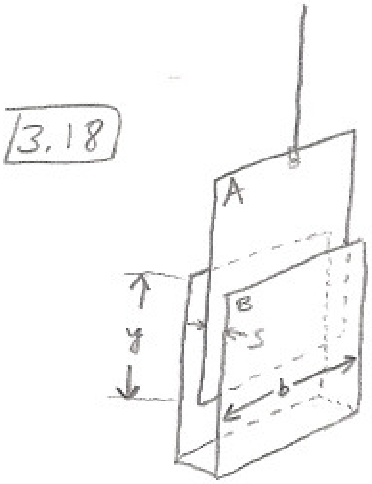
VRH

Physics 24 Problem Set 5.

Solutions by Viva

3.18

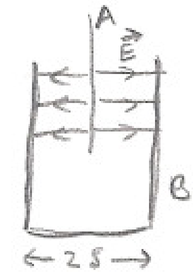


Aluminum sheets A and B, oppositely charged.

F = electrostatic force pulling A downward

V = potential difference between plates.

Find V in terms of F, s, y, and b.



Q = charge on plate A, located on the portion of the plate between B. Q is constant; it doesn't depend on y.

C = capacitance of system. Depends on y.

Both F and V depend on y. (Had there been a constant V, A would have been pushed out.)

σ = charge density on <u>one</u> side of plate A, between B.

$$\sigma = \frac{Q}{2by}.$$ (Depends on y.) The charge stays in the region between B.

U = energy of system. Depends on y.

$$|\vec{E}| = 4\pi\sigma = \frac{2\pi Q}{by}.$$ (You can get this from Gauss's Law.)

$$V = \int_A^B \vec{E}\cdot d\vec{s} = |\vec{E}|\, s = \frac{2\pi Q s}{by}.$$ (V is inversely proportional to y.)

$$C = \frac{Q}{V} = \frac{by}{2\pi s}.$$

$$U = \frac{1}{2}\frac{Q^2}{C} = \frac{\pi s}{by} Q^2.$$ (U is inversely proportional to y.)

$$F = -\frac{dU}{dy} = -\frac{1}{2} Q^2 \frac{d}{dy}\left(\frac{1}{C}\right) = -\frac{1}{2}\frac{\pi s}{b} Q^2 \frac{d}{dy}\left(\frac{1}{y}\right) = \boxed{\frac{\pi s\, Q^2}{by^2}}.$$

But $Q = \frac{byV}{2\pi s}$ so $F = \frac{\pi s}{by^2}\left(\frac{byV}{2\pi s}\right)^2 = \frac{b}{4\pi s} V^2.$

$$\boxed{V = \sqrt{\frac{4\pi s F}{b}}}$$