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Batch - A-2

Assignment - IV

P-4.32 $\oint D \cdot da = Q_{f\,enclosed}$

$$D = \frac{q}{4\pi r^2}\hat{r} \qquad E = \frac{D}{\varepsilon}$$

$$P = \varepsilon_0 \chi_e E = \frac{q\chi_e}{4\pi(1+\chi_e)}\frac{\hat{r}}{r^2}$$

$$\rho_b = -\nabla \cdot P = -\frac{q\chi_e}{4\pi(1+\chi_e)}\left(\nabla \cdot \frac{\hat{r}}{r^2}\right)$$

$$\sigma_b = P \cdot \hat{r} = \frac{q\chi_e}{4\pi(1+\chi_e)R^2}$$

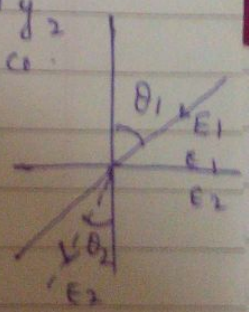
$$Q_{surf} = \sigma_b 4\pi R^2 = \frac{q\chi_e}{1+\chi_e}$$

The compensating (-ve) charge is at center.

$$\int \rho_b \, d\tau = -\frac{q\chi_e}{1+\chi_e}\int \delta^3(r)\, d\tau = -\frac{q\chi_e}{1+\chi_e}$$

P-4.3 $E_{\parallel}$ is continous $D_{\perp}$ is continous ($\sigma_f = 0$) so $E_{x1} = E_{x2}$, $D_{y1} = D_{y2}$
$\Rightarrow \varepsilon_1 E_{y1} = \varepsilon_2 E_{y2}$ and hence

$$\frac{\tan\theta_2}{\tan\theta_1} = \frac{E_{x2}/E_{y2}}{E_{x1}/E_{y1}} = \frac{E_{y_1}}{E_{y_2}} = \frac{\varepsilon_2}{\varepsilon_1}$$



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P-4.20 $\int D \cdot da = Q_{enclosed} \Rightarrow D \times 4\pi r^2 = \rho \times \frac{4}{3}\pi r^3$

$$D = \frac{\rho r}{3}$$

$$E = \frac{\rho r}{3\varepsilon_0}\hat{r}, \text{ for } r<R,$$

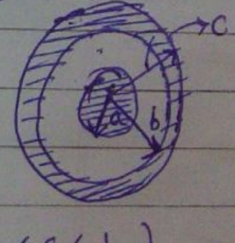
$$D \times 4\pi r^2 = \rho \times \frac{4}{3}\pi R^3$$

$$D = \frac{\rho R^3}{3r^2}, \quad E = \left(\frac{\rho R^3}{3\varepsilon_0 r^2}\right)\hat{r}, \text{ for } r>R$$

$$V = -\int_\infty^0 E \cdot dl = \frac{\rho R^3}{3\varepsilon_0}\frac{1}{r}\Big|_\infty^R - \frac{\rho}{3\epsilon}\int_R^0 r\,dr$$

$$= \frac{\rho R^2}{3\varepsilon_0} + \frac{\rho R^2}{3\varepsilon} = \frac{\rho R^2}{3\varepsilon_0}\left(1+\frac{2}{2\varepsilon r}\right)$$

P.4.21 Let Q be the charge on a length l of inner conductor.



$$\oint D \cdot da = D \cdot 2\pi s l = Q$$

$$D = \frac{Q}{2\pi s l} \qquad E = \frac{Q}{2\pi\varepsilon_0 s l} \quad (a<s<b)$$

$$E = \frac{Q}{2\pi\varepsilon s l} \quad (b<r<c)$$

$$V = -\int_c^a E \cdot dl = \int_a^b \frac{Q}{2\pi\varepsilon_0 l}\frac{ds}{s} + \int_b^c \left(\frac{Q}{2\pi\varepsilon l}\right)\frac{ds}{s}$$

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

$$\frac{C}{l} = \frac{Q}{Vl} = \frac{2\pi\varepsilon_0}{\ln\left(\frac{b}{a}\right) + \left(\frac{1}{\varepsilon_r}\right)\ln\left(\frac{c}{b}\right)}.$$