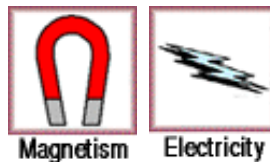
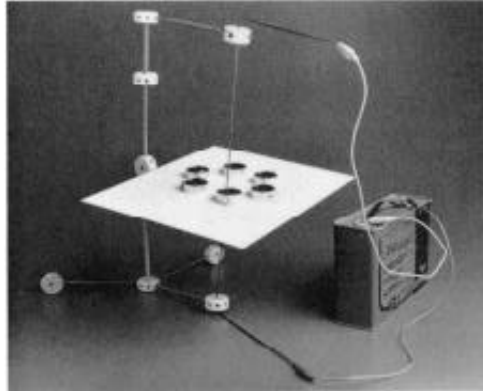




Circles of Magnetism I

You can make a magnetic field that's stronger than the earth's!



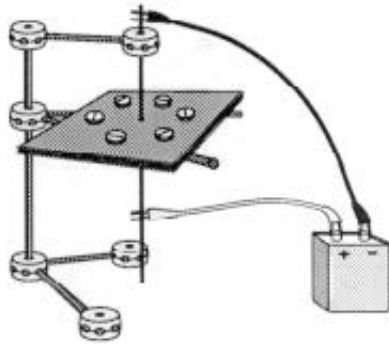
Compass needles are little magnets that are free to rotate. Compasses allow us to observe the direction of a magnetic field. Normally, they respond to the earth's magnetic field, orienting themselves parallel to magnetic field lines. If we create a magnetic field that is stronger than the field of the earth - for example, by using electric currents - a compass needle will orient itself parallel to the new field.

materials

- ✓ A 6- or 12-volt lantern battery.
- ✓ A 1 foot (30 cm) length of heavy wire that is rigid enough to stand by itself. (You can use the wire from a coat hanger.)
- ✓ A TinkertoTM set for building the stand (or another improvised stand).
- ✓ A flat, rigid support surface measuring approximately 6 x 6 inches (15 x 15 cm). (This can be made of posterboard or even a manila file folder.) It should have a hole in the center of it that is large enough for the wire to pass through.
- ✓ 4 or 6 small compasses, measuring about 1 inch (2.5 cm) in diameter.
- ✓ 2 electrical lead wires with alligator clips at both ends (available at Radio Shack).
- ✓ Adult help.

assembly

(30 minutes or less)



Construct a Tinkertoy™ stand (or the equivalent), and lay the flat support surface in position on the stand. (See the photo and the diagram above.)

If the coat hanger wire is painted or varnished, scrape the coating off to expose about 1 inch (2.5 cm) of bare metal at each end.

Insert the wire through the hole in the flat support surface, and support the wire vertically in the stand, as shown in the photo and diagram.

Arrange the compasses in a circle on the support surface as shown in the diagram.

Attach one clip lead to each battery terminal. but donot attach the other ends of the lead wires to the coat hanger wire yet.

to do and notice

Observe the compass needles around the wire as when there is no current passing through the wire. Rotate the support surface. What happens to the compass needles? They will point north, orienting themselves so that they are parallel to the earth's magnetic field. (*Note*: a few of your compasses may point south! Inexpensive compasses that are exposed to a strong magnet will sometimes become magnetized in the reverse direction. It's nothing to worry about, though - just keep in mind which end of your compasses points north.)

Attach the clip leads to the ends of the coat hanger wire where it has been scraped. Watch what happens to the compass needles as current passes through the wire. If the electrical current is large enough, each compass will point in a direction tangent to a circle centered on the wire.

Rotate the support surface again. What happens to the compass needles this time? The compasses will continue to point in a direction tangent to a circle centered on the wire.

Don't leave the clip leads connected too long, because the electric current will rapidly drain the battery. A few seconds should be long enough to make good observations.

Switch the clip leads to the other terminals of the battery. What happens? The compass needles will reverse direction when the electrical current reverses direction.

what's going on?

Compass needles line up with magnetic fields. Since the earth is a magnet, a compass will normally line up with the earth's magnetic field. Because opposite magnetic poles attract, the magnetic north pole of the compass points toward the magnetic south pole of the earth. (The magnetic south pole of the earth is located in northern Canada! That is not a misprint. The south pole of the earth magnet is near the geographic north pole.)

The electric current passing through the wire creates a magnetic field that is stronger than the earth's field (in a region close to the wire). You can visualize the shape of this new field as a set of concentric circles surrounding the wire. Each of these circles has its center at the wire.

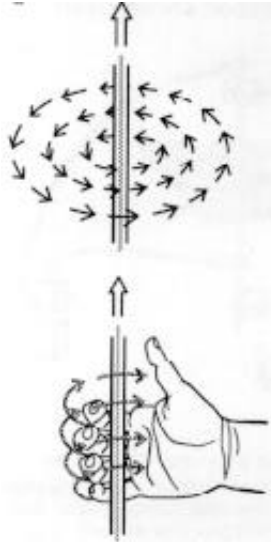
The closer to the wire you are, the stronger the magnetic field. The compass needles align themselves with the total magnetic field at each point, the sum of the earth's field and that of the wire. Since the magnetic field from the wire is significantly larger than that from the earth, each needle ends up pointing essentially in the direction of the magnetic field of the wire.

When you reverse the current, the direction of the magnetic field also reverses, and the needles dutifully follow it.

etcetera

To find the direction of the magnetic field made by an electrical current, use a technique called the *righthand rule*.

Place your right hand with the thumb parallel to the wire carrying the current. Point your thumb in the direction of the electrical current in the wire. (Remember: The electric current flows from the plus side of the battery through the wire to the minus side.) Wrap your fingers around the wire. Your fingers will now point in the direction of the magnetic field around the wire. If there are compasses near the wire, they will point in the same direction as your fingers.



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