NAME PERIOD DATE

10. MAGNETIC FIELDS

STRUCTURED

Driving Question | Objective

How do the characteristics of the magnetic field created by a bar magnet and a current-carrying coil differ? Determine the shape (including direction) of the magnetic fields created by a bar magnet and a current-carrying coil, and then compare the two, outlining the distinct differences and similarities between them.

Materials and Equipment

- PASCO AC/DC Electronics Laboratory[1]
- Magnaprobe™ wand
- Power supply, 18-VDC, 3-A
- Bar magnet
- Magnet wire or enameled wire (4 m), 22-gauge
- Appendix Parts 1 and 2
- Sandpaper
- Scissors or wire cutters
- Beaker, 400-mL
- Wire lead
- Banana plug patch cord (2), 4-mm

[1]www.pasco.com/ap04

PASCO AC/DC
Electronics Laboratory

Background

Sources of magnetic fields include permanent magnets and moving electrically charged objects, such as a current-carrying wire. Like electric fields, magnetic fields have direction. While electric field direction is determined by the distribution of positive and negative charges, magnetic field direction is determined by magnetic domains, which we label as *north* and *south*.

The direction and shape of a magnetic field can be determined by observing the direction in which a smaller magnet aligns itself in the field, similar to the pointer in a compass aligning to the earth's magnetic field. Use this technique with a Magnaprobe™ wand to determine the shapes and directions of the magnetic fields created by a bar magnet and a current-carrying coil, and then compare the two fields.

Safety

Follow these important safety precautions in addition to your regular classroom procedures:

- Do not allow current to flow through the wires any longer than a few seconds. The wires (and possibly the power supply) can become hot and cause burns and damage equipment.
- Handle the magnets carefully. When held near each other, the magnets can suddenly snap together and pinch fingers.
- Keep the magnets away from electronic devices.

Procedure

Part 1 – Magnetic Field around a Bar Magnet

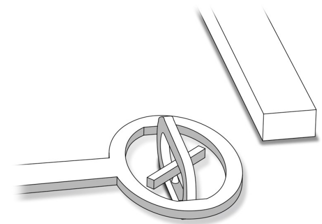
SET UP

1. Remove the two Appendix pages from the end of this activity handout and set the second page (Part 2) aside.

2. Place the bar magnet in the center of the dashed area on the Part 1 appendix page, making sure that the polarity (N or S) of each end of the magnet is aligned with the markings provided on the paper.

COLLECT DATA

3. Hold the probe end of the Magnaprobe wand at some point near the magnet, close to the paper, and observe how the small magnet probe aligns itself in the field of the bar magnet. The north pole of the probe (colored red) indicates the direction of the field.



4. Beneath the probe, draw a small arrow (about the length of the magnet on the wand) with the arrow pointing in the direction of the field.

5. Repeat this for other points around the magnet until the area bordered by the dashed lines is filled with arrows. Keep the arrows evenly spaced (do not clump arrows) and include a sufficient number to identify the patterns of the magnetic field.

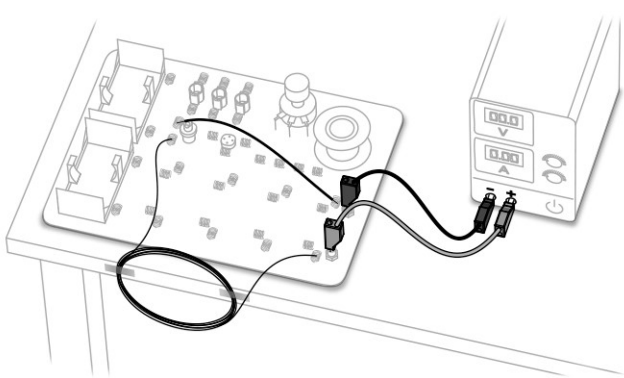
Part 2 – Magnetic Field around a Current-Carrying Coil

SET UP

6. Wrap the magnet (or enameled) wire 10 times around the beaker, forming a coil. Use scissors or wire cutters to leave about 20 cm of straight wire on each end, and then use sandpaper to sand off about 1 cm of insulation from the tips of each end of the wire.

7. Carefully slip the coil off the beaker and tape it to the edge of a table so half of the coil sits above the edge of the table.

