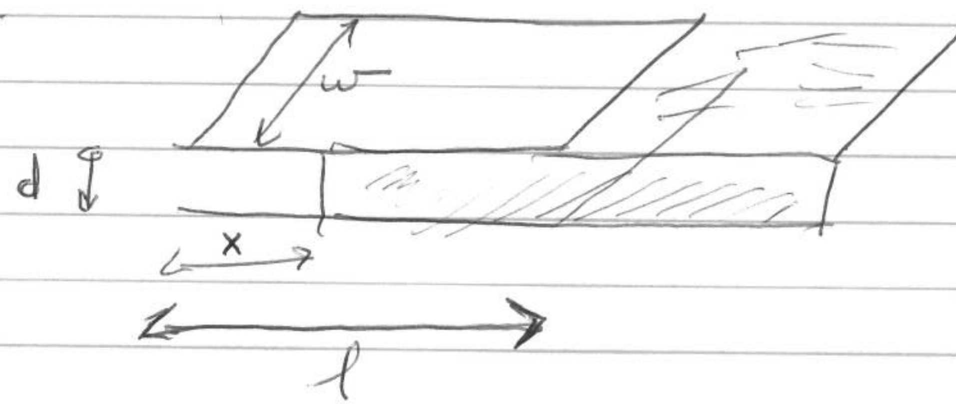
#1



NEED CAPACITANCE OF 2 PARALLEL CAPS.

USE $\oint \underset{\sim}{D} \cdot d\underset{\sim}{S} = Q_f$

AIR PIECE: $D x w = \sigma x w$

$$\varepsilon_0 E = \sigma$$

$$E = \sigma / \varepsilon_0$$

$V = -\int \underset{\sim}{E} \cdot d\underset{\sim}{l} = \sigma d / \varepsilon_0$ (ABSOLUTE ONLY COUNTS)

$$C = Q/V = \frac{\sigma x w}{\sigma d/\varepsilon_0}$$

$$\boxed{C_A = \varepsilon_0 x w / d} \quad \text{AIR PIECE}$$

DIELECTRIC PIECE

$$\oint \underset{\sim}{D} \cdot d\underset{\sim}{S} = \sigma w (l - x)$$

$$\varepsilon E (l - x) w = \sigma w (l - x)$$

$$E = \sigma / \varepsilon$$

#1 CONT.

$$V = -\int \underset{\sim}{E} \cdot d\underset{\sim}{l} = \sigma d/\varepsilon$$

$$C_D = Q/V = \frac{\sigma(l-x)w}{\sigma d/\varepsilon}$$

$$\boxed{C_D = \frac{\varepsilon w(l-x)}{d}}$$

$$C_{TTL} = C_A + C_D = \varepsilon_0 x w/d + \varepsilon w(l-x)/d$$

$$= (w/d)\left[\varepsilon_0 x + \varepsilon(l-x)\right]$$

$$= (w/d)\left[\varepsilon_0 + \varepsilon_0(1+\chi_e)(l-x)\right]$$

$$\boxed{C_{TTL} = \frac{\varepsilon_0 w}{d}\left[\varepsilon_r l - \chi_e x\right] \quad w/\ \varepsilon_r = 1 + \chi_e}$$

#2. ELECTRODE SET IS EQUIVALENT TO 5 PLATE PAIRS IN PARALLEL. "PARALLEL" MEANS SAME V ACROSS A PLATE PAIR.

ADD C's IN PARALLEL.

$$C_{TTL} = 5\,\varepsilon A/d$$

#3 FIND h WHEN

$$F_{ELEC} = F_{GRAVITY} = mg$$

$$F_g = \rho \pi (b^2 - a^2) h g$$

$$F_{ELEC} = \frac{1}{2} V^2 \, dC/dx$$

COAXIAL TUBES ACT AS 2 C'S IN PARALLEL. FIND C OF A COAXIAL PAIR.

$$\oint \underset{\sim}{D} \cdot d\underset{\sim}{S} = Q_f$$

$$D \cdot 2\pi r l = \lambda l$$ λ = LINEAR CHARGE DENSITY

$$\varepsilon E \cdot 2\pi r = \lambda$$

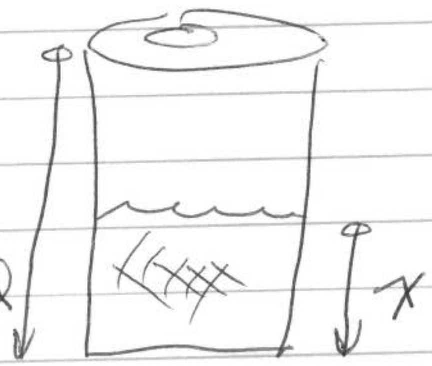
$$E = \frac{\lambda}{\varepsilon 2\pi r}$$

$$V = -\int \underset{\sim}{E} \cdot d\underset{\sim}{l}$$

$$= \frac{\lambda}{2\pi \varepsilon} \ln b/a$$ (ABS VALUE COUNTS)

$$C = Q/V = \frac{\lambda l}{\frac{\lambda \ln b/a}{2\pi\varepsilon}} = \frac{2\pi\varepsilon l}{\ln b/a}$$

#3 CONT



$$C_{oil} = \frac{2\pi \varepsilon x}{\ln b/a}$$

so

$$C_{air} = \frac{2\pi \varepsilon_0 (l - x)}{\ln b/a}$$

$$C_{TTL} = C_{oil} + C_{air}$$

$$= \frac{2\pi}{\ln b/a}\left[\varepsilon_0 l + (\varepsilon - \varepsilon_0) x \right]$$

$$dC/dx = \frac{2\pi (\varepsilon - \varepsilon_0)}{\ln b/a}$$

$$mg = \frac{1}{2} V^2 \, dC/dx$$

$$\rho \pi (b^2 - a^2) g h = \frac{1}{2} V^2 \frac{2\pi (\varepsilon - \varepsilon_0)}{\ln b/a}$$

$$h = \frac{V^2 (\varepsilon - \varepsilon_0)}{\rho (b^2 - a^2) g \ln b/a}$$

$$= \frac{\chi_e \varepsilon_0 V^2}{\rho g (b^2 - a^2) \ln b/a}$$

#4. QUESTION ABOUT BOUNDARY CONDITIONS.

$$D^{\perp}_{ABOVE} - D^{\perp}_{BELOW} = \sigma_f = 0 \qquad (1)$$

$$E^{\parallel}_{A} = E^{\parallel}_{BELOW} \qquad (2)$$

$(1) \Rightarrow \quad \varepsilon_2 E_2 \cos\theta_2 = \varepsilon_1 E_1 \cos\theta_1$

$(2) \Rightarrow \quad E_2 \sin\theta_2 = E_1 \sin\theta_1$

$$\tan\theta_2 / \varepsilon_2 = \tan\theta_1 / \varepsilon_1$$

$$\therefore \frac{\tan\theta_1}{\tan\theta_2} = \varepsilon_1 / \varepsilon_2$$