**Transformed E&M I materials**

**Polarization and Fields of Polarized Objects**

**Linear Dielectrics**

 **(Griffiths Chapter 4)**

**TIMELINE**

Prof A covers this in lectures 21-23

Prof B. covers this in lecture21 and 24.

Transformed course covered in lectures 22-23.

**LEARNING GOALS**

Polarization and dielectrics

1. Students should be able to go between two representations of dipoles – as point charges, and as generalized dipole vectors – for simple charge configurations.
2. Students should be able to calculate the dipole moment of a simple charge distribution.
3. Students should be able to describe similarities and differences between a conductor and a dielectric (both shield E, conductor shields E completely, dielectric shields via fixed dipoles, conductor shields via mobile electrons).
4. Students should be able to predict whether a particular pattern of polarization will result in bound surface and/or volume charge
5. Students should be able to explain the physical origin of bound charge at a macroscopic and microscopic level.

Field of a polarized object

1. Students should be able to sketch the E field inside and outside a dielectric sphere placed in an electric field.
2. Students should be able to explain what happens to a dielectric, when it is placed in an electric field.
3. Students should be able to explain the difference between free and bound charge.
4. Students should be able to identify the appropriate boundary conditions on D given its relationship to E and Qf.

Linear dielectrics

1. Students should be able to articulate the difference between a linear and nonlinear dielectric.
2. Students should be able to write down Maxwell’s equations (for electrostatics) in matter, when given the appropriate equations in vacuum.

**CLASS ACTIVITIES**

**Whiteboard**

**Dipole field**

Sketch the E field from an ideal dipole, given the formula (and from a real dipole)

**Demo**

**Charged rods and water**

(CU Demo # 5A40.40)

<http://physicslearning.colorado.edu/website_new/Common/ViewDemonstration.asp?Topic=5&SubSubtopic=5A40.40&DemoCode=5A40.40>

Demonstrate the deflection of water with a charged rod, indicating that it is polarizeable. Note the HW problem on the same topic.

**Tutorial**

**Electric Fields in Matter**

**Paul van Kampen – Dublin University (Tutorials 9-16, page 14)**

Electric Fields in Matter tutorial. Calculate polarization of hydrogen atom, potential near a dipole, expand for small r, put into spherical coordinates.

**Whiteboard**

**Charged fluid**

Imagine two fluids, red (positive) and blue (negative), each uniform, identical, in a rectangular shape (area A, height H). This fluid is made up from N "atoms"/m^3, and each "atom" (or unit) has available a charge q (which can separate/move). Imagine the red fluid moves UP the page, uniformly, a distance "d". For them to work out

1) How much charge Q appears on the top surface? (How much on the bottom? the sides?)

2) What is sigma on the top, in terms of the given variables (N, q, d, A, and/or H)

3) What is the polarization P in terms of those variables?

4) What is sigma on the top in terms of P?=

5) What if we displace the fluid that same distance "d", but at an angle theta with respect to the vertical. What are the answers above?

Purpose was for THEM to derive sigma(bound) = P dot nhat. Took about 10 minutes, 10/12 whiteboards we looked at afterwards had gotton through part 4 correctly, and a few had dealt with the theta story. Many had a hard time getting started, visualizing the story, deciding if "q" was all the info they needed or if there was some OTHER "charge" needed. Some were confused about whether or not "H" plays a role, (e.g. a couple thought the polarization P should be calculated by looking only at the top and bottom sheets, and the distance H between them)

**Demo**

**Polarize coke can**

Activities: I brought rods (+ and -), an empty coke can to attract, a small smooth plastic wine cork (which CAN be budged, although friction is high so it doesn't do much, but that's really part of the point) and I brought a small low friction pivot (from Mike Thomason, it's used to put a bar magnet on, but I just laid a 1 meter wooden stick on it, and was able to get enough torque to easily move it around by attraction through polarization) Also brought an electroscope to show sign of charges.

**Demo**

**Faraday’s Ice Pail**

(CU Demo # 5B20.10)

Charge is transferred to a conductor. Glass jar, filled with conducting water, wrap in al foil and charge. Capacitor. Remove glass jar from Al foil and pour out water. Another one… the glass jar has an induced polarization and that’s stored and it discharges into new one. Nice intro to polarization.

**Griffiths by Inquiry (Lab 7): Dielectric materials**

**Griffiths by Inquiry (Lab 8): Dielectrics II**

**Tutorial**

**Polarization of hydrogen atom**

***Paul van Kampen – Dublin University (Tutorials 9-16, page 14)***

In document “Tutorials 9-16”

Calculate polarization of hydrogen atom, potential near a dipole, expand for small r, put into spherical coordinates.