Date ______ Period ______ Name ______

CHAPTER 24

Physics Lab 24-1

Safety Precautions

Materials

- compass
- DC power supply
- ammeter
- 14–18 gauge wire
- large iron nail
- knife switch
- ring stand
- ring-stand clamp
- iron filings
- cardboard sheet
- paper
- meterstick
- masking tape
- box of steel paper clips

How can a current produce a strong magnetic field?

While experimenting with electric currents in wires, Hans Christian Oersted discovered that a nearby compass needle is deflected when current passes through a wire. This deflection indicates a magnetic field around the wire. You have learned that a compass shows the direction of the magnetic field lines. Likewise, the first right-hand rule determines the direction of the magnetic field: when the right thumb points in the direction of the conventional current, the fingers point in the direction of the magnetic field.

When an electric current is carried through a loop of wire, a magnetic field appears around the loop. A wire that is looped several times forms a coil and a coil has a field like that of a permanent magnet. A coil consisting of many loops is a type of electromagnet called a solenoid. Another type of electromagnet is made by winding the coil around a soft iron core. The magnetic field produced by the current in the wire causes the iron in the core to become a temporary magnet. The magnetic field of the iron core adds to the magnetic field produced by the wire and creates a stronger magnet.

In this lab, you will investigate the magnetic field produced by current-carrying wires using a compass and iron filings. Iron filings show the shape of a magnetic field, but they also show the relative strength of the field. As field strength increases, the iron filing pattern becomes more distinct and the pattern becomes thicker as the filings bunch together.

Objectives

- **Observe** the magnetic field around a wire that carries current.
- **Demonstrate** the relationship between current and magnetic field strength.
- **Observe** the relationship between magnetic field polarity and direction of current.
- **Relate** the magnetic field strength of an iron-core coil to that of an air-core coil.

Procedure

A. The Field Around a Long, Straight Wire

1. Place the cardboard at the edge of the lab table. Arrange the wire so that it passes vertically through a hole in the center of the cardboard, as shown in Figure A. Position the ring stand and clamp so that the wire continues vertically from the hole to the clamp. Bring

the wire down the clamp and ring stand to the ammeter, and then to the positive terminal of the power supply.

2. The wire should pass vertically at least 10 cm below the cardboard before running along the table to the knife switch and then to the negative terminal of the power supply. Observe the proper polarity of the power supply and the ammeter as you connect the wires.

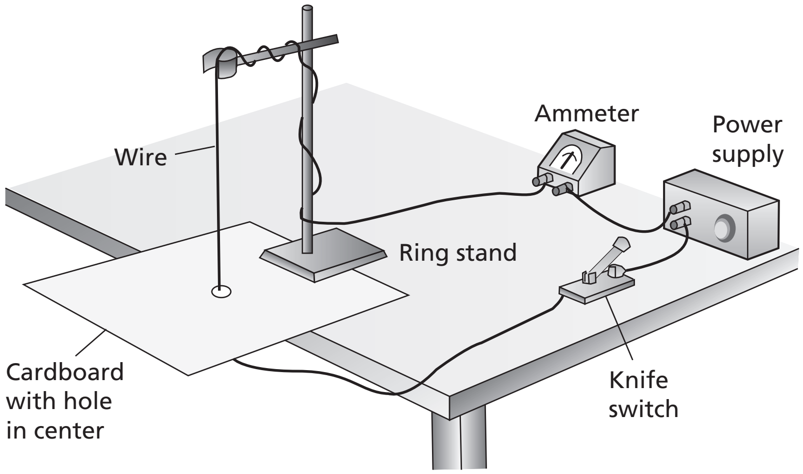

Figure A

3. Close the switch and set the current to 2–3 A. Open the switch. Place the compass next to the wire. ***CAUTION: The wire may become hot. Close the switch long enough to make your observations.*** Move the compass about the wire to map the field. In Part A of Data and Observations, sketch the field around the wire.

