LECTURE 2/11/09

ANNOUNCEMENT $\boxed{\text{QUIZZ 1 NOW DUE } 2/25}$

INTRODUCTION TO ELECTRODYNAMICS GRIFFITHS

LAST TIME: DIELECTRICS

$$\vec{P} = \varepsilon_0 \chi_e \vec{E}$$: POLARIZATION: DIPOLE MOMENT PER UNIT VOLUME

$$\vec{D} = \varepsilon_0 \vec{E} + \varepsilon_0 \chi_e \vec{E}$$

χ_e: ELECTRIC SUSCEPTIBILITY

$$\vec{D} = \varepsilon_0 (1 + \chi_e) \vec{E}$$

$\vec{D}$: DISPLACEMENT

$$\varepsilon = \varepsilon_0 (1 + \chi_e)$$

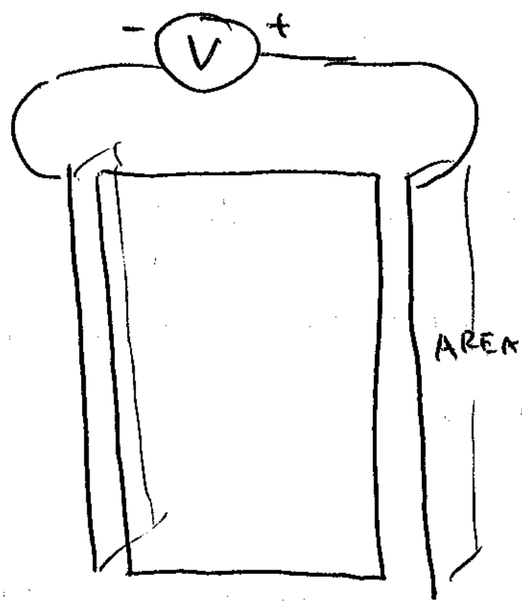
ε_0: PERMITTIVITY OF FREE SPACE

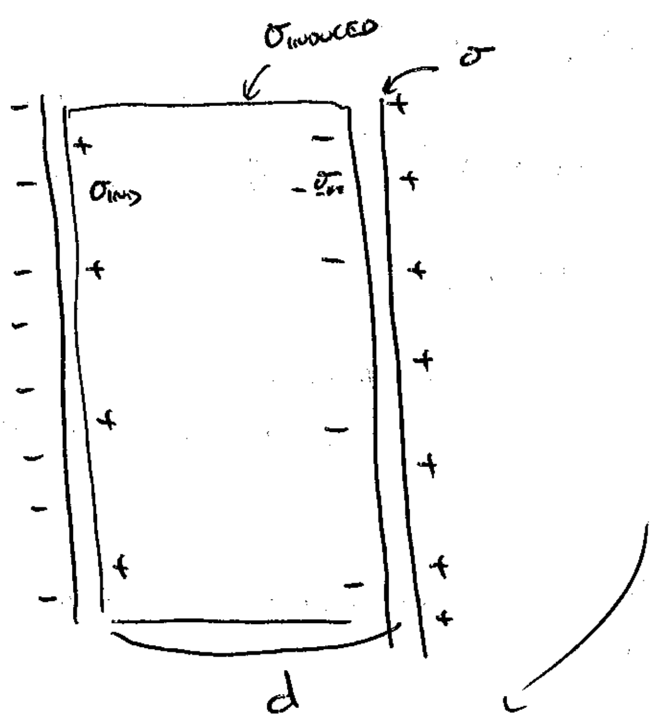
ε: PERMITTIVITY OF MATERIALS

$$k \stackrel{\text{def}}{=} \frac{\varepsilon}{\varepsilon_0} = \text{DIELECTRIC CONSTANT} = 1 + \chi_e$$

$$\boxed{C' = k C}$$

REQUEST
EM 352
EM 353a FOR FRIDAY





o Q

o −Q

DIPOLE : $\underline{\underline{Q \cdot d}}$

$$\vec{P} = \frac{\sigma_{INDUCED} \cdot \cancel{A} \cdot \cancel{d}}{\cancel{A}\ \cancel{d}} = \text{DIPOLE MOMENT PER UNIT VOLUME}$$