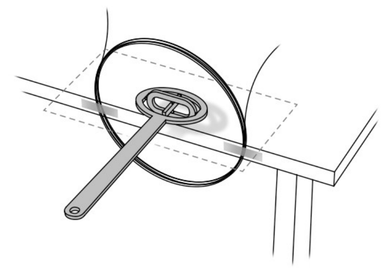
8. Connect the power supply, coil, and switch on the AC/DC Electronics Board as shown.



9. Turn the power supply on, press and hold the switch on the circuit board, and adjust the power supply so that 3.0 A of current is output to the coil. Release the switch after the adjustment is complete.

   CAUTION: Do not hold the switch for more than a few seconds. Repeatedly press the switch to adjust the power supply if needed, waiting 1–2 seconds in between adjustments.

COLLECT DATA



10. Observe the figure on the Part 2 appendix page. For your measurements in this part, hold the probe only in the plane perpendicular to the coil, as shown in the figure.

11. Hold the probe near the coil (in the plane perpendicular to it), and then press and hold the switch. Observe the orientation of the probe as it aligns itself in the magnetic field of the current-carrying coil. Release the switch.

    CAUTION: Do not hold the switch for more than a few seconds.

12. Draw an arrow in the blank plane on the Part 2 appendix page to represent the position and direction of the field while current was flowing through the coil. Also indicate the direction of current through the coil, using the convention of current flowing from positive to negative.

13. Repeat this for other points around and within the current-carrying coil until the dashed area is filled with arrows. Keep the arrows evenly spaced (do not clump arrows) and include a sufficient number to identify the patterns of the magnetic field.

Data Analysis

Part 1 – Magnetic Field around a Bar Magnet

Submit Appendix Part 1 showing the magnetic field lines of the bar magnet with your lab report.

Part 2 – Magnetic Field around a Current-Carrying Coil

Submit Appendix Part 2 showing the magnetic field lines of the current-carrying coil with your lab report.

Analysis Questions

❷ 1. How does the magnetic field pattern created by a bar magnet compare to the magnetic field pattern created by a current-carrying coil? What are some of the significant differences and similarities between them?

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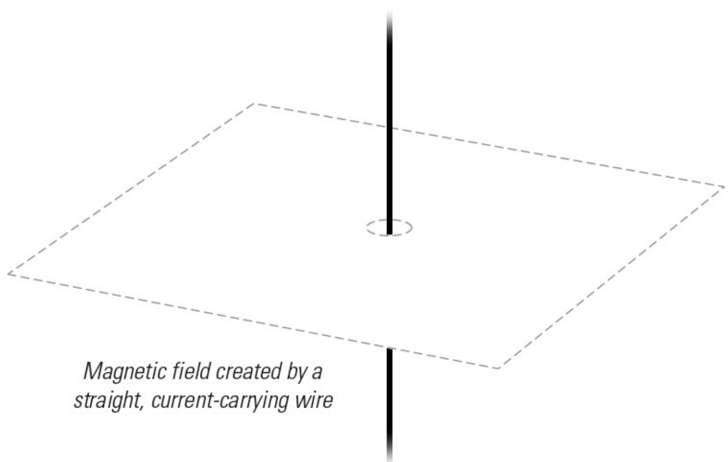
❷ 2. Describe how the coil used in your experiment could be rearranged or bent to create a magnetic field more closely resembling a field created by a bar magnet. Explain why you chose the bends and rearrangement that you did.

❷ 3. Based on your exploration of the magnetic fields using the Magnaprobe wand, where did each magnetic field seem to be strongest? How did you come to these conclusions?

❷ 4. If the coil in your experiment was unwound to create a very long, straight wire, what would the magnetic field look like in a plane perpendicular to the wire? Draw arrows in the diagram below to represent the magnetic field surrounding the wire when the current is directed upward.

