

Transformed E&M I materials

Conductors + Capacitors (Griffiths Chapter 2)

TIMELINE

Prof A covers this in lectures 8 & 9.

Prof .B covers this in lecture 9 & 10.

Transformed course covered in lectures 10-12

LEARNING GOALS

- Students should be able to sketch the induced charge distribution on a conductor placed in an electric field.
 - Students should be able to explain what happens to a conductor when it is placed in an electric field, and sketch the E field inside and outside a conducting sphere placed in an electric field.
 - Students should be able to explain how conductors shield electric fields, and describe the consequences of this fact in particular physical problems (e.g., conductors with cavities).
 - Students should be able to state that conductors are equipotentials, that $E=0$ inside a conductor, that E is perpendicular to the surface of a conductor (just outside the conductor), and that all charge resides on the surface of a conductor.
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CLASS ACTIVITIES

Whiteboard

E in cubical conductor

We whiteboarded the E field in a cubical conductor with a cubical cavity, with a $+Q$ on the outside. Not enough time to finish!

Discussion

Questions for Lecture (from UIUC)

1.) Important properties of a (good) electrical conductor are that: any free (or induced) electric charges must reside on the *surface* of the conductor. Why?

2.) Why is the boundary condition $\frac{\partial V}{\partial r}|_{\text{surface}}$ physically equivalent to specifying the electric field $E(r)|_{\text{surface}}$ at the surface of the conductor?

Visualization

Conductors

I showed them <http://www.falstad.com/emstatic/>, but it was just at the end of class. See next Wed for more details! Prep it ahead of class: Setup was "conducting box". You must first set mouse = "make floater", then make the box floating potential, then set mouse = "adjust voltage", and adjust the voltage to zero. (It helps to temporarily increase brightness to REALLY set voltage=0) Then finally, turn brightness back down, and set mouse = add +draggable charge. You can put the charge outside, or drag it inside the box - you can see the polarization of the box, you can see the shielding, and the "shielding of position information" when Q is inside.

Then, I switched the setup to "charge and plane", which is a great setup for the method of images problem. And after SOLVING method of images, you can instantly "flip" the sim from "charge and plane" to dipole, it works great, you can visibly see that the E field on the upper half of the screen is unchanged!

Kinesthetic

Room as a conductor

I reviewed last class by imagining one wall of the room a giant conductor at 0 V, the other a giant conductor at +100 V, and we "visualized" the e field and equipotential planes in the room.

Demo

Leyden Jar

(CU Demo # 5C30.05)

Energy of a capacitor. The jars hold a charge even after having been dissembled and reassembled.

Demo

Electrophorus

(CU Demo # 5A10.20)

The lecture demo area has a historical electrophorus, or you can make your own with pie plates and Styrofoam

(http://www.exo.net/~pauld/summer_institute/summer_day14electrostatic/Electrophorus.html). Students rub wool on Styrofoam to charge it, and then transfer the charge to a metal plate via polarization. Some of the questions that arise in this

activity are quite deep regarding the nature of insulators and conductors. It can also be a challenge for students to explain the process of charging the aluminum plate.

Demo

Charge distribution

(CU Demo # 5B30.20)

The effect of surface curvature on charge distribution is demonstrated with a curved metal body.

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.

Demo

Electric Whirlie

(CU Demo # 5B30.50)

A "whirlie" is placed on top of the van de Graaf generator, and it will spin due to repulsions of the ions produced by electrical discharge.

Worksheet

Taylor Series

Dawn Meredith – Meaning in Mathematics

Taylor series; worksheet (this is not really guided inquiry, but hits some key confusions). Reminds students of how to find Taylor series and convergence issues; introduces the idea that the expansion variable must be unitless; does an example; gives a practice problem