

Transformed E&M I materials

Magnetization – diamagnetic, paramagnets, ferromagnets (Griffiths Chapter 5)

TIMELINE

Prof A covers this in lectures 37,41.

Prof B. covers this in lecture38.

Transformed course covered in lectures 39-42

LEARNING GOALS

1. Students should be able to calculate the torque on a magnetic dipole in a magnetic field.
 2. Students should be able to explain the difference between para, dia, and ferromagnets, and predict how they will behave in a magnetic field.
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CLASS ACTIVITIES

Magnetization

Discussion

Magz toys

I also brought some strong magnets and Magz toys - the magz are dipoles, and I used them to engage in a class discussion of "how do you know this is NOT just electrostatics". They would come up with solutions ("you can't ground it, if it was electric you could") which I tried to counter ("it's coated in a thin plastic film") ("So scrape off the plastic"-> "Maybe it's an electret") ("If you cut it in half, you get two smaller magnets" -> "As I said, maybe it's an electret"...)

Group Activity

Polarization and Magnetization

Start of class, asked them to write down (on paper) everything they could remember about P (electric polarization). ~3 minutes for that. Then, got in groups of three (new groups, this time!) and went to *boards* (so we had 6 groups, each group got one "board section") and they had to write down what their group came up with. ~5 minutes for that. Then the "scribes" sat down, we picked the nicest handwriting to go first, and they read/explained what they had done. Other groups erased what they had that was duplicated, and we argued when groups had disagreements (e.g. if there is an ϵ_0 in the formula $P = \chi \epsilon_0 E$, if there is a minus sign in $\rho_{bound} = -\nabla \cdot P$, etc.) until all groups had presented. In the end, we had reviewed much of Chapter 4, and the analogies to Ch 5 (magnetization) were on everyone's fingertips. Took a little long (~20 minutes) but was fun, seemed pretty worthwhile. Many old formulas and ideas got "dredged up", they hit almost everything except the integral formulas for potential.

Simulations

B field and magnets

Activities: Had several MIT sim/quicktimes, showing B field for falling superconducting ring onto a magnet (or vice versa, or with finite resistance) See <http://web.mit.edu/8.02t/www/802TEAL3D/visualizations/faraday/index.htm> and "Activity Resources" folder.

Demo

Floating Magnet above another magnet

"Magnet floating above another magnet" demo (which provoked some questions and discussion - what determines the height, how does it scale, what happens if you let TWO strong magnets "stick" and then try to float them...)

Demo

Solenoid

Also brought in a solenoidal electromagnet and nails, to introduce ferromagnets.

Demo

Barkhausen Effect

(CU Demo # 5G20.10)

Hear the sound of magnetic domains aligning themselves.

Demo

Permalloy Bar and Tape

(CU Demo # 5G20.55)

A bar will attract wire when aligned with the earth's magnetic field, and not when it is not. The effect is possible due to the high permeability of the alloy.

Demo

Diamagnetism and paramagnetism

(CU Demo # 5G30.11)

See how diamagnetic and paramagnet align in different directions with B field.

Dipoles

Whiteboard/paper

Dipoles

I put up the FORMULA for the B field from an ideal magnetic dipole (from Griffiths), and asked them to sketch it, as well as sketching the field for a *real* current loop of finite radius, and think about the differences. Gave about 5 minutes for this, they did it on paper but talked to each other. It was a very useful exercise - we'd done this before for the electric dipole (same thing!) but they STILL struggled in a variety of ways. Some (most) "knew the answer" either from memory or their heuristics about fields around rings, but they were not good about seeing the connection to the formula. I poked some groups with questions like "on the x axis, at very small x, what is the direction of B for the two cases (ideal and real), and can you reconcile these"?)