

Gauss's Law $\vec{\nabla} \cdot \vec{E} = \frac{\rho}{\epsilon_0}$ $\leftarrow -\vec{\nabla} \cdot \vec{P}$

Dielectrics $\rho = \rho_f + \rho_b$ $\epsilon_0 \vec{\nabla} \cdot \vec{E} = \rho_f + \rho_b$

$$\vec{\nabla} \cdot (\underbrace{\epsilon_0 \vec{E} + \vec{P}}_{\vec{D}}) = \rho_f$$

$$\vec{\nabla} \cdot \vec{D} = \rho_f$$

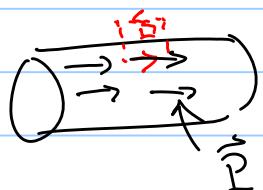


$$\int \vec{D} \cdot d\vec{a} = \int \rho_f d\tau$$

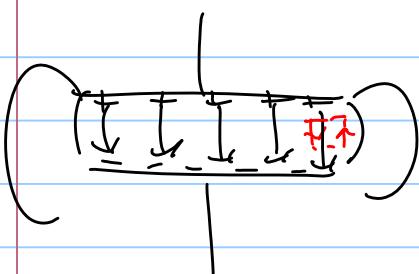
$$\oint \vec{D} \cdot d\vec{a} = Q_f \text{ integral}$$

To uniquely determine a vector function you need

$$\vec{\nabla} \cdot \vec{D} \quad \vec{\nabla} \times \vec{D} = \vec{\nabla} \times (\epsilon_0 \vec{E} + \vec{P}) = \underbrace{\epsilon_0 \vec{\nabla} \times \vec{E}}_{0} + \vec{\nabla} \times \vec{P}$$



$$\int \vec{\nabla} \times \vec{P} \cdot d\vec{a} = \oint \vec{P} \cdot d\vec{l} \neq 0 \text{ Stokes}$$



$$\int \vec{\nabla} \times \vec{E} \cdot d\vec{a} = \oint \vec{E} \cdot d\vec{l} = 0$$

How do we find \vec{P} ?

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

Linear material

$$\vec{P} \propto \vec{E}$$

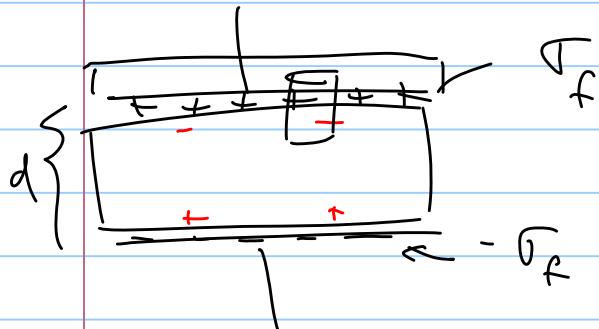
\uparrow
susceptibility

$$\vec{D} = \epsilon_0 \vec{E} + \vec{P} = \epsilon_0 \vec{E} + \epsilon_0 \chi_e \vec{E} = \underbrace{\epsilon_0 (1 + \chi_e)}_{\epsilon \text{ permittivity}} \vec{E}$$

$$\epsilon = \epsilon_0(1+\chi_e) \quad (1+\chi_e) = \frac{\epsilon}{\epsilon_0} = K \quad \text{dielectric constant}$$

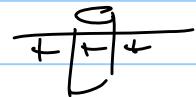
relative Permittivity

Air $\chi_e = 0.00059$ at STP



$$\sigma_b = P = \epsilon_0 \chi_e E$$

find $E =$



$$EA = \frac{\sigma_f A}{\epsilon_0}$$

$$E_{\text{tot}} = \frac{\sigma_f - \sigma_b}{\epsilon_0} = \frac{\sigma_f - \epsilon_0 \chi_e E_{\text{tot}}}{\epsilon_0}$$

$$E_{\text{tot}} = \frac{\sigma_f}{\epsilon_0} \frac{1}{1 + \chi_e} < E_0$$

$$\frac{\sigma_f}{\epsilon_0}$$

$$V = Ed = \frac{\sigma_f d}{\epsilon_0} \frac{1}{1 + \chi_e}$$

$$C = \frac{Q}{V} = \frac{\sigma_f A}{\frac{\sigma_f d}{\epsilon_0} \frac{1}{1 + \chi_e}} = \frac{\epsilon_0 A}{d} (1 + \chi_e) = C_0 \frac{\epsilon}{\epsilon_0}$$