If you put a dielectric in an external field $\mathbf{E}_e$, it polarizes, adding a new field, $\mathbf{E}_p$ (from the bound charges). These superpose, making a total field, $\mathbf{E}_T$. What is the vector equation relating these three fields?

A. $\mathbf{E}_T + \mathbf{E}_e + \mathbf{E}_p = 0$
B. $\mathbf{E}_T = \mathbf{E}_e - \mathbf{E}_p$
C. $\mathbf{E}_T = \mathbf{E}_e + \mathbf{E}_p$
D. $\mathbf{E}_T = -\mathbf{E}_e + \mathbf{E}_p$
E. Something else

ANNOUNCEMENTS

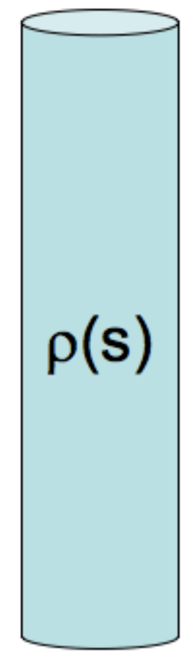
- Exam 2 (Wednesday, October 8th 7-9pm)
- Covers through Homework 9 (solutions posted after class)
- "Comprehensive" exam (need to remember old stuff)
- 1 sheet of your own notes; formula sheet posted

WHAT'S ON EXAM 2?

- Using Legendre polynomials and separation of variables in spherical coordinates, solve for the potential and distribution of charge in a boundary value problem
- Using the multipole expansion, find the approximate form of the potential for a distribution of charge
- Determine the bound charge in a material with a given polarization
- Find the electric potential for a 1D Laplace problem and explain how you would determine it using the method of relaxation
- (BONUS) Solve a 3D Laplace problem in Cartesian coordinates

A solid non-conducting dielectric rod has been injected ("doped") with a fixed, known charge distribution $\rho(s)$. (The material responds, polarizing internally.)

When computing D in the rod, do you treat this $\rho(s)$ as the "free charges" or "bound charges"?



A. "free charge"
B. "bound charge"
C. Neither of these - $\rho(s)$ is some combination of free and bound
D. Something else.

We define "Electric Displacement" or "D" field,

$$\mathbf{D} = \varepsilon_0 \mathbf{E} + \mathbf{P}$$

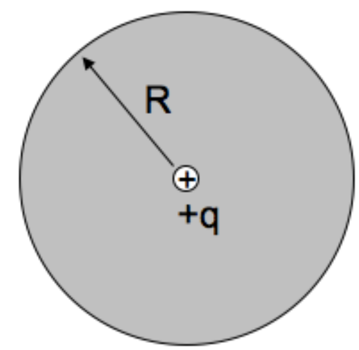
If you put a dielectric in an **external** field, it polarizes, adding a new **induced** field (from the bound charges). These superpose, making a **total** electric field. Which of these three E fields is the "E" in the formula for D above?

A. $\mathbf{E}_{ext}$
B. $\mathbf{E}_{induced}$
C. $\mathbf{E}_{tot}$

We define $\mathbf{D} = \varepsilon_0 \mathbf{E} + \mathbf{P}$, with

$$\oint \mathbf{D} \cdot d\mathbf{A} = Q_{free}$$

A point charge $+q$ is placed at the center of a dielectric sphere (radius R). There are no other free charges anywhere. What is $|\mathbf{D}(r)|$?



A. $q/(4\pi r^2)$ everywhere
B. $q/(4\varepsilon_0 \pi r^2)$ everywhere
C. $q/(4\pi r^2)$ for $r < R$, but $q/(4\varepsilon_0 \pi r^2)$ for $r > R$
D. None of the above, it's more complicated
E. We need more info to answer!

For linear dielectrics the relationship between the polarization, $\mathbf{P}$, and the total electric field, $\mathbf{E}$, is given by:

$$\mathbf{P} = \varepsilon_0 \chi_e \mathbf{E}$$

where X_e is typically a known constant. Think about what happens if (1) $X_e \rightarrow 0$ or if (2) $X_e \rightarrow \infty$. What do each of these limits describe?

