Magnetic fields

Physics 225 – Week 9 activity

LEARNING OBJECTIVES

- Perform basic error analysis/propagation.
- Perform graphical analysis of data, including a variety of functional fits (e.g. linear, parabolic, power law).
- Measure and map magnetic field.
- Write a formal lab report.

BEFORE, DURING, AFTER

1. Before the experiment, read this document and finish the prelab on Blackboard.
2. During the experiment, take notes in your lab notebook.
3. After the experiment, collaborate with your team on a post-lab report.

RESEARCH QUESTIONS

The goal in this lab is to test the superposition of magnetic fields. Here are questions that you will answer using this lab's materials:

① How does the magnetic field from a single coil vary with position? What about a pair of coils?

② Is the magnetic field from two coils the vector sum of the fields from the individual coils?

RESOURCES

Lab documents:

Materials list and safety notes:
https://drive.google.com/open?id=1lTeitBIXMnLPjehR5YlA_l-rcMpNTFxn

Details about the magnetic field produced by the coils and superposition:
https://drive.google.com/open?id=1lN891Uf3cSM9mNm7el0nmafasTImquPJ

Recommended web resources:

Webpage: Has the equation for fields from coils and a helpful graph showing the magnetic fields adding up from two coils. https://www.didaktik.physik.uni-muenchen.de/elektronenbahnen/en/b-feld/B-Feld/Helmholtzspulenpaar.php

Video: From Michael Melloch, auto-captions, 12:44. The first three minutes show a miniature version of the setup we use for a single coil.
https://www.youtube.com/watch?v=bq6IhapfucE

Other resources

Randall Knight, Physics for Scientists and Engineers: A Strategic Approach, 4 th ed. (Pearson, 2017), Chapter 29.

EXPLORE QUALITATIVELY

Be careful to use the 10A port/A setting on the dial on your multimeter to measure currents, which may reach several amps in this lab.

❶ Add magnetic field graph paper to the plastic table. Connect the power supply to one coil. Use a compass to measure the direction of the magnetic field at many points on the grid and draw arrows on your paper. Create a "map" of the field direction. Does the right-hand rule for a current-carrying coil hold?

❷ Repeat with current applied to the other coil, then to both coils. Continue mapping magnetic field direction. Some notes:

- The currents in the coils can flow in the same (parallel) or opposite (anti-parallel) direction, but you should use the same choice in this section and the following quantitative section.
- Use different color pens/pencils to distinguish between fields for each coil and the combination (include a color key).

Use your map (coil 1, coil 2, and both) to explain field superposition. (That is, does it look like the fields from 1 and 2 add up to match the field from both?)

Your group post-lab report should include an image and discussion of your magnetic field map.

EXPLORE QUANTITATIVELY

MEASURE THE FIELD FROM A SINGLE COIL

Use the field probe to measure the Earth's magnetic field. See if you can determine the field's direction by finding the strongest magnitude. When you are ready to take any measurements, make sure you zero the sensor to subtract Earth's field from your data.

❶ Measure the magnetic field as a function of position for points along the axis with current running through a single coil. You should include measurements over the axis from one end of the table to the other. Position can be measured using the half-meter stick under the plastic table.

CHECK SUPERPOSITION OF FIELDS, AS A FUNCTION OF POSITION

❷ Repeat the measurement for current only in the second coil, then for current in both coils. Check that current in the coils is the same in all these trials.

Combine all the field vs. position data on one graph and use it to discuss superposition--whether the field from both coils is the same as coil 1 added to coil 2.

Compare your results with the theoretical results expected for a multiple-turn current-carrying loop.

DELIVERABLES

As a group, use the Lab Work Submission form to finish the post-lab activity. Save your work as a PDF file, and then submit it on Blackboard.