Electricity and Magnetism

Objective

The purpose of this experiment is to investigate (a) the properties of magnets, (b) the relationships between magnetism and electricity, and (c) practical applications of electricity and magnetism.

Materials

1. Alligator wires
2. Battery packs
3. Compass
4. Copper wire (half meter)
5. D-cell battery
6. Fluke digital multimeter
7. Green stickers
8. Large iron nails (x2)
9. Large paper clips (x2)
10. Magnet packets
11. Number-22 enamel-coted copper wire
12. Pliers
13. Rubber bands (x2)
14. Sandpaper
15. Small ceramic magnet
16. Small paper clips

Procedure

Part I: Becoming Familiar with Magnets

1. Determine which objects from the given packet are affected by the stack of magnets. Then determine which objects on and around you are affected. What do the affected objects have in common?
2. Does the magnetic force act through materials? Try to use the magnets to pick up a paper clip through a piece of paper, through a piece of aluminum foil, through plastic, etc. Report what you observe.
3. Determine whether distance affects the magnetic force. Describe what you did, record your results, and give your conclusions.
4. Attract an object like a paper clip to the magnets. Is the object then repelled the way an electrically uncharged object is sometimes first attracted to and then repelled from a charged object? Can you describe a magnet as having an excess of something the way a charged object has an excess of one kind of charge?

5. Start with two paper clips that do not attract each other. Magnetize one of the paper clips by stroking it with the stack of magnets. What effect does the magnetized paper clip have on the un-magnetized paper clip? Is something rubbing off the magnets onto the paper clips? Throw the magnetized paper clip hard against the floor several times. How does it now affect the un-magnetized paper clip? What do you conclude?

6. Place one small disk magnet flat on the desktop. Stick a green label on its top. Carefully bring the stack of other magnets down over it until they almost touch. If the magnet does not jump up to the stack, slowly move the stack to one side. Repeat with the same stack orientation and with the disk's labeled side down. Explain the behavior you observe.

7. Take your labeled magnet and another magnet from the stack and separate them far enough so that they do not interact noticeably. Using one end of the remaining stack as a probe, determine which face of each magnet attracts or repels the probe. Label this disk like the first. Labels should be on the faces that are like in their behavior toward the stack. In generally accepted magnet terminology, we have labeled like poles. Without bringing it closer than about 1 cm use your small compass to see if your like poles are alike in their behavior toward this compass. Now bring the labeled disks near one another. How do like poles affect one another? How do unlike poles affect one another?

Part Two: Making an Electromagnet

Acquire about a half-meter of insulated copper wire. Scrape the insulation off about 1 cm of the wire at each end. Wrap copper wire around the nail making at least 20 full turns and leaving at least 15 cm of wire free at each end. Connect the free ends of the wire to the battery.

WARNING: Do not leave the battery connected for more than one half minute at a time. Disconnect one end of the wire between parts of the experiment to avoid draining the battery and causing the wire to heat up excessively.

1. Try to pick up some paper clips with the wire and nail electromagnet. What will happen with one wire disconnected? Where is the electromagnet the strongest?

2. Place a compass at the point end of the nail. Carefully observe the compass needle. Place the compass at the head of the nail. Carefully observe the compass needle. What can you infer about the poles at the ends of the nail?

3. Predict what would happen if you reverse the connections to the battery. Reverse the connections, and repeat Step 2.

4. Remove the nail from the coil. Compare the magnetic strength of the empty coil with that of the coil containing the nail.

5. Form a hypothesis about how to improve the electromagnet. Experiment with your hypothesis. Name three ways you found to improve your electromagnet.

Part Three: Making a Simple Motor

1. Wind a coil of wire of about 20 turns around a "former" (something to provide a definite form to coil, such as a short piece of plastic pipe or the D-cell battery itself), and leave the two ends straight and going in opposite directions out of the middle of the coil (see the diagram in Figure 1). It is very important that these two ends, which will serve as the axle of the coil and its electrical contact, be straight, stable and lined up with the center of the coil. You can either secure them by means of tape or by wrapping them two or three times about the wire bundle. Scrape the insulation from the top half of the axle wires where they will rest on the paper clip loop supports. Make sure to remove only half the insulation and the same half on both ends.
2. With pliers, form loops on the ends of the two paper clips after they have been straightened.
3. Using the two rubber bands (doubled several times each) attach the paper clips to the ends of the battery as shown in the diagram. Make sure the paper clips make good contact with the terminals. You may want to place a piece of tape over the battery ends for extra support.
4. Place the rectangular magnet on top of the battery just under the coil. There should be just a little clearance between the magnet and coil but they must not hit one another.
5. Give your coil a little help getting started; it should continue on its own.
6. Explain, in terms of what you learned earlier in this lab, how the motor works. You may get a hint by removing the magnet and noting the effect of a very slowly tumbled coil on a compass held nearby.

