Phy 112

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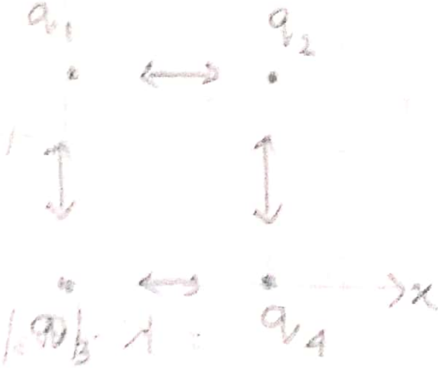
Section : 10

Chapter 21 :- Problem 11

$\Rightarrow$ Here,

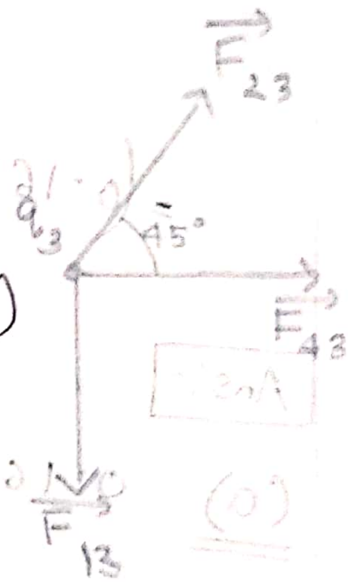


$$\vec{F}_{q_3,net} = \vec{F}_{13} + \vec{F}_{23} + \vec{F}_{43}$$

Now,

$$\vec{F}_{13} = |F_{13}| \cdot (-\hat{j})$$

$$K \frac{|q_1| \cdot |q_3|}{r_{13}^2} (-\hat{j})$$



And,

$$\vec{F}_{23} = |F_{23}| \cdot (\cos\theta\, \hat{i} + \sin\theta\, \hat{j})$$

$$= K \frac{|q_2| \cdot |q_3|}{r_{23}^2} \cdot (\cos 45^\circ\, \hat{i} + \sin 45^\circ\, \hat{j})$$

$$= \frac{K\, |q_2|\, |q_3|}{\sqrt{2} \cdot r_{23}^2} (\hat{i} + \hat{j})$$

And,

$$\vec{F}_{43} = |F_{43}| \cdot \hat{i}$$

$$= K \cdot \frac{|q_4| \cdot |q_3|}{r_{43}^2} \cdot \hat{i}$$

$$\therefore \vec{F}_{q_3,net} = K \frac{|q_1||q_3|}{r_{13}^2}(-\hat{j}) + \frac{K|q_2||q_3|}{\sqrt{2}\cdot r_{23}^2}(\hat{i}+\hat{j})$$

$$+ K\frac{|q_4|\cdot|q_3|}{r_{43}^2}\cdot\hat{i}$$

$$= K\cdot|q_3|\left[-\frac{|q_1|}{r_{13}^2}\hat{j} + \frac{|q_2|}{\sqrt{2}\cdot r_{23}^2}(\hat{i}+\hat{j}) + \frac{|q_4|}{r_{43}^2}\hat{i}\right]$$

$$= 8.987\times10^9\cdot|200\times10^{-9}|\left[-\frac{|100\times10^{-9}|}{0.05^2}\hat{j} + \frac{|+100\times10^{-9}|}{\sqrt{2}\cdot(0.05)^2}(\hat{i}+\hat{j}) + \frac{|-200\times10^{-9}|}{0.05^2}\hat{i}\right]$$

$$= (0.16921107 46\,\hat{i} - 0.0464769 2543\,\hat{j})\ N$$

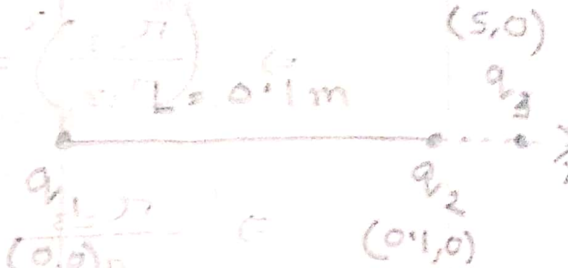
$\boxed{\text{Ans:-}}$

(a) 0.1692110746 N

(b) $-0.0464769 2543$ N

——— o ——— x ——— o ———

Chapter 21 : Problem 13



⇒ Here,

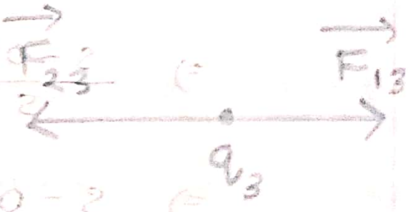
$$\vec{F}_{q_3,net} = \vec{F}_{13} + \vec{F}_{23}$$