BUT BY DEFINITION

$$\vec{P} = \varepsilon_0 \chi_0 \vec{E}$$

$$\chi_0 \vec{E} = \frac{\sigma_{INDUCED}}{\varepsilon_0}$$

$$\vec{E} = \frac{\sigma_{PLATE} - \sigma_{INDUCED}}{\varepsilon_0}$$

$$\chi_0 \left[\frac{\sigma_{PLATE} - \sigma_{INDUCED}}{\cancel{\varepsilon_0}} \right] = \frac{\sigma_{INDUCED}}{\cancel{\varepsilon_0}}$$

$$\chi_0 \sigma_{PLATE} = (1 + \chi_0)\, \sigma_{IND}$$

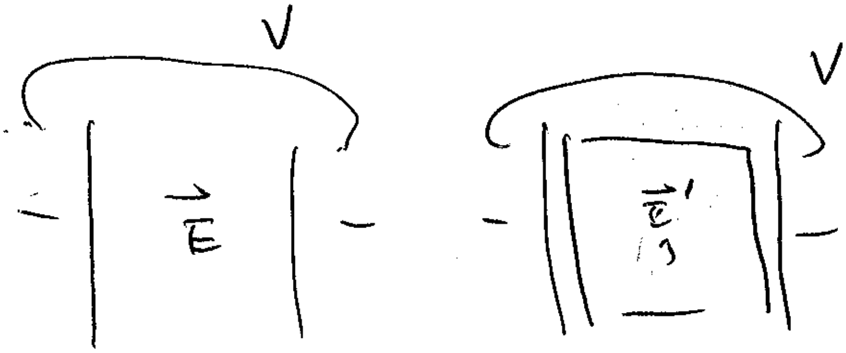
$$\chi_0 \sigma_{PLATE} = 1 + \chi_0 \; \sigma_{INDUCED}$$

$$\frac{\chi_0}{1+\chi_0} \sigma_{PLATE} = \sigma_{INDUCED}$$

$$\vec{E} = \frac{\sigma_{PLATE} - \sigma_{INDUCED}}{\varepsilon_0} = \frac{\sigma}{\varepsilon_0}\left[1 - \frac{\chi_0}{1+\chi_0}\right]$$

$$\vec{E} = \frac{\sigma_{PLATE}}{\varepsilon_0} \frac{1}{[1+\chi_0]}$$

BUT $K = \frac{\varepsilon}{\varepsilon_0}$ = DIELECTRIC CONST = $1 + \chi_0$



$\vec{E}' = \frac{\vec{E}}{K}$ BOOK 26.7

$$\vec{E} = \frac{\sigma_{PLATE}}{\varepsilon_0}\left[\frac{1}{1+\chi_0}\right] = \frac{\sigma_P}{\varepsilon_0}\frac{1}{K}$$

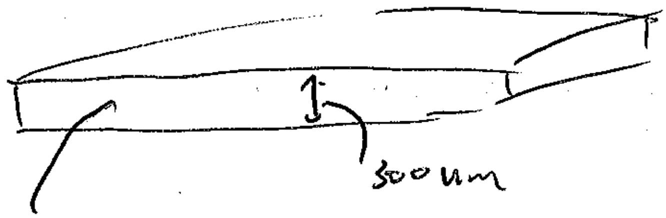
$$\Delta V = \frac{\sigma_p d}{\varepsilon_0 K} = \frac{Q_P d}{K \varepsilon_0 A}$$

