ANNOUNCEMENT  QUIZ 1 NOW DUE 2/25

INTRODUCTION TO ELECTRODYNAMICS - GRIFFITHS

LAST TIME: DIELECTRICS

\[ \vec{P} = \varepsilon_0 \chi e \vec{E} \]  
POLARIZATION: DIPOLAR MOMENT PER UNIT VOLUME

\[ \vec{D} = \varepsilon_0 \vec{E} + \varepsilon_0 \chi e \vec{E} \]

\[ \varepsilon_0 \chi e \] ELECTRIC SUSCEPTIBILITY

\[ \vec{D} = \varepsilon_0 (1 + \chi e) \vec{E} \]
\( \vec{D} \) : DISPLACEMENT

\[ \varepsilon = \varepsilon_0 (1 + \chi e) \]

\( \varepsilon_0 \) : PERMITTIVITY OF FREE SPACE

\( \varepsilon \) : PERMITTIVITY OF MATERIALS

\[ \varepsilon = \frac{\varepsilon}{\varepsilon_0} = \text{DIELECTRIC CONSTANT} = 1 + \chi e \]

\[ C' = \varepsilon C \]
\[
P = \frac{\sigma_{\text{induced}} \cdot A \cdot d}{A \cdot d} = \text{dipole moment per unit volume}
\]
By definition

\[ P = \varepsilon_0 \chi_0 E \]

\[ \chi_0 E = \frac{\sigma \text{invoiced}}{\varepsilon_0} \]

\[ \varepsilon = \frac{\sigma \text{plate}}{\sigma \text{invoiced}} \]

\[ \chi_0 \left[ \frac{\sigma \text{plate} - \sigma \text{invoiced}}{\varepsilon_0} \right] = \frac{\sigma \text{invoiced}}{\varepsilon_0} \]

\[ \chi_0 \sigma \text{plate} = (1 + \chi_0) \sigma \text{invoiced} \]

\[ \chi_0 \sigma \text{plate} = 1 + \chi_0 \sigma \text{invoiced} \]

\[ \frac{\chi_0 \Delta \sigma}{1 + \chi_0} \sigma \text{plate} = \frac{\sigma \text{plate}}{\varepsilon_0} \sigma \text{invoiced} \]

\[ E = \frac{\sigma \text{plate} - \sigma \text{invoiced}}{\varepsilon_0} = \frac{\sigma \text{plate}}{\varepsilon_0} \left[ 1 - \frac{\chi_0}{1 + \chi_0} \right] \]

\[ \varepsilon = \frac{\sigma \text{plate}}{\varepsilon_0} \left[ 1 + \chi_0 \right] \]
\[ k = \frac{\varepsilon}{\varepsilon_0} = \text{Dielectric Constant} = 1 + \chi \]

\[ \varepsilon' = \frac{\varepsilon}{\varepsilon_0 k} \]

**Book 26.7**

\[ \varepsilon = \frac{\sigma_{\text{plate}}}{\varepsilon_0} \left[ \frac{1}{1 + \chi k} \right] = \frac{\sigma_p}{\varepsilon_0} \frac{1}{k} \]

\[ \Delta V = \frac{\sigma_p d}{\varepsilon_0 k} = \frac{\sigma_p d}{k \varepsilon_0 A} \]

\[ \frac{k \varepsilon_0 A}{d} \Delta V = \sigma_p \quad C' = \frac{k \varepsilon_0 A}{d} \text{ increases} \]
EXAMPLE

CALCULATE CAPACITANCE OF SiO₂

\[ \frac{\varepsilon}{\varepsilon_0} = 3.9 \quad \text{SiO₂} \]

\[ C = 3.9 \cdot \frac{\varepsilon_0 A}{d} \quad \text{FARADS} \]

\[ = 3.9 \cdot \frac{8.85 \times 10^{-12}}{10^{-3}} \left( \text{m}^2 \right) \]

\[ = \frac{300 \times 10^{-9}}{10^{-9}} \]

\[ C/\mu\text{m}^2 = 1.15 \times 10^{-4} \text{ F/\mu m}^2 \]

\[ C \Delta V = Q \]

So PER 1 VOLT

\[ 1.15 \times 10^{-4} \text{ F/\mu m}^2 \cdot 1 \text{V} = 1.15 \times 10^{-4} \text{ C/\mu m}^2 \]

\[ \frac{1.15 \times 10^{-4}}{1.60 \times 10^{-19}} = 7.2 \times 10^{-12} \text{ e/\mu m}^2 \cdot \text{V} \]
**Example 2**

METALLIC SCA D = THICKER EGS

CAPACITANCE BEFORE = $\frac{\varepsilon_0 A}{d}$

AFTER = $\frac{1}{C_{\text{TOTAL}}} = \frac{1}{C_1} + \frac{1}{C_2}$

$d_1 + d_2 = \frac{d-t}{2} = d_z$

$C_1 = C_2 = \frac{\varepsilon_0 h}{d-t} = \frac{2 \varepsilon_0 A}{d-t}$

$\frac{1}{C_{\text{TOTAL}}} = \frac{1}{C_1} + \frac{1}{C_2} = \frac{1}{C_T} = \frac{2}{d-t} \frac{\varepsilon_0 A}{d-t}$

$\frac{1}{C_T} = \frac{d-t}{\varepsilon_0 A}$
\[ C_t = \frac{\varepsilon_0 A}{d-t} \]

\[ \frac{1}{C_t} = \frac{1}{C_d} + \frac{1}{C_u} \]

\[ C_d = \frac{k \varepsilon_0 A}{f d} \quad C_u = \frac{\varepsilon_0 A}{(1-f)d} \]

\[ \frac{1}{C_t} = \frac{f d}{k \varepsilon_0 A} + \frac{(1-f)d}{\varepsilon_0 A} \]

\[ = \frac{f d + k(1-f)d}{k \varepsilon_0 A} \]

\[ C_t = \frac{k \varepsilon_0 A}{f d + (k-f)d} \]

- If \( \phi = 0 \), \( f = 1 \):
  \[ C_t = \frac{\varepsilon_0 A}{d} \quad C_t = \frac{k \varepsilon_0 A}{d} \]
\[ \nabla \cdot \mathbf{E} = \frac{\rho}{\varepsilon_0} \quad \text{(Gauss's law)} \]

\[ \nabla \cdot \mathbf{D} = \rho_f \]

\[ \rho = \rho_f + \rho_{\text{bound}} \]

\[ j_0 = -\nabla \cdot \mathbf{\overrightarrow{P}} \]