If,

$$\vec{F}_{q_3,net} = 0 ,$$

then,

$$\vec{F}_{13} = \vec{F}_{23}$$



Now,

$$F_{13} = k . \frac{|q_1| \cdot |q_3|}{r_{13}^2}$$

And,

$$F_{23} = k . \frac{|q_2| \cdot |q_3|}{r_{23}^2}$$

If,

$$F_{13} = F_{23}$$

$$\Rightarrow k \frac{|q_1| \cdot |q_3|}{r_{13}^2} = k . \frac{|q_2| \cdot |q_3|}{r_{23}^2}$$

$$\Rightarrow \frac{|q_1|}{r_{13}^2} = \frac{|q_2|}{r_{23}^2}$$

$$\Rightarrow \left(\frac{r_{23}}{r_{13}}\right)^2 = \frac{|q_2|}{|q_1|}$$

$$\Rightarrow \frac{r_{23}}{r_{13}} = \sqrt{\frac{|q_2|}{|q_1|}}$$

$$\Rightarrow \frac{s-0.1}{s} = \sqrt{\frac{|-3\times10^{-6}|}{|1\times10^{-6}|}}$$

$$\Rightarrow \frac{s-0.1}{s} = \sqrt{3}$$

$$\Rightarrow s-0.1 = \sqrt{3}\,s$$

$$\Rightarrow s(\sqrt{3}-1) = -0.1$$

$$\Rightarrow s = -0.1366025404 \text{ m}$$

$\boxed{\text{Ans:-}}$

(a) -0.1366025404 m

(b) 0 m

Chapter 22 : Problem 27

⇒ Here, radius, $R = 8 \cdot 5$ cm $= 0 \cdot 085$ m

total charge of upper rod $= +q$

" " " lower " $= -q$

$q = 15$ pC $= 15 \times 10^{-12}$ C

As the upper and lower rods have same but opposite charge in them, the net electric field will be twice of the electric field caused by any one rod.

$$\therefore \vec{E}_{net}(P) = 2\, \vec{E}_{upper,\,p}(P)$$

We know, $dE = K \dfrac{dq}{R^2}$

$$= K \frac{\lambda\, ds}{R^2} \qquad \left[\because \frac{dq}{ds} = \lambda\right]$$

$$= K \frac{\lambda \cdot R\, d\theta}{R^2} \qquad \left[\because \frac{ds}{d\theta} = R\right]$$

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$$= \frac{K \lambda \, d\theta}{R}$$

As, the net electric force will only work towards the negative y axis, due to the cancelation of electric fields by one another through x axis, taking the component of y - coordinate,

$$dE_y = dE \cdot \sin\theta = \frac{K\lambda}{R} \sin\theta \, d\theta$$

Now, $E = \int dE_y = \frac{K\lambda}{R} \int_{\theta_1}^{\theta_2} \sin\theta \, d\theta$

$$= -\frac{K\lambda}{R} \left[\cos\theta\right]_{\theta_1}^{\theta_2}$$

For the upper rod, $\vec{E}_{upper,\,p}(P) = -\frac{K\left(\frac{q}{\pi R}\right)}{0{\cdot}085} \left[\cos\theta\right]_{0^\circ}^{180^\circ} (-\hat{j})$

$$= -11{\cdot}87813542 \, \hat{j}$$

$\therefore \vec{E}_{net}(P) = 2 \times (-11{\cdot}87813542) \, \hat{j}$

$$= -23{\cdot}75627084 \, \hat{j}$$

Ans:-

(a) $23{\cdot}75627084 \ NC^{-1}$

(b) Along the $-\hat{j}$ direction.