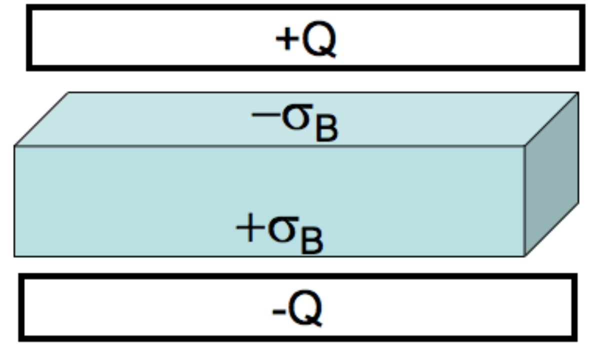
A. (1) describes a metal and (2) describes vacuum
B. (1) describes vacuum and (2) describes a metal
C. Any material can gave either $X_e \rightarrow 0$ or $X_e \rightarrow \infty$

When there are no free charges, ρ_{free} = 0, in a linear dielectric material, the electric potential, V, in that material satisfies Laplace's equation?

$$\nabla^2 V = 0$$

A. True
B. False
C. ???

A very large (effectively infinite) capacitor has charge Q. A neutral (*homogeneous*) dielectric is inserted into the gap (and of course, it will polarize). We want to find $\mathbf{E}$ everywhere.



Which equation would you head to first?

A. $\mathbf{D} = \varepsilon_0 \mathbf{E} + \mathbf{P}$

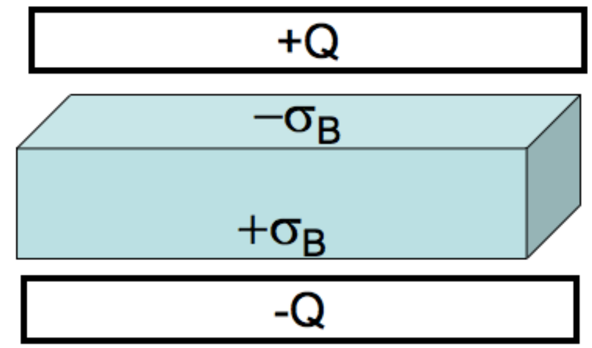
B. $\oint \mathbf{D} \cdot d\mathbf{A} = Q_{free}$

C. $\oint \mathbf{E} \cdot d\mathbf{A} = \frac{Q}{\varepsilon_0}$

D. More than one of these would work

E. Can't solve unless we know the dielectric is linear.

A very large (effectively infinite) capacitor has charge Q. A neutral (*homogeneous*) dielectric is inserted into the gap (and of course, it will polarize). We want to find $\mathbf{D}$ everywhere.



Which equation would you head to first?

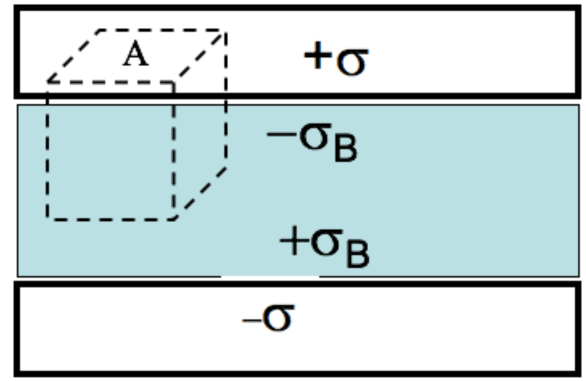
A. $\mathbf{D} = \varepsilon_0 \mathbf{E} + \mathbf{P}$

B. $\oint \mathbf{D} \cdot d\mathbf{A} = Q_{free}$

C. $\oint \mathbf{E} \cdot d\mathbf{A} = \frac{Q}{\varepsilon_0}$

D. More than one of these would work

An ideal (large) capacitor has charge Q. A neutral linear dielectric is inserted into the gap. We want to find $\mathbf{D}$ in the dielectric.