4. Reverse the connections at the power supply and ammeter so that the current will be in the opposite direction. Close the switch and use the compass to map the field around the wire. Sketch the field around the wire.

B. Strength of the Field

1. Make a slit and a hole in a piece of paper and put it over the cardboard with the wire at the center. Sprinkle some iron filings on the paper around the wire.

2. Close the switch and set the current to about 4.0 A. Gently tap the cardboard several times with your finger. Turn off the current. In Part B of Data and Observations, record your observations.

3. Tap the cardboard to disarrange the filings. Turn on the current and reduce it to 2.5 A. Gently tap the cardboard several times with your finger. Record your observations.

4. Tap the cardboard to disarrange the filings. Turn on the current and reduce it to 0.5 A. Gently tap the cardboard several times with your finger. Record your observations. Return the iron filings to the container.

C. The Field Around a Coil

1. Remove the straight wire from the cardboard. At the center of the wire, make three loops of wire around your hand to form a coil of wire with a diameter of approximately 10 cm. Tape the three loops together at the top, bottom, and each neck of the loops.

2. Connect the coil to the power supply through the ammeter and knife switch. Close the switch and adjust the current to 2.5 A. Hold the wire coil in a vertical plane and bring the compass near the

coil, moving it through and around the coil of wire. In Part C of Data and Observations, sketch the magnetic field direction around the coil. Show the positive and negative connections of your coil.

D. An Electromagnet

1. Uncoil your large loops. Wind loops of wire around the nail or another iron core until about half of the core is covered. Connect the coil to the power supply, knife switch, and ammeter. Close the switch and adjust the current to 1.0 A. Bring the nail near the box of paper clips and see how many paper clips the electromagnet can pick up. Open the switch and record your observations in Part D of Data and Observations.
2. Wind more turns of wire on the iron core to double the number of turns from step 1. Close the switch and see how many paper clips the electromagnet can pick up. Open the switch and record your observations.
3. Increase the current to 2.0 A and see how many paper clips the electromagnet can pick up. Record your observations.
4. Turn the current on and, using the compass, determine the polarity of the electromagnet.

Data and Observations

A. The Field Around a Long, Straight Wire

Observations of direction of north pole:

B. Strength of the Field

Observations of magnetic field with different currents:

C. The Field Around a Coil

Observations of magnetic field around a coil of current-carrying wire:

D. An Electromagnet

1. Several loops of wire on nail:

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2. Double the number of loops:

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3. Double the number of loops and double the current:

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Analysis and Conclusions

1. How does the right-hand rule apply to the current in a long, straight wire?

2. What is the effect of increasing the current in a wire?

3. In Figure B draw the magnetic field direction and the polarities for the current-carrying coil.

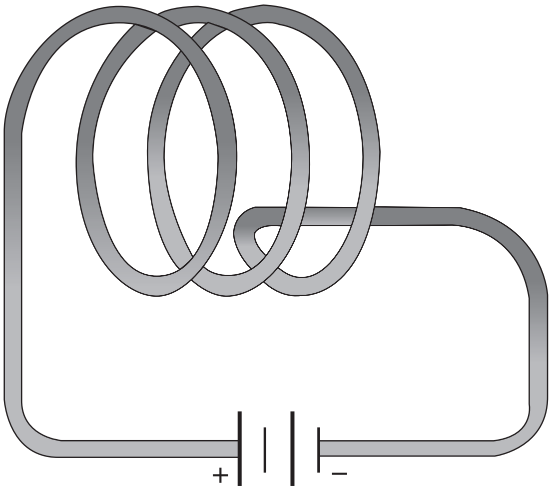

Figure B

4. What three factors determine the strength of an electromagnet?

5. Explain the difference between a bar magnet and an electromagnet.

Extension and Application

1. List several solenoid applications that operate with either continuously applied or intermittently applied currents.