Chapter 22 : Problem 32

⇒ Here, total charge, $q = 7.81\ pC = 7.81 \times 10^{-12} C$

length of rod, $L = 14.5\ cm = 0.145\ m$

distance of p from rod, $R = 6\ cm = 0.06\ m$

From the symmetry of contiguous charge distribution of a rod, we know,

$$\vec{E}(P) = \frac{2kq}{R\sqrt{4R^2 + L^2}}\hat{j}$$

$$= \frac{2 \times 8.987 \times 10^9 \times 7.81 \times 10^{-12}}{0.06 \times \sqrt{4 \times 0.06^2 + 0.145^2}}\hat{j}$$

$$= 12.43052844\ \hat{j}\ NC^{-1}$$

$\boxed{\text{Ans:-}}$

(a) $12.43052844\ NC^{-1}$

(b) Along the $+\hat{j}$ direction

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Chapter 22 :- Problem 83

⇒ Here,

$$\vec{P} = (3\hat{i} + 4\hat{j}) \times 1.24 \times 10^{-30} \text{ Cm}$$

$$\vec{E} = 4000\hat{i}\ NC^{-1}$$

(a) Potential Energy,

$$U = -\vec{P}\cdot\vec{E}$$

$$= -\left[(3\hat{i}+4\hat{j}) \times 1.24 \times 10^{-30}\right] \cdot \left[4000\hat{i}\right]$$

$$= -3 \times 1.24 \times 10^{-30} \times 4000$$

$$= -1.488 \times 10^{-26} \text{ J}$$

(b) Torque, $\vec{\tau} = \vec{P} \times \vec{E}$

$$= \left[(3\hat{i} + 4\hat{j}) \times 1.24 \times 10^{-30}\right] \times \left[4000\hat{i}\right]$$

$$= -1.984 \times 10^{-26}\ \hat{k} \quad \text{Nm}$$

(c) Given, $\vec{P_2} = (-4\hat{i} + 3\hat{j})(1.24 \times 10^{-30})$ Cm

we know, $W = \Delta U = -\Delta\vec{P}\cdot\vec{E}$

$$\therefore W = -(\vec{P_2} - \vec{P})\cdot\vec{E} = -\left[(-7\hat{i} - \hat{j}) \times 1.24 \times 10^{-30}\right] \times 4000\hat{i}$$

$$= 7 \times 1.24 \times 10^{-30} \times 4000$$

⑨

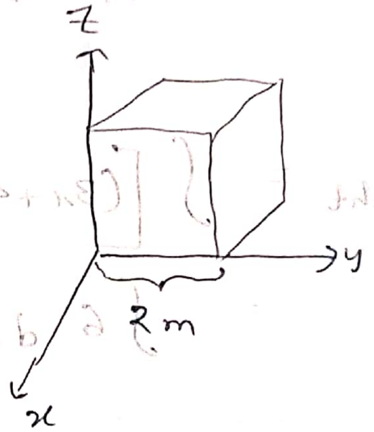
$= 3.472 \times 10^{-26}$ J

— o — x — o —

Chapter 23 :- Problem 10

$\Rightarrow$ Here,

$\vec{E} = (3x+4)\hat{i} + 6\hat{j} + 7\hat{k} \ NC^{-1}$



For,

$\phi_{Front} = \int E \cdot dA \ \hat{i}$

$= \int [(3x+4)\hat{i} + 6\hat{j} + 7\hat{k}] \cdot dA \ \hat{i}$

$= \int (3x+4) \cdot dA$

$= \int (3 \times 0 + 4) \cdot dA$

$= 4 \int dA$

$= 4A$

$= 4 \times 2^2$

$= 16$

$$\phi_{Back} = \int \left[(3x+4)\hat{i} + 6\hat{j} + 7\hat{k}\right] \cdot dA(-\hat{i})$$

$$= \int -(3x+4)\, dA$$

$$= -\left[3\times(-2)+4\right] \cdot \int dA$$

$$= 2A = 2\times 2^2 = 8$$

$$\phi_{Right} = \int \left[(3x+4)\hat{i} + 6\hat{j} + 7\hat{k}\right] \cdot dA\, \hat{j}$$

