**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.

**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 epsilon\_0 in the formula P = xi\*E\*epsilon0, if if there is a minus sign in rho\_bound = -? del.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"?)