rotates. Rotate the nail, pulling the wire gently from the spool and causing the wire to wind around the nail. Keep the wire firmly wound around the nail, and the windings close together. Push the windings together from time to time as you wind. Don’t wind one turn over another. When working with magnet wire, it makes it easier to have another person help by keeping a tally of the numbers of turns. Treat the wire gently – if you damage the insulation it will not work properly.
4. When you have reached the required number of turns, leave a tail of about 6” of wire and then cut the wire off. Use the tape to fix the end of the wire in place, or for a very sturdy job, put a rubber band around the wire and the nail, twisting it and putting another turn around the nail until the band is tight.
5. Write the number of turns on a label and tie it to the electromagnet. For the first one that you make, 50 turns will be enough to show how the magnet works. Magnets with more turns can then be made. It should be possible to get at least 50 windings on the nail using bell wire and 200 using magnet wire.
6. Now strip off the insulation from about one inch at each end of the bell-wire by (carefully!) using the wire-strippers or heating the wire with a match or lighter then cleaning off the melted insulation with a clean rag. Sandpaper will rub the insulation off the magnet-wire. It will look copper-colored when it is bare, rather than reddish.
7. Connect the ends of the wire to the battery terminals using the test leads. When the current from the battery is flowing through the wire, you should be able to pick up small pieces of iron, such as staples or paperclips.



8. Batteries run down as they are used, so to make your battery last as long as possible disconnect it when you are not actually using it. Don't leave the battery connected for more than a couple of minutes at a time **otherwise the wire may get quite hot.**