$$= \int 6\, dA = 6A = 6\times 2^2 = 24$$

$$\phi_{Left} = \int \left[(3x+4)\hat{i} + 6\hat{j} + 7\hat{k}\right] \cdot dA\,(-\hat{j})$$

$$= \int -6\, dA = -6\times 4 = -24$$

$$\phi_{Top} = \int \left[(3x+4)\hat{i} + 6\hat{j} + 7\hat{k}\right] \cdot dA\, \hat{k}$$

$$= \int 7\, dA = 7\times 2^2 = 28$$

$$\phi_{Bottom} = \int \left[(3x+4)\hat{i} + 6\hat{j} + 7\hat{k}\right] \cdot dA\,(-\hat{k})$$

$$= \int -7\, dA = -7\times 2^2 = -28$$

$\therefore \phi_{net} = \phi_{Front} + \phi_{Back} + \phi_{Right} + \phi_{Left} + \phi_{Top} + \phi_{Bottom}$

$= 16 + 8 + 24 - 24 + 28 - 28$

$= 24$

We know, $\phi_{net} \varepsilon_0 = q_{enclosed}$

$\therefore q_{enclosed} = 24 \times 8.854 \times 10^{-12}$ ~~[illegible]~~ C

$= 2.12496 \times 10^{-10}$ C

(Ans)

Chapter 23 :- Problem 24

$\Rightarrow$ Here,

radius, $R = 3\ cm = 0.03\ m$

linear charge density, $\lambda = 2 \times 10^{-8}\ cm^{-1}$

$\boxed{(a)}$ at $r = \frac{R}{2} = \cancel{1 \times 10^{-8}}\ 0.015\ m$, $q_{enclosed} = 0\ C$

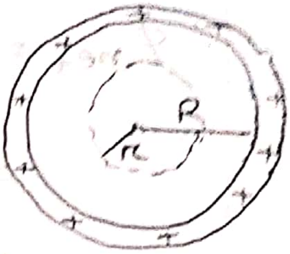
$\therefore \varepsilon_0 \phi = q_{enclosed}$

$\Rightarrow \varepsilon_0 \int E \cdot dA = 0$

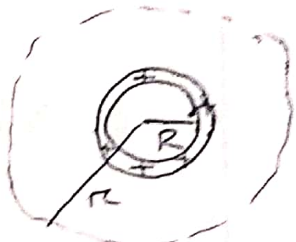
$$\Rightarrow \varepsilon_0 E \cdot 2\pi r = 0$$

