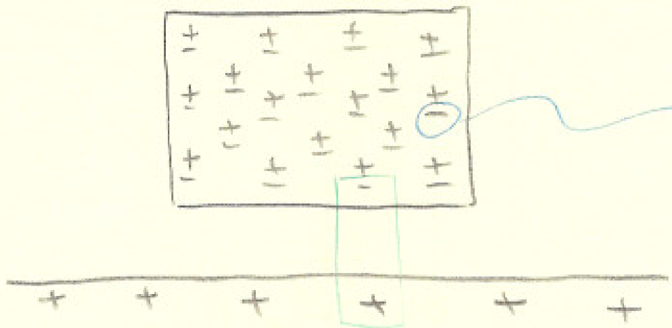
Physics Oct 3

Free charge



bound charge.

$$\oint \vec{D} \cdot d\vec{S} = q_{free}$$

$$\vec{D} = \varepsilon \vec{E}$$

already accounts for bound charges.

EX:

$$\varepsilon_r = 2$$

Dialectric sphere of radias R

$$\varepsilon = \varepsilon_r \varepsilon_0$$

Find $\vec{E}$ inside if $\rho = \rho_0$

free charges.

$$\oint \vec{D} \cdot d\vec{S} = \rho_0 \frac{4\pi}{3} r_p^3$$

when $r_p < R$

$$|\vec{D}(r_p)| \cdot 4\pi r_p^2$$

$$|\vec{D}(r_p)|_r = \rho_0 \frac{4\pi}{3} r_p^3 \cdot \frac{1}{4\pi r_p^2}$$

$$= \frac{\rho_0}{3} r_p$$

$$|\vec{D}| = \varepsilon |\vec{E}|$$

$$|\vec{E}| = \frac{\rho_0 r_p}{3\varepsilon_0}$$

$$= \frac{\rho r_p}{6\varepsilon_0}$$

$r_p > R$

$$\oint \vec{D} \cdot d\vec{S} = q_{free}$$

$$|\vec{D}(r_p)| \, 4\pi r_p^2 = \rho_0 \frac{4}{3}\pi R^3$$

Problem: Which ε do we use?

We use the ε of the vacuum b/c that is where we are

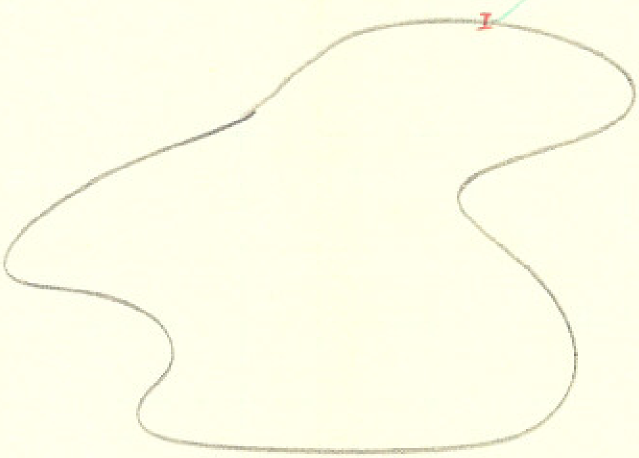
Note: $\varepsilon_r(\text{air}) = 1.0007 \approx \varepsilon_r(\text{vaccum})$

If the is more than one medium ω diff. ε, then we need to study what happens at the boundary between the media.

Electric Boundary conditions. (static case)

$$\oint \vec{E} \cdot d\vec{l} = 0$$

$$\oint \vec{D} \cdot d\vec{S} = q_{free}.$$



What happens when when go from inside the material to outside?

We look at peices that are so small they are basically flat.

this is a very small circuit.

$$\boxed{\oint \vec{E} \cdot d\vec{l} = 0}$$

$$= \int_A^B \vec{E} \cdot d\vec{l} + \int_B^C \vec{E} \cdot d\vec{l} + \int_C^D \vec{E} \cdot d\vec{l} + \int_D^A \vec{E} \cdot d\vec{l}$$

$$\vec{E} = E_x \hat{x} + E_y \hat{y} + E_z \hat{z}$$

$$\int_A^B \vec{E} \cdot d\vec{l}$$

$$d\vec{l} = \hat{x}\, dx$$

$$= E_x\, dx = |\vec{E}|\, \Delta l$$

$$\int_C^B \vec{E} \cdot d\vec{l} = |\vec{E}|\, \Delta h$$

we make so small it is ~~equal to zero~~.
negligible

$$\int_C^d \vec{E} \cdot d\vec{l} = -|\vec{E}| \cdot \Delta l$$

$$\int_D^A \sim \Delta h \rightarrow 0$$

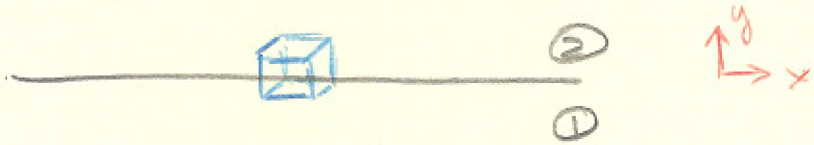
$$\oint \vec{E} \cdot d\vec{l} = \left(|E_{x_1}| - |E_{x_2}| \right) \Delta l = 0$$

$$\therefore\ |E_{x_1}| = |E_{x_2}|$$

This E_x is the component that is to the surface

Looking at the other condition

$$\oint \vec{D} \cdot d\vec{s} = q_{free}$$



We make the height of our box so small that the flux lost through the side panels is negligeble.

$$\therefore \oint \vec{D} \cdot d\vec{S} = \int_{Top} \vec{D} \cdot d\vec{S} + \int_{Bottom} \vec{D} \cdot d\vec{S} + \cancelto{0}{\int_{sides} \vec{D} \cdot d\vec{S}}$$

$$(D_{y②}) \Delta S - (D_{y①}) \Delta S = \sigma_{free} \Delta S$$

$D_{y②} \Rightarrow D_{n,2}$ $\quad$ $D_{n;2}$: component of $\vec{D}$ that is normal to the interface.

What is $\sigma_{free} = \sigma_{free,2} + \sigma_{free,1}$

$$(D_{n2} - D_{n2}) = \sigma_{free}$$

$$\varepsilon_1 E_{n2} - \varepsilon_2 E_{n1} = \sigma_{free}$$