Lab Combine – Magnetic Fields and Electromagnets

Overview

You will be working on a combination lab this week. The objective is to build a magnet. This may seem a little weird – don't you just go buy a magnet? If you have not ever built an electromagnet you will appreciate the experience. You have already seen that a moving charge produces a magnetic field. This is the first half of a fundamental connection between electricity and magnetism!

Equipment

- Battery (D-cell), wire, nail, permanent magnet, paperclips
- Battery eliminator, DMM
- VPython, Python and the graphical user interface (GUI) IDLE

Objective

Physics Concepts

- Magnetic field from moving charges
- Electromagnetism

Gain experience writing VPython programs

- Use new command: cross()
- Effectively use reference manuals

Clearly express assumptions and limits to models

Directions for Electromagnet:

- Wind insulated wire around an iron nail.
- Connect ends of wire (with insulation removed) to battery
- Voila! You have a magnet.

Conceptual (C-Level)

A 1.0 cm radius ring has a current of 0.25A flowing in it. Assume the ring lies in the x-y plane centered at the origin. Determine the magnetic field at an arbitrary point $\vec{r} =< 4,5,0 >$.

1. Break the ring into 8 segments.
2. Write down an expression for the (unit) vector for each segment.
3. Write down an expression for the cross product of each segment with the observation point.
4. Write down an expression for the total magnetic field as a sum of the magnetic fields produced by the eight segments.
5. Determine a generalization for N segments.

Basic Lab (B-Level)

Magnets and Electromagnets:

- How many different ways can you use a nail to pick up a paperclip? (Hooking the paperclip on the tip of the nail does not really count)
- Determine the magnetic field strength for your electromagnet. Compare your theory with measurement.
- Use Vpython to graphically represent the net magnetic field created by the ring and current specified above. You must demonstrate (run) working code for full credit.
- Is it better to have more windings along the nail (long solenoid) or more windings that are concentric? Assume the length of your windings – i.e. the length of the wire – is constant

- Why is a battery better than a battery eliminator (power supply)?
- Watch the temperature of circuit components.
- How can you increase the amount of paperclips your electromagnet can pick up?
- What purpose does the nail serve?

Advanced/Extended Lab Ideas (A-Level)

- Extra Credit