$$\Rightarrow E = \frac{0}{2\pi r \varepsilon_0}$$

$$\therefore E = 0 \ \text{NC}^{-1}$$



(b) at, $r = 2R = 0.06$ m,



$$\varepsilon_0 \oint E \cdot dA = q_{enclosed}$$

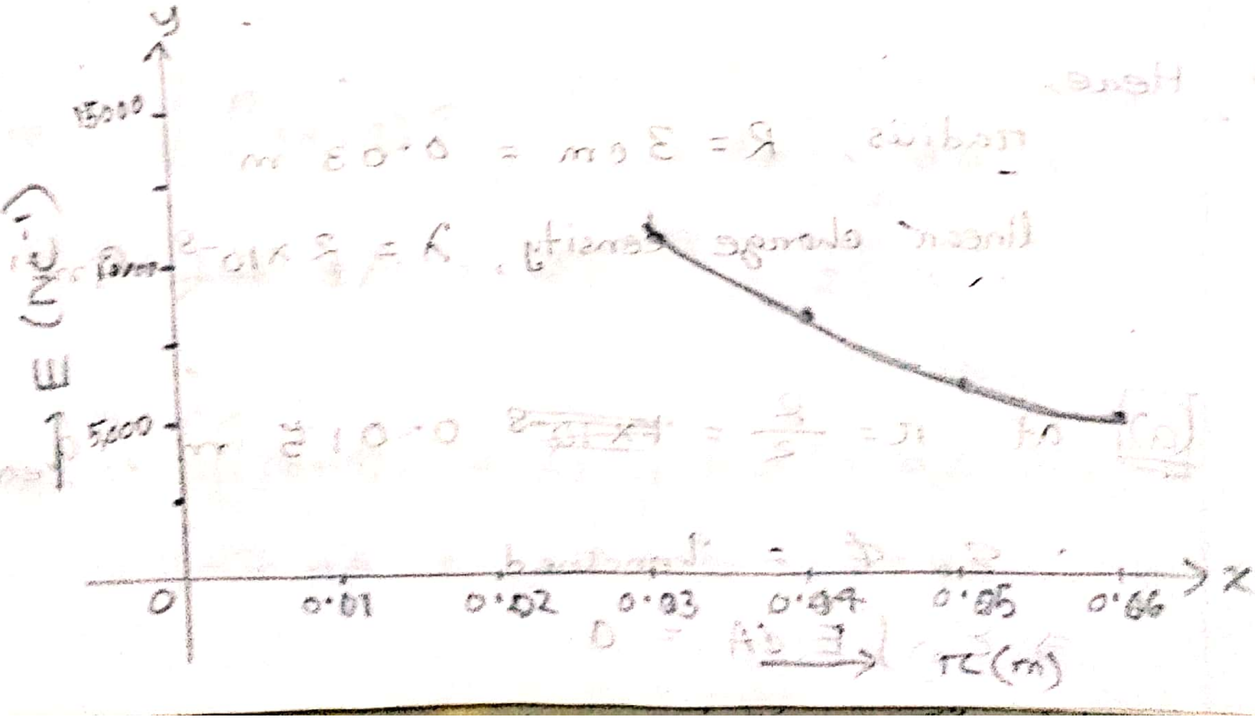
$$\Rightarrow \varepsilon_0 E \cdot 2\pi r l = \lambda l$$

$$\Rightarrow E = \frac{\lambda l}{2\pi \varepsilon_0 r l} = \frac{\lambda}{2\pi \varepsilon_0 2R} = \frac{\lambda}{4\pi \varepsilon_0 R}$$

$\cancel{= 1129.433025 \ \text{NC}^{-1}}$

$= 5991.828292 \ \text{NC}^{-1}$

(c)



Chapter 23 ; Problem 29

⇒ Given that,

$R_1 = 1.3\ mm$
$= 1.3 \times 10^{-3}\ m$

$L_1 = 11\ m$

$Q_1 = 3.4 \times 10^{-12}\ C$

$R_2 = 10 R_1$
$= 1.3 \times 10^{-2}\ m$

$L_2 = 11\ m = L_1$

$Q_2 = -2Q_1$

(a) at $r = 2R_2$, $r > R_2 > R_1$

$\therefore\ \varepsilon_0 \oint E \cdot dA = q_{enclosed}$

$$\Rightarrow E \cdot 2\pi r L = \frac{Q_1 + Q_2}{\varepsilon_0}$$

$$\Rightarrow E = \frac{-Q_1}{2\pi r \varepsilon_0 L} = -0.2136945754\ NC^{-1}$$

(b) As, the sign of E is negative, so angle between $\vec{E}$ and $\vec{A}$ will be $180°$. So, ~~Di~~ direction of $\vec{E}$ will be radially inward.

(c) at $r = 5R_1$, $R_2 > r > R_1$

$\therefore \varepsilon_0 \oint E \cdot dA = q_{enclosed}$

$\Rightarrow E \cdot 2\pi r L = \frac{Q_1}{\varepsilon_0}$

$\therefore E = \frac{Q_1}{2\pi r \varepsilon_0 L} = 0.854778 3018 \ NC^{-1}$

(d) As E is positive, the angle between $\vec{E}$ and $\vec{A}$ will be $0°$. so, $\vec{E}$ will point radially outward.

(e) Since, there is a charged rod inside the shell, the inner sufrface of the shell will ~~contatt~~ contain the opposite charge of the rod.

$\therefore Q_{interior} = -Q_1 = -3.4 \times 10^{-12}$ C

(f) $Q_2 = Q_{interior} + Q_{exterior} = -2Q_1$

$\Rightarrow Q_{exterior} = -2Q_1 - Q_{interior}$

$= -3.4 \times 10^{-12}$ C

—o—x—o—