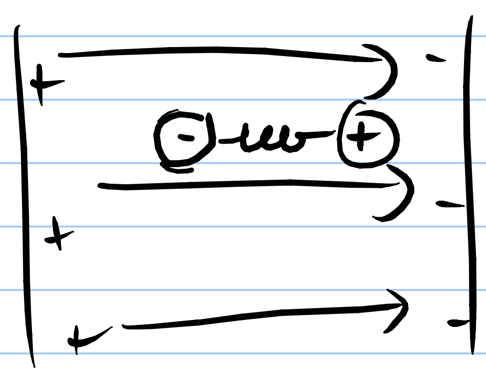
Note Title 2/27/2011

LINEAR DIELECTRICS



INDUCED

$p = \alpha E$ $\quad \frac{\text{dipole mom}}{\text{atom}}$

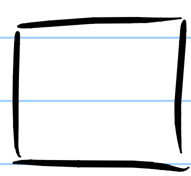
n # atoms/vol

$\vec{P} = \epsilon_0 \chi_e E$ $\quad \frac{\text{dipole mom}}{\text{vol}}$

$n\alpha = \epsilon_0 \chi_e$ ← measure in cap

$n\alpha\vec{E} = \vec{P}$

$= \epsilon_0 \chi_e \vec{E}$



glass

$$\vec{D} \equiv \epsilon_0 \vec{E} + \vec{P} = \epsilon_0 \vec{E} + \epsilon_0 \chi_e \vec{E}$$

displacement vector

$$= \epsilon_0 (1 + \chi_e) \vec{E}$$

suc

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

permittivity

$1 + \chi_e$ = "relative permittivity"
or dielectric constant

$$1 + \chi_e = \frac{\epsilon}{\epsilon_0} = K$$

ϵ_0 permittivity in free space $(\chi_e = 0)$

$K = 1$ in free space

$$3 < \overset{1+\chi_e}{\kappa} < 5$$

in air $\chi_e = 0.00059$ at STP

$\vec{\nabla} \cdot \vec{E} = \rho/\epsilon_0$ Gauss's law

$= \frac{\rho_f + \rho_b}{\epsilon_0} \Rightarrow \epsilon_0 \vec{\nabla} \cdot \vec{E} = \rho_f + \rho_b$

$$\rho_b = -\vec{\nabla}\cdot\vec{P}$$

$$\epsilon_0 \vec{\nabla}\cdot\vec{E} = \rho_f - \vec{\nabla}\cdot\vec{P}$$

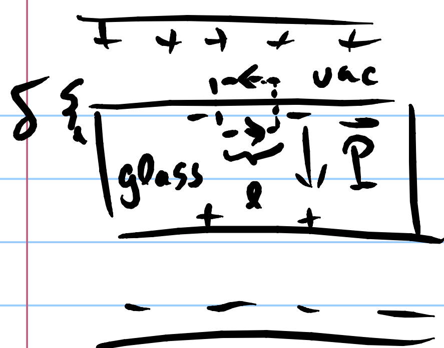
$$\epsilon_0 \vec{\nabla}\cdot\vec{E} + \vec{\nabla}\cdot\vec{P} = \rho_f$$

$$\vec{\nabla}\cdot\underbrace{\left[\epsilon_0\vec{E} + \vec{P}\right]}_{\vec{D}} = \rho_f \Rightarrow \boxed{\vec{\nabla}\cdot\vec{D} = \rho_f}$$

To determine a vector field need 2 relations (1) $\vec{\nabla} \cdot \vec{D} = ?$

(2) $\vec{\nabla} \times \vec{D} = ?$

$$\vec{\nabla} \times \left(\epsilon_0 \vec{E} + \vec{P} \right) = \epsilon_0 \underbrace{\vec{\nabla} \times \vec{E}}_{0} + \vec{\nabla} \times \vec{P}$$



$$\int \vec{\nabla}\times\vec{P}\cdot d\vec{a} = \oint \vec{P}\cdot d\vec{l}$$

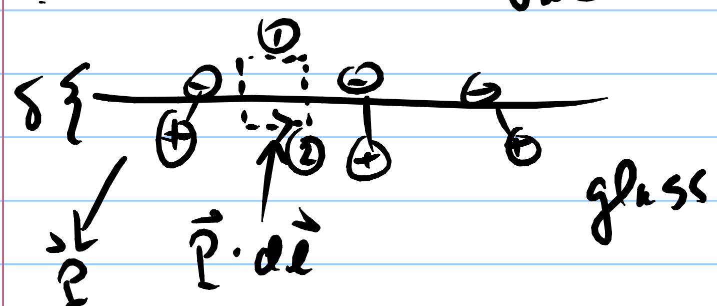
let $\delta \to 0$

$\vec{P} = 0$ vac $\quad P \times l = 0$

$\vec{P} \neq 0$ glass $\quad \vec{P} \perp d\vec{l} \quad \int \vec{P}\cdot d\vec{l} = 0$

$$\Rightarrow \quad \vec{\nabla}\times\vec{P} = 0$$

$\vec{P} = 0$ ⊕



$$\oint \vec{P}\cdot d\vec{l}$$

$$\int_{1} \vec{P}\cdot d\vec{l} = 0$$

$$\int_{\text{vert. side}} \vec{P}\cdot d\vec{l} \to 0$$

$$\int_{2} \vec{P}\cdot d\vec{l} \neq 0$$

$$\vec{\nabla}\times\vec{P} \neq 0$$