Portions of this lab were adapted from Glue and Sticky Tape Labs and Operation Physics.

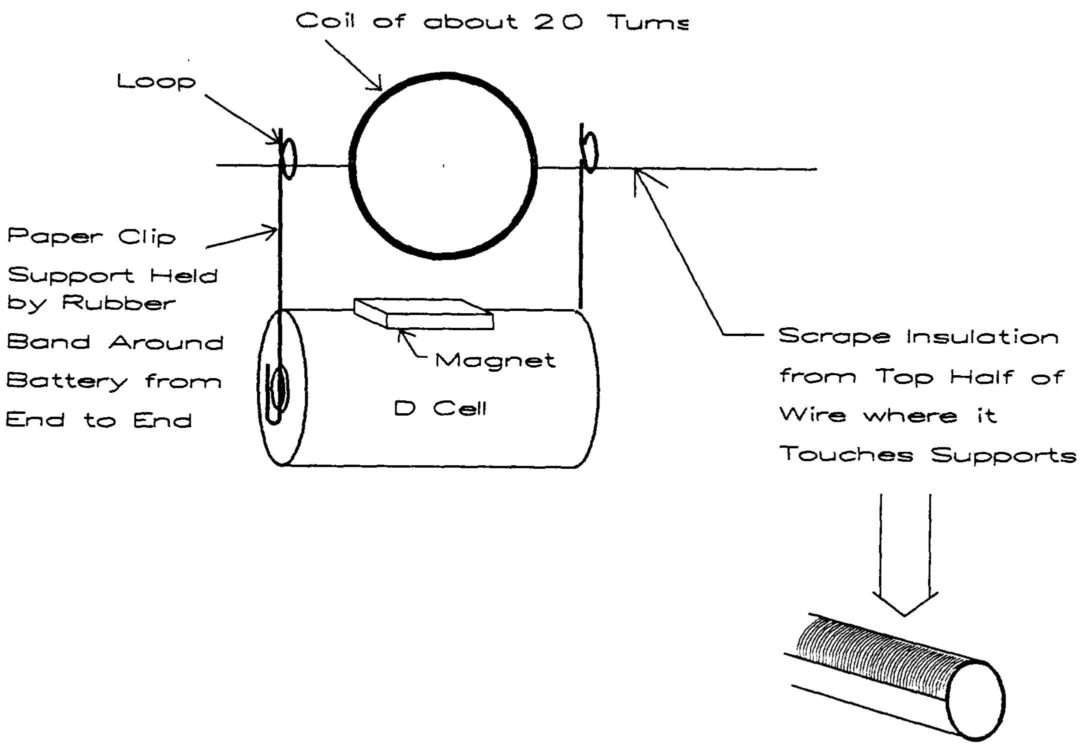
Coil of about 20 Turns
Loop
Paper Clip
Support Held
by Rubber
Band Around
Battery from
End to End
Magnet
D Cell
Scrape Insulation
from Top Half of
Wire where it
Touches Supports

Figure 1

Take-Home Activity: Electricity in Your Home

Introductory Statement

As charges move through circuits they do *work*. This results in heating the circuit or in turning a motor. The rate at which work is done—that is, the rate at which electric energy is converted into another form of energy such as mechanical energy, heat energy, or light—is called electric power. Electric power P is equal to the product of current I and voltage V. If we measure voltage in volts V and current in amperes A, power is expressed in watts W.

$$P = IV$$

Electric energy use is given the produce of power and time.

$$E = Pt$$

One watt used for one second (1 watt·second) is one joule (J). Electric energy used in households is measured in kilowatt-hours (kwh). One kilowatt used for one hour is one kilowatt-hour. The meter outside of a home or office reads how many kilowatt-hours are used and is checked at regular intervals to determine the amount of the electric bill.

Procedure

1. Sketch a diagram of your place of residence, indicating all electrical devices.
2. Record the power rating (watts, wattage, or W) and the current (amperes, amps, or A), if given, of each electrical device.
3. Estimate the amount of time the device is used each day.
4. Use the estimated time-of-use and power rating for each device to find the amount of electricity you use for each device per day.
5. Given that the cost for electricity is in this area is approximately $0.10/kwh[1], determine the cost of operating each device for one day.
6. Now determine the total cost you spend on electricity each day.

[1] http://www.4county.org/resrates.php