S8 Assignment # 2

1/ (a) Inside a 3D charge, the distribution increases as you move toward the surface, increasing the field. On the surface, it hits a maximum and outside it falls off in an inverse square law fashion as the observation distances increases.

(b) volume charge density, $\rho = \frac{Q}{V}$.

$$\rho = \frac{80 \times 10^{-9} C}{\frac{4\pi}{3}(20 \times 10^{-2} m)^3}$$

(c) Using Gauss's Law, $Q_{enc} = \epsilon_0 \Phi_E$

For $r_1 = 5 \times 10^{-2} m$, $\Phi_E = \oint \vec{E}_{in} \cdot d\vec{a}_1$

Note for ST

Application of Gauss's Law for volume charges may be explained only once in the beginning.

$$= \frac{Q r_1}{4\pi\epsilon_0 R^3} \oint da_1$$

$$= \frac{Q r_1}{\cancel{4\pi}\epsilon_0 R^3} \times \cancel{4\pi} r_1^2$$

$$= \frac{Q}{\epsilon_0} \times \frac{r_1^3}{R^3}$$

$$Q_{enc} = Q \times \frac{r_1^3}{R^3}$$

$$= 80 \times 10^{-9} C \times \left(\frac{5 \times 10^{-2} m}{20 \times 10^{-2} m}\right)^3$$

$$= 1.25 \times 10^{-9} C \sim 1.25 \text{ nC}.$$

For $r_2 = 10 \times 10^{-2} m$, $\Phi_E = \oint \vec{E}_{in} \cdot d\vec{a}_2$

$$Q_{enc} = Q \times \frac{r_1^3}{R^3}$$

$$= 80 \times 10^{-9} C \times \left(\frac{10 \times 10^{-2} m}{20 \times 10^{-2} m}\right)^3$$

$$= 10.0 \times 10^{-9} C \sim 10 \text{ nC}.$$

For $r_3 = 20 \times 10^{-2} m$, $\Phi_E = \oint \vec{E}_{\text{on-surface}} \cdot d\vec{a}$

$$Q_{enc} = Q = 80 \times 10^{-9} C.$$

(d) At $r_1 = 5 \times 10^{-2} m$,

$$E_1 = \frac{Q r_1}{4\pi\epsilon_0 R^3}$$

$$= 4.494 \times 10^3 \text{ NC}^{-1}.$$

At $r_2 = 10 \times 10^{-2}\,m$, $E_2 = \dfrac{Q r_2}{4\pi\epsilon_0 R^3}$

$$= 8.988 \times 10^{3}\ NC^{-1}.$$

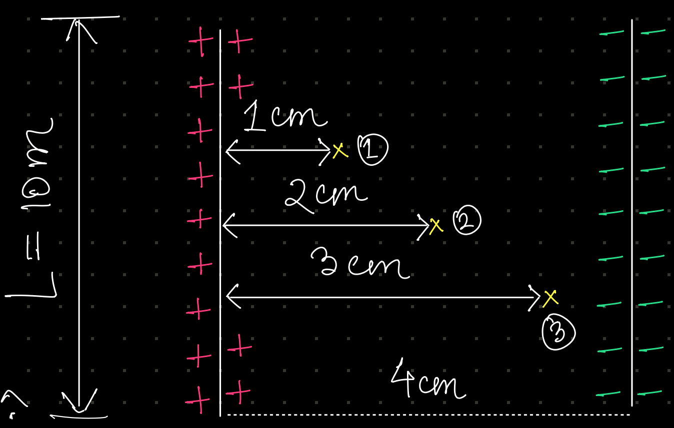
At $r_3 = 20 \times 10^{-2}\,m$, $E_3 = \dfrac{Q}{4\pi\epsilon_0 R^2}$

$$= 17.975 \times 10^{3}\ NC^{-1}.$$

2/ $\lambda_+ = \lambda_- = \dfrac{Q}{L}$

$$= 10^{-9}\ Cm^{-1}.$$

$Q_+ = +10 \times 10^{-9}\,C$ $\quad$ $Q_- = -10 \times 10^{-9}\,C$



Glass Rod $\qquad$ Plastic Rod

$$\vec{E_1} = \vec{E}_{+1} + \vec{E}_{-1}$$

$$= \frac{\lambda_+}{2\pi\epsilon_0 r_{+1}}\,\hat{i} + \frac{\lambda_-}{2\pi\epsilon_0 r_{-1}}\,\hat{i}$$

$$= \frac{10^{-9}\ Cm^{-1}}{2\pi\epsilon_0 (10^{-2}\,m)}\,\hat{i} + \frac{10^{-9}\ Cm^{-1}}{2\pi\epsilon_0 (3 \times 10^{-2}\,m)}\,\hat{i}$$

$$= (1797.510\,\hat{i} + 599.170\,\hat{i})\ NC^{-1}.$$

$$= (2396.68\,\hat{i})\ NC^{-1}.$$

Note for ST

Application of Gauss's Law for line charges may be explained only once in the beginning.

$$\vec{E}_2 = \vec{F}_{+2} + \vec{E}_{-2}$$

$$= \frac{\lambda_+}{2\pi\epsilon_0 r_{+2}}\hat{i} + \frac{\lambda_-}{2\pi\epsilon_0 r_{-2}}\hat{i}$$

$$= \frac{10^{-9}\,Cm^{-1}}{2\pi\epsilon_0(2\times10^{-2}m)}\hat{i} + \frac{10^{-9}\,Cm^{-1}}{2\pi\epsilon_0(2\times10^{-2}m)}\hat{i}$$

$$= (898.755\,\hat{i} + 898.755\,\hat{i})\,NC^{-1}.$$

$$= (1797.510\,\hat{i})\,NC^{-1}.$$

$$\vec{E}_3 = \vec{F}_{+3} + \vec{E}_{-3}$$

$$= \frac{\lambda_+}{2\pi\epsilon_0 r_{+3}}\hat{i} + \frac{\lambda_-}{2\pi\epsilon_0 r_{-3}}\hat{i}$$

$$= \frac{10^{-9}\,Cm^{-1}}{2\pi\epsilon_0(3\times10^{-2}m)}\hat{i} + \frac{10^{-9}\,Cm^{-1}}{2\pi\epsilon_0(10^{-2}m)}\hat{i}$$

$$= (599.170\,\hat{i} + 1797.510\,\hat{i})\,NC^{-1}.$$

$$= (2396.68\,\hat{i})\,NC^{-1}.$$