Lab 24. ELECTRIC CURRENTS AND MAGNETIC FIELDS

Guiding Questions

- What causes magnetic fields?
- How do magnetic fields affect electric currents?
- What is the relationship between electric currents and magnetic fields?

Equipment

1. square conductor frame, momentary switch, wires, DC source, compasses
2. wire coil, on/off switch, wires, DC source, compass
3. swinging wire apparatus, horseshoe magnet, momentary switch, wires, DC source
4. vertical-filament incandescent bulb, light bulb socket fixture, horseshoe magnet, convex lens

Recording Observations

When you record observations in your notebook, record the experimental conditions as well as the results. The experimental conditions include, at a minimum, the identity of the apparatus (a sketch might help) and what you did with it. Do not merely refer to these instructions. The record in your lab book should be clear and complete enough for another student to reproduce your activity and compare results without consulting these instructions.

Your instructor will evaluate the quality of your notebook records when signing your notebook. This may take a while, so turn in your notebook well in advance of when you intend to leave the classroom.

Activities

Here we look at electric and magnetic fields, particularly to visualize them and understand their direction and magnitude.

This lab consists of several stations. Complete stations 1–3 before proceeding to station 4.

1. Magnetic Field Around a Straight Wire

This apparatus consists of a conducting wire wound many times around a square frame. The direction of the current through the wire can be reversed by switching the leads to the input jacks. The current is controlled by a momentary switch so that current is not used when it is not needed.

Place compasses on the platforms around the vertical segments of the wire. Before the current is turned on, all the compasses should point north, in alignment with the earth's magnetic field. If any of the compass needles do not turn freely, or if any of the compasses point south, notify the instructor so that they can be corrected. If any of the compasses point in other directions, find and remove the source of the interference.

1.1. What happens to the compasses when the current is turned on? Record your observations in your notebook.

1.2. Draw a diagram of the magnetic field around each current-carrying straight wire. Indicate the direction of the current as well as the direction of the field. Remember that a compass needle points along a tangent to the magnetic field lines.

1.3. Reverse the current through the wire. Record any effects on the compasses in your notebook.

2. Magnetic field of a solenoid

2.1. Close the switch to send current through the solenoid. Use the compass to explore the magnetic field around and within the solenoid. Note the direction of the field and also its strength. Also make sure to note which wat the current flows *along* the solenoid, and which way the current flows *around* the solenoid. Record your investigtions and results in your notebook.

2.2. Reverse the current. Explore the field as before. Note how it compares to the previous current direction.

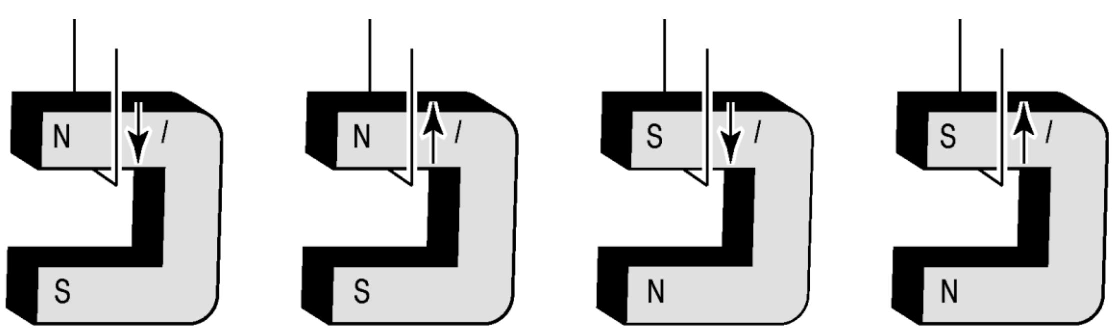
2.3. Open the switch to stop the current.

3. Magnetic Force on a Current-Carrying Wire

In this activity, a straight current-carrying wire hangs between the poles of a strong horseshoe magnet. The wire is free to swing in a direction transverse to its current. The current is controlled by a momentary switch. Use it sparingly: the short wire can carry a lot of current, and we don't want to waste power.

Check that the horizontal part of the swinging wire is roughly midway between the poles of the horseshoe magnet. If it is not, adjust the height of its platform and the placement of the magnet to make it so.

3.1 Set up all four combinations of magnet and current polarity, as shown below. For each combination, observe the direction that the wire swings when the current is turned on. Record the direction of the current, of the magnetic field at the wire, and of the force on the hanging wire in your notebook.



3.2 Return the magnet to its initial position.

4. Straight-Filament Light Bulb

The wall current powering the bulb is alternating current, which switches direction at 60 Hz. This light bulb is bright, so don't stare at it when lit. For safe viewing, project its image onto a screen or wall.

4.1 First, inspect the bulb to see how the filament is mounted. Notice the points where it is secured.

4.2 Hold the horseshoe magnet so that the filament is between the poles of the magnet. Without touching the magnet to the glass of the bulb, slowly move the magnet along the length of the filament. Is the filament affected in any way? Record your observations in your notebook.

4.3 Plug the fixture in so that the bulb lights.

4.4 Hold the hand lens to project the image of the filament onto the wall. To see how the image relates to the filament itself, move something opaque, such as your finger or a pencil, between the bulb and the screen. Relative to the orientation of the filament itself, how is the filament's image oriented?

4.5 Hold the horseshoe magnet so that the light bulb is between the poles of the magnet. Without touching the magnet to the glass of the bulb, slowly move the magnet up and down along the length of the filament. Is the filament affected in any way? What happens? Record your observations in your noteboook.

4.6 Rotate the bulb so that its filament is in a different orientation with respect to the magnetic field. Is the filament affected any differently? Record your observations in your noteboook.

Report

Abstract, Purpose

Briefly explain what you did, the information you sought from the activity, and what questions you werwe trying to answer.

Theory

Identify and explain the essential physics demonstrated by these activities.

Experimental

Describe each apparatus. Give make and model number of any commercial components.

Observations and Data

Your instructor will check these items when signing your notebook entry.

Analysis and Discussion

For each actvity, explain what you did and what you observed. Diagrams may be the best way to communicate some ideas. Answer the following questions.

1. *Straight Wire*

What is the nature of the magnetic field surrounding a straight current-carrying wire?

How are the magnetic fields resulting from opposite current directions related to each other?

Does the field near the straight wire have a north or south magnetic pole associated with it? (Magnetic field lines *diverge from* a north pole and *converge to* a south magnetic pole.)

Does the field of the entire square frame have a north and south pole associated with it?

Taking the long view, draw the magnetic field created by the entire current-carrying square loop.

2. *Solenoid*

Sketch field lines for the magnetic field created by the coil. Recall that field lines point in the direction of the field, and that they are closer together where the field is stronger. Indicate the direction of the current in the coil.

Compare and contrast the field that was present when the current direction was reversed.

3. *Swinging wire*

Draw arrows to indicate the directions of the vectors $I\vec{L}$, $\vec{B}$, $I\vec{L} \times \vec{B}$, and $\vec{F}$ in each of the four current-magnet combinations. Vectors into the page should be denoted × and vectors out of the page should be denoted •. Make it clear which vectors are which; a color code may help. If you use a color code, include a key.

Explain why the wire moved as it did when it carried a current.

4. *Incandescent filament*

Report how the filament behaved when there was no current, when there was a magnetic field and no current, when there was a current and no magnetic field, and when there was both a current ans a magnetic field. Describe any differences when the position or orientation of the magnet varied.

Explain your observations in terms of what we have learned about electric charges, electric currents, and magnetic fields.

Conclusion

What did these activities demonstrate about the relationship between electric currents and magnetic fields?