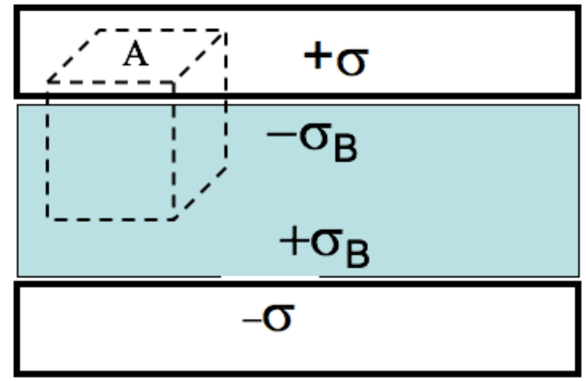


$$\oint \mathbf{D} \cdot d\mathbf{A} = Q_{free}$$

For the Gaussian pillbox shown, what is $Q_{free,enclosed}$?

A. σA
B. $-\sigma_B A$
C. $(\sigma - \sigma_B)A$
D. $(\sigma + \sigma_B)A$
E. Something else

An ideal (large) capacitor has charge Q. A neutral linear dielectric is inserted into the gap. We want to find $\mathbf{D}$ in the dielectric.



$$\oint \mathbf{D} \cdot d\mathbf{A} = Q_{free}$$

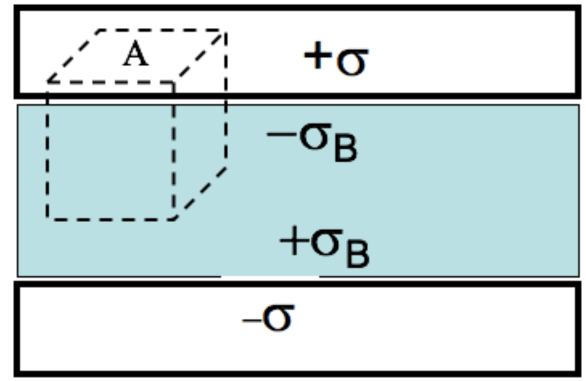
Is $\mathbf{D}$ zero INSIDE the metal? (i.e., on the top face of our cubical Gaussian surface)

A. It must be zero in there.

B. It depends.

C. It is definitely not zero in there.

An ideal (large) capacitor has charge Q. A neutral linear dielectric is inserted into the gap. We want to find $\mathbf{D}$ in the dielectric.

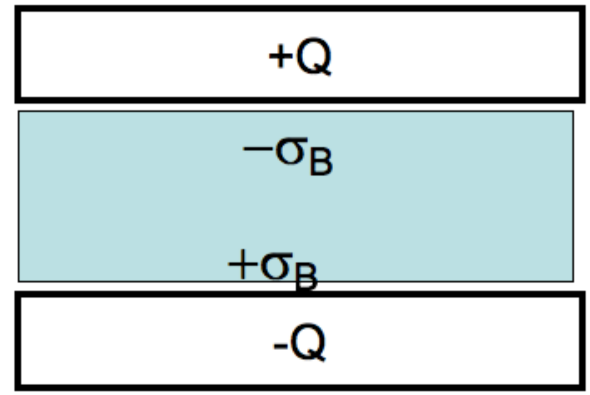


$$\oint \mathbf{D} \cdot d\mathbf{A} = Q_{free}$$

What is $|\mathbf{D}|$ in the dielectric?

A. σ
B. 2σ
C. $\sigma/2$
D. $\sigma + \sigma_b$
E. Something else

An ideal (large) capacitor has charge Q. A neutral linear dielectric is inserted into the gap. Now that we have $\mathbf{D}$ in the dielectric, what is $\mathbf{E}$ inside the dielectric?



A. $\mathbf{E} = \mathbf{D}\varepsilon_0\varepsilon_r$

B. $\mathbf{E} = \mathbf{D}/\varepsilon_0\varepsilon_r$

C. $\mathbf{E} = \mathbf{D}\varepsilon_0$

D. $\mathbf{E} = \mathbf{D}/\varepsilon_0$

E. Not so simple! Need another method