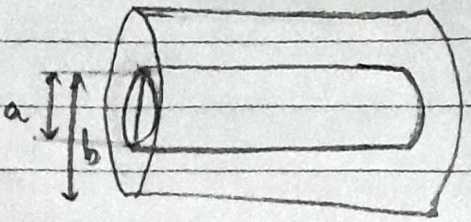
Q. Find the capacitance per unit length of two co-axial metal cylinder tubes of radii a and b.



A. Say the charge on inner cylinder is Q for a length L. The field is given by gauss's law:-

$$\int E \cdot da = \frac{Q_{enc}}{\varepsilon_0}$$

$$E \cdot 2\pi s \cdot L = \frac{Q_{enc}}{\varepsilon_0} \Rightarrow E = \frac{Q_{enc} \cdot \hat{s}}{2\pi s \varepsilon_0 L}$$

Potential difference between cylinder is

$$V(b) - V(a) = -\int_a^b E \cdot dl = \frac{-Q}{2\pi\varepsilon_0 L} \int_a^b \frac{1}{s} ds. = \frac{-Q}{2\pi\varepsilon_0 L} \ln(b/a)$$

By set up (here), a_1 is at higher potential so,

$$V(a) - V(b) = \frac{Q}{2\pi\varepsilon_0 L} \ln(b/a)$$

$$C = Q/V = \frac{Q}{(Q/2\pi\varepsilon_0 L)\ln(b/a)} = \frac{2\pi\varepsilon_0 L}{\ln(b/a)}$$

capacitance per unit length $= \frac{2\pi\varepsilon_0}{\ln(b/a)}$

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