Electricity and Magnetism Discovery Bundle

P6-2500

Contents

Lenz's Law Apparatus

Magnet Wire Spool

Japanese Yen

Electromagnetic Flashlight

Small Clear Compass 20 pack

Galvanometer, ±500 µA

World's Simplest Motor

Giant Neodymium Magnet

Ceramic Ring Magnet

Item	Topic	Instructions
Lenz's Law Apparatus (P8-8400)	Induced magnetic fields Eddy currents	Instructional Guide Included
Magnet Wire Spool (100 ft, 26 AWG) (P8-1190)	Induced electric currents Simple motor construction	See attached instructions for building a simple motor.
Japanese Yen (3)	Induced magnetic fields	Place a coin on a piece of ordinary paper. Hold the neodymium magnet next to the coin so that students can confirm that it is not attracted to the magnet. Place the magnet under the coin and paper. *Quickly* move it back and forth. What happens? The aluminum coin should slide back and forth with the movement of the magnet. Now touch the magnet to the coin and quickly lift up. What happens? The coin should be pulled into the air.
Electromagnetic Flashlight (P6-6052)	Generators	Shake the body and see the magnet move through the coil of wire. The changing magnetic field induces an electric current in the wire, which lights the bulb.
Clear Compasses, 20/pk (P8-1170)	Magnetic fields	Place compasses around a current-carrying wire and observe the direction of the magnetic field.
Galvanometer, ±500 µA (P4-1208)	For measuring small induced currents	Make a coil of magnet wire with about 50 turns, large enough to accommodate the Giant Neodymium Magnet. Use sandpaper to strip the enamel off the ends and connect it to the galvanometer. Quickly pass the magnet back and forth through the coil and observe the induced current. You can also connect the ends of a long extension cord to the meter and swing the cord like a jump rope. The earth's magnetic field will induce a small current!
World's Simplest Motor (P8-8300)	Motors	Instructional Guide Included
Giant Neodymium Magnet (P8-1124)	Magnetic fields	Use as described above with Japanese Yen, Magnet Wire, and Galvanometer.
Ceramic Ring Magnet, Small (0.75" x 0.25" x 0.25") (P8-1131)	Motors	See attached instructions for building a simple motor.

Related Products

Investigating Electrical Circuits Kit (96-1500) With this easy-connecting kit, students learn the fundamentals of electricity by building various circuits, and then are introduced to the concepts of voltage, resistance, and electrical current. Each of the electrical components is mounted on a durable plastic magnetic base (embedded Neodymium magnets) designed to help keep things organized on a custom magnetic receptive mat that also functions as a dry erase board.

Faraday's Law and Lenz's Law Complete Demo Set (98-8600) The Faraday's Law and Lenz's Law Complete Demo Set contains everything needed for a show-stopping electromagnetism demonstration. Use this demo set to explain what happens when the falling magnet disappears into the copper collar. It is not magic—it is physics!

Electromagnetic Force Demonstrator (P6-2625) The Electromagnetic Force Demonstrator is a dynamic way of showing the interaction between magnetism and electricity. Watch how the aluminum pipe travels along the track in the direction the current is applied, reinforcing the interrelated concepts of Current, Magnetic fields and the Lorentz Force.

Build a Motor

Materials:

- 2 large paper clips
- 1 rubber band
- 1 D battery
- 1m length of magnet wire
- Small ring magnet
- Sandpaper

Instructions

1. Use sandpaper to remove the enamel coating from the last inch of both ends of the magnet wire.
2. Wind the wire into a loop around 2 or 3 fingers, leaving 2” free on each end.
3. Twist the free ends through the loop to secure it, leaving the free ends pointing out of the loop. (See fig. 1.)

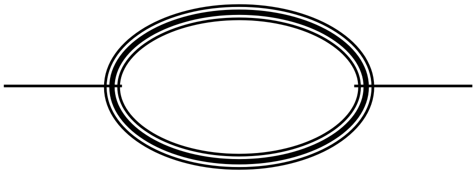

Figure 1

4. Unfold the paper clip so it forms an “S.”
5. Push one end of the “S” inward so that a small loop forms. (See Fig. 2.)
6. Use the rubber band to secure the lower ends of the paper clips to the ends of the battery. The top (loop) ends should extend above the battery.
7. Place the ring magnet on top of the battery between the paper clips. (It will stick.)
8. Thread the ends of the wire loop through the paper clip loops. Make sure the sanded portion of the wire contacts the paper clip.
9. Give the loop a push and see what happens. If you’re lucky, it will spin on its own. If you’re like most people, you will have to adjust one of several things:
    a. The size of the loop.
    b. The shape of the loop.
    c. The placement of the magnet.
    d. The way you initially push the loop.
    e. Sand more enamel off the end of the wire.
10. What you’ve done is reproduce the “World’s Simplest Motor” using even simpler materials!

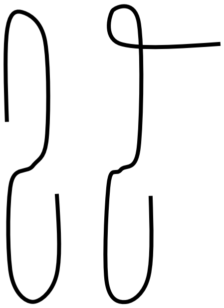

Figure 2

This page intentionally left blank.

