  Investigation 23

Magnetic Field of a Current

How can you determine that electrical current exists within a conductor? And, how do you determine how much current there is? This is important, since currents greater than 0.005 ampere cause pain when passing through human bodies, and only 0.050 ampere of current is extremely dangerous. Placing a simple ammeter or current sensor in series in a “live” circuit has the potential to be highly hazardous, depending on conditions.

Preliminary Observations

Part I

Use the magnetic compass to determine the direction of north in your classroom. Create a circuit with a light bulb and the meter-long piece of wire, connected to 3 V of potential difference. Stretch the long wire out so that a portion of it is straight and aligned with the north-south direction, and spread the circuit out so the straight segment is as far as you can get it from the rest of the circuit, as in Figure 1. Tape the wire to the table, if necessary. Place the compass underneath the wire as in Figure 2, and disconnect the wire from the battery to open the circuit. Ensure that the wire is aligned with the compass needle, adjusting the tape as necessary.

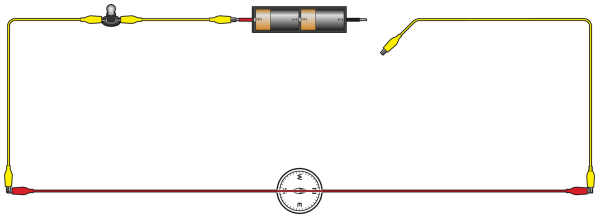


Figure 1

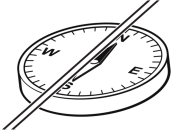


Figure 2

Re-connect the circuit, and observe the compass needle. Also make observations with the compass on top of the wire instead of underneath. Discuss what the compass indicates about the direction of the magnetic field relative to the wire. What can you change to investigate further? Do so.

Part II

Align the long wire so that it is vertical, and passing through a small hole in a piece of cardboard. Place the magnetic compass flat on the cardboard near the wire, as in Figure 3.  Observe what happens as you move the compass around the wire and towards and away from it, both with the circuit open and closed. Discuss how the results of Part I match (or don't match) the results of Part II.

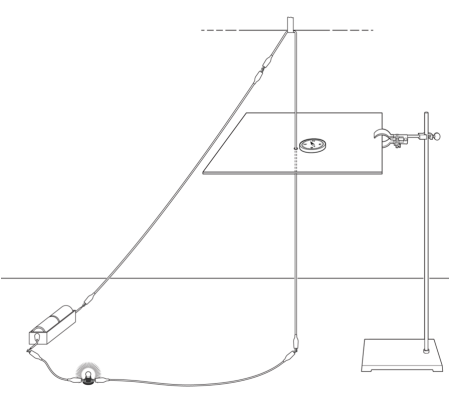


Figure 3

Procedure

1. We have observed that a compass needle aligned along a wire is deflected from magnetic north when the wire carries current. Discuss and decide on what variables you will measure to model the magnetic field of a straight current-carrying wire.
   * Consider your available tools and choose reasonable variables.
   * Remember there can be only one dependent variable.
2. Develop a purpose and a procedure for your investigation.
   * Your purpose should ask a question or propose a relationship between variables.
   * Include the measurement equipment you will use.
   * Decide how much data to take in order to have enough information to satisfy your purpose and stand up to questioning by your peers.
   * Remember to change only one independent variable at a time.
3. Carry out the investigation.

Analysis

Is the graph of variables you measured a linear graph? If not, you may need to perform one or more mathematical operations on your data. Develop a mathematical model for your data and discuss with your group how your variables fit into the model. When you discuss the results with your class, be sure to share your model and ideas. You may wish to do some research.

Extensions

1. Investigate magnetic fields surrounding another configuration of wire, such as a circular loop or a circular coil of wire, or a helical coil of wire.
2. Borrow a clamp-style ammeter that electricians use. Explore how this device works and research its limitations.
3. Use the results of your experiment to calculate the value of µ0. Compare your calculated value to the accepted value of 1.2566 × 10-7 T·m/A.