Lab 8. STEADY CURRENTS AND MAGNETIC FIELDS

1. Guiding Questions

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

2. 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

3. Activities

Here we look at electric and magnetic fields, particularly to visualize them and understand the direction and magnitude of forces on items subject to the fields.

This lab consists of several stations. You may do them in any order.

1. Magnetic Field Around a Straight Wire

Compasses should be placed 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 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?

1.2. Draw a diagram of the magnetic field around both current-carrying straight wires. 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. What happens to the shape and direction of the magnetic field when the current through the wire is reversed?

1.4. Does the field close to 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.)

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

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

2. Magnetic field of a solenoid

Close the switch to send current through the solenoid. Use the compass to map the magnetic field around and within the solenoid. Note the direction of the field and also its strength. (How quickly does the compass needle swing around, and how quickly does it settle down?)

2.1. 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.

2.2. Reverse the current. Explore the field as before. How does it compare to the previous current direction?

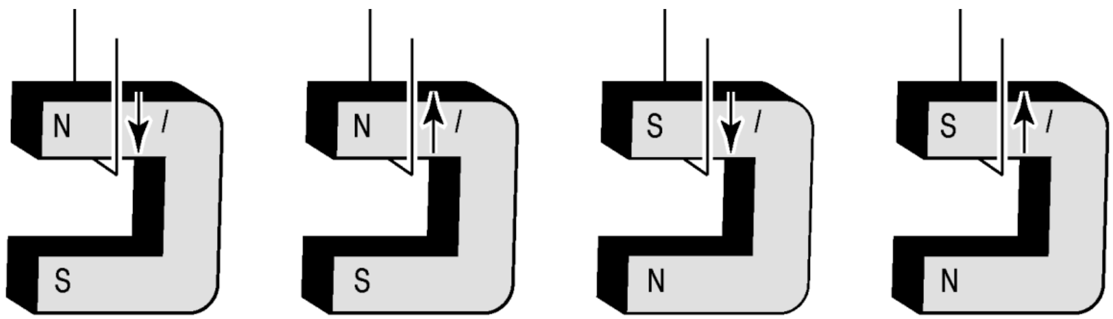
Open the switch to stop the current.

3. *Magnetic Force on a Current-Carrying Wire*

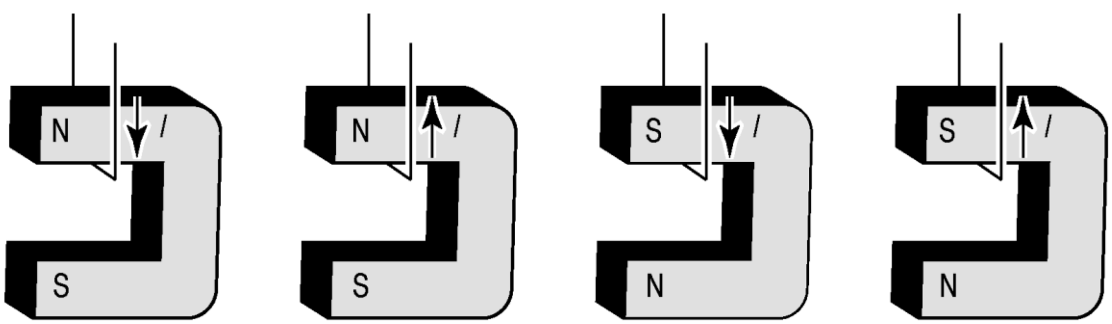
In this activity, a straight current-carrying wire hangs between the poles of a strong horseshoe magnet. The wire is free to swing in a direction transverse to its current. The current is controlled by a momentary switch (telegraph key). Use it sparingly! The short wire can carry a lot of current, and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

Check that the horizontal part of the swinging wire is 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, what direction does the wire swing when the current is turned on? Draw arrows on the diagrams below to indicate.



3.2 What are the directions of the vectors $I\vec{L}$, $\vec{B}$, and $I\vec{L}\times\vec{B}$ in each of the four combinations? Draw arrows to indicate them. All of these vectors vary with position, so confine your attention to the region between the poles of the magnet, where the current and field most strongly interact. 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.



3.3. What can you do to reverse the direction that the wire swings?

Return the strong magnet to its position.

4. Straight-Filament Light Bulb

This light bulb is bright, so don't stare at it when lit. For safe viewing, project its image onto a screen or wall.

The wall current powering the bulb is alternating current, which switches direction at 60 Hz.

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? What happens?

4.3 Plug the fixture in so that it 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. How is the filament's image oriented?

4.5 Hold the horseshoe magnet so that the filament of the light bulb runs 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? What happens?

4.6 Rotate the bulb so that the direction of the magnetic field across the filament changes. Is the filament affected any differently?