$$\frac{K \varepsilon_0 A}{d}\Delta V = Q_P$$

$C' = \frac{K \varepsilon_0 A}{d}$ INCREASES

EXAMPLE

CALCULATE CAPACITANCE OF SiO_2 3



$$\frac{\varepsilon}{\varepsilon_0} = 3.9 \quad SiO_2 .$$

$$C = 3.9 \cdot \frac{\varepsilon_0 \, A}{d} \quad \text{FARADS}$$

$$= \frac{3.9 \cdot 8.85\times10^{-12}\ 10^{-3}\ (.m^2)}{300\times10^{-9}}$$

$$\boxed{C/m^2} = 1.15\times10^{-4}\ F/m^2$$

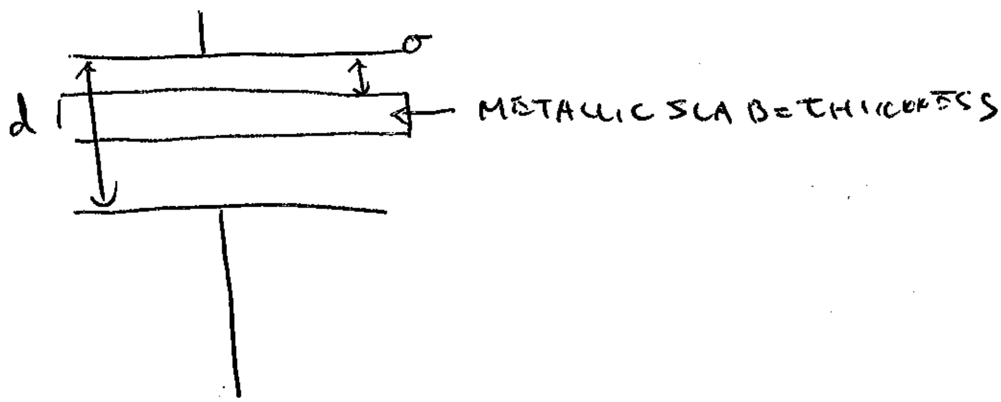
$$C\Delta V = Q$$

So PER 1 VOLT

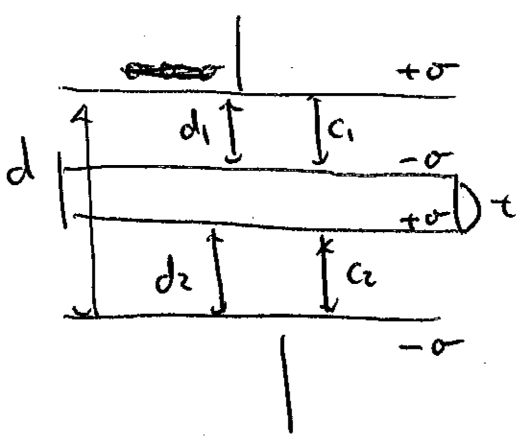
$$1.15\times10^{-4}\ F/m^2 \cdot 1V = 1.15\times10^{-4}\ C/m^2$$

$$\frac{1.15\times10^{-4}}{1.603\times10^{-19}} = 7.2\times10^{14}\ e/m^2\cdot V$$

EXAMPLE 2



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



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

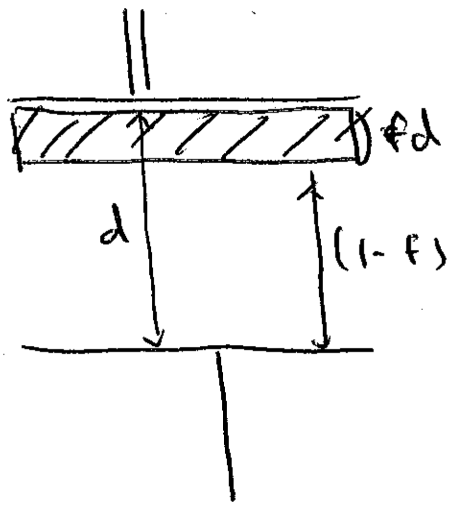
$$d_1 = \frac{d-t}{2} = d_2$$

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

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

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

$$C_T = \frac{\varepsilon_0 A}{d - t}$$



$\Rightarrow$ EQUIVALENT TO

$$\frac{1}{C_T} = \frac{1}{C_d} + \frac{1}{C_v}$$

$$C_d = \frac{k \varepsilon_0 A}{f d} \qquad C_v = \frac{\varepsilon_0 A}{(1-f) d}$$

$$\frac{1}{C_T} = \frac{f d}{k \varepsilon_0 A} + \frac{(1-f) d}{\varepsilon_0 A}$$

$$= \frac{f d + k(1-f) d}{k \varepsilon_0 A} \Rightarrow C_T = \frac{k \varepsilon_0 A}{f d + k(1-f) d}$$

IF $f = 0$ $\qquad f = 1$

$C_T = \frac{\varepsilon_0 A}{d}$ $\qquad C_T = \frac{k \varepsilon_0 A}{d}$ ✓

$$\vec{\nabla} \cdot \vec{E} = \frac{\rho}{\varepsilon_0} \quad \text{(GAUSS'S LAW)}$$

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

$$\rho = \rho_f + \rho_{BOUND}$$

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