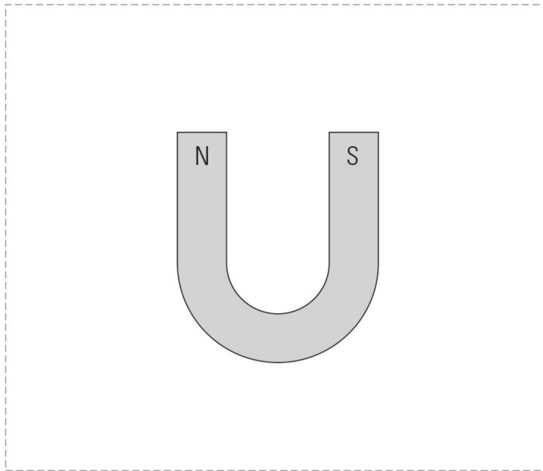


Magnetic field created by a straight, current-carrying wire

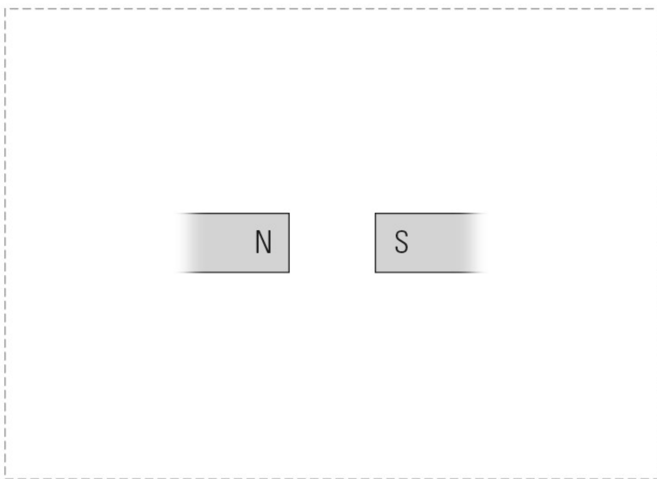
Synthesis Questions

1. Three arrangements of bar magnets are shown below. Draw the resultant magnetic field around the poles for each case.

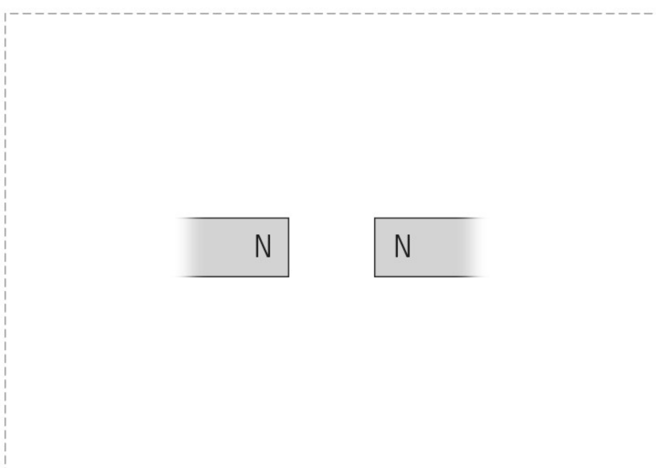
   a. Horseshoe magnet



   b. North pole facing a south pole

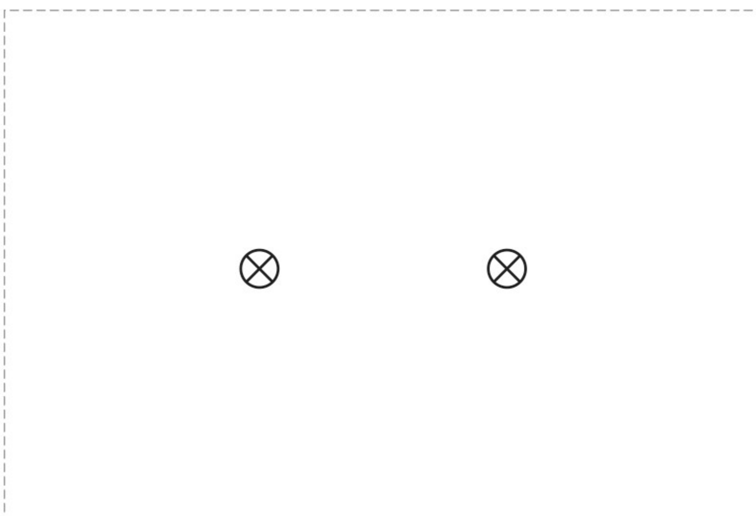


   c. North pole facing a north pole



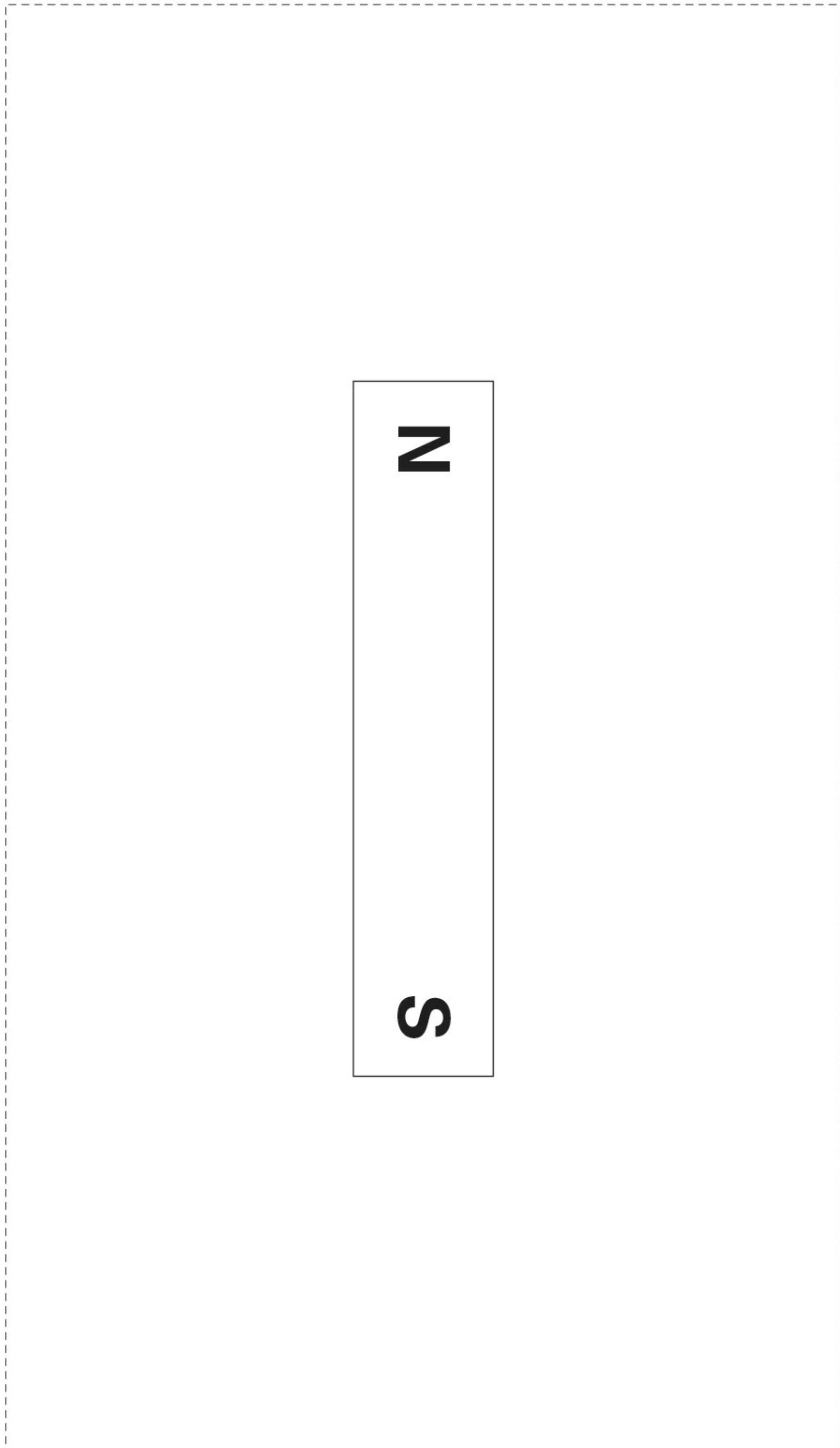
2. The symbols below represent two current-carrying wires extending vertically through the page (perpendicular to the surface of this page). ⊗ represents current flowing *into the page*, and ⊙ represents current flowing *out of the page*. Assuming that the magnitude of the current is the same in both wires, draw the magnetic field surrounding and between them.

3. The symbols below represent two current-carrying wires extending vertically through the page (perpendicular to the surface of this page), except now the current in both wires is flowing into the page. Assuming that the magnitude of the current is the same in both wires, draw the magnetic field surrounding (and between) them.



Appendix

Part 1 – Magnetic Field around a Bar Magnet



Magnetic field around a bar magnet

Part 2 – Magnetic Field around a Current-Carrying Coil