World's Simplest Motor

P8-8300

INSTRUCTIONAL GUIDE

Contents

Contents:

- 1 Plastic Base
- 2 Metal Supports
- Wire

Required but not included:

- **D-cell battery (04-2106)**

Recommended for Activities:

- **Small Clear Compasses 20 pack (P8-1170)**
- **Magnaprobe (P8-8006)**

Background

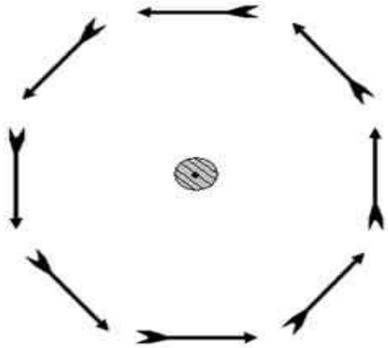

Figure 1

Use the World's Simplest Motor to study electricity and magnetism. Show energy conversions. Show how electricity creates magnetic fields and how it is used to create motion.

The discovery that currents produce magnetic fields was made by Hans Christian Ørsted in 1820. Ørsted made his discovery during a classroom demonstration on "electricity, galvanism, and magnetism." Because Ørsted made his important discovery while teaching, the American Association of Physics Teachers awards a medal named after him each year to a teacher who has made a significant impact on the teaching of physics.

Figure 1 shows a modification of Ørsted's experiment. A central wire carrying a strong current is surrounded by several compass needles. The dot signifies that the current on the wire is emerging from the page. If there is no current in the wire, then the compass needles would point toward the magnetic north pole of the earth. But when a strong current is present in the wire, the compass needles align themselves with the magnetic field created by the current. Adding more compasses suggests that the magnetic field is circular and surrounds the wire, as in **Figure 1.** This is what surprised Ørsted. Not only is the field perpendicular to the current, but it is circular!

Field lines are used to represent the magnetic field in **Figure 2**. The spacing between the lines represents the strength of the field—the denser the lines the stronger the field. Notice that the spacing of the lines increases with distance from the wire. This represents the 1/r decrease in the strength of the field—just like the decrease in the brightness of a candle.

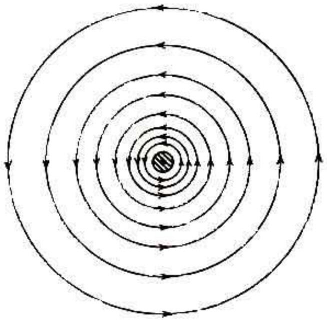

Figure 2

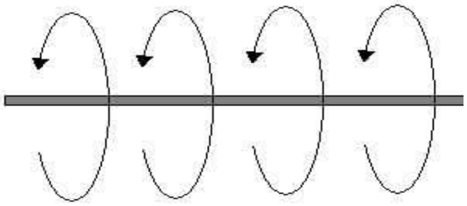

Figure 3

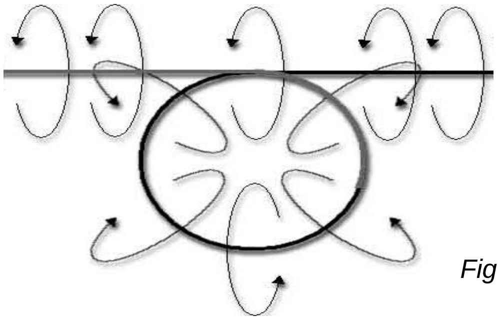

Figure 4

Figure 3 is another representation, from a different angle, of the single wire carrying a current and the magnetic field that it creates. The Right-hand Rule can be used with a single wire to show the direction of the field lines or current.

What happens if you put a loop in the wire, as in **Figure 4**? If you follow the right-hand rule all the way around the loop, you'll see that all of the magnetic field lines inside the loop point in the same direction and field outside the loop point in the same direction. Inside the loop, however, there is a high concentration of magnetic field lines that point in the same direction. Dense field lines indicate a high magnetic field. The quantitative description of the relationship between current and the magnetic field it creates is called *Ampere's Law* and it states that the magnetic field is proportional to the current. Thus, one loop of wire, regardless of how big the wire is, will create roughly the same magnetic field as another wire, as long as the same size current runs through it. But, if there are multiple loops of wire, then *each loop creates its own field* and the magnetic field is very strong as compared to a single loop with the same size current.

In the World's Simplest Motor, the coil of wire makes a strong magnetic field when the shiny ends of the wire are down against the metal supports and a current is flowing through the wire. The coil will want to align its magnetic field with the field from the magnet. If the coil always had current flowing through it, it would tend to get stuck in one position. When properly assembled, the motor will have current for half of a turn. It will turn to try to align itself. Then the motor coasts through the other half of the turn to allow it to keep going before it is charged again. Otherwise, it would want to spin back the other way.

Activities

- Put compasses around the magnet. Turn the magnet and see the magnetic field created. Without the magnet, place the compasses near the coil of the motor. Slowly turn the coil and show how the magnetic field is created when current is flowing through the coil. Note the direction of the magnetic field.
- Use a Magnaprobe to see the magnetic field surrounding the wire in three dimensions.
- Flip the magnet over. How does this affect the performance of the motor?

Related Products

Electromagnetic Force Demonstrator (P6-2625) The Electromagnetic Force Demonstrator is a dynamic way of showing the interaction between magnetism and electricity.

Homopolar Motor Kit (P8-8350) You've seen the World's Simplest Motor™. We have a classroom set so you can make one that's even simpler than that...

Lenz's Law Apparatus (P8-8400) Experience the fundamental principle behind electric motors with this demonstration.