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Assignment: 03

Question: 01

$q_1 = 3nC = 3\times10^{-9}C$

$q_2 = -7nC = -7\times10^{-9}C$

$q_3 = 5nC = 5\times10^{-9}C$

$r_1 = 2cm = 2\times10^{-2}m$

$r_2 = 4cm = 4\times10^{-2}m$

$k = 9\times10^{9}\ Nm^2C^{-2}$

Sol:-

$$F_{13} = \frac{kq_1q_3}{r_1^2} \qquad F_{23} = \frac{kq_2q_3}{r_2^2}$$

$$F_{13} = \frac{(9\times10^{9})(3\times10^{-9})(5\times10^{-9})}{(2\times10^{-2})^2}$$

$$\boxed{F_{13} = 3.374\times10^{-4}N\ (\text{to the left})}$$

$$F_{23} = \frac{(9\times10^{9})(-7\times10^{-9})(5\times10^{-9})}{(0.04)^2}$$

$$= -1.96\times10^{-4}$$

$$\boxed{F_{23} = 1.96\times10^{-4}N\ (\text{to the right})}$$

Total force $= F_{13} + F_{23}$

$F = 1.414\times10^{-4}N$

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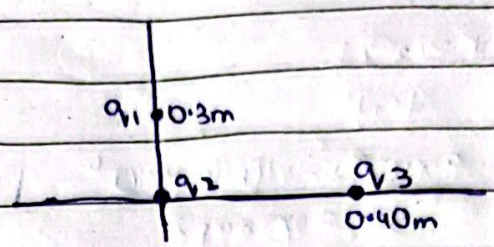
Question: 02:

$q_1 = 2\mu C$ at $y = 0.3m$

q_2 at origin

$q_3 = 4\mu C$ at $x = 0.40m$



Sol:-

Acc to question:-

$$q_1 = q_2 = 2\times10^{-6}\,C$$

$$q_3 = 4\times10^{-6}\,C$$

$$r_{23} = 0.40m$$

$$r_{12} = 0.3m$$

$$r_{13} = \sqrt{(r_{12})^2 + (r_{23})^2}$$

$$r_{13} = \sqrt{(0.4)^2 + (0.3)^2}$$

$$r_{13} = 0.5m$$

$$\Sigma F = \Sigma F_x + \Sigma F_y$$

$$\Sigma F = (F_{13x} + F_{23x}) + (F_{13y} + F_{23y})$$

$$F_{13} = \frac{Kq_1q_3}{(r_{13})^2} \Rightarrow \frac{9\times10^9 \times 2\times10^{-6} \times 4\times10^{-6}}{(0.5)^2}$$

$$F_{13} = 0.288\,N$$

$$\theta_1 = \tan^{-1}\left(\frac{P}{H}\right)$$

$$= \tan^{-1}\left(\frac{0.3}{0.4}\right)$$

$$\theta_1 = 36.87°$$

$$F_{13_x} = F_{13}\cos\theta_1 \qquad F_{13y} = F_{13}\sin\theta_1$$

$$F_{13_x} = 0.230\,(right) \qquad F_{13y} = 0.172\,(down$$

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$$F_{23} = \frac{k q_2 q_3}{(r_{23})^2}$$

$$= \frac{9\times10^9 \times 2\times10^{-6} \times 4\times10^{-6}}{(0.4)^2}$$

$$\boxed{F_{23} = 0.449\,N}$$

* F_{23} only applies to right

$F_{23} = F_{23_x} = 0.449\,N$ & $F_{23_y} = 0$

NOW $\Sigma F = \Sigma F_x + \Sigma F_y$

$F_x = F_{13x} + F_{23x}$

$= 0.230 + 0.449$

$F_x = 0.679\,N$ (downwards)

$F_y = F_{13y} + F_{23y}$

$= 0.172 + 0$

$F_y = 0.172\,N$

$F_{net} = \sqrt{(F_x)^2 + F_y^2}$

$= \sqrt{(0.679)^2 + (0.172)^2}$

$F_{net} = 0.701\,N$

$\theta = \tan^{-1}\left(\frac{F_y}{F_x}\right)$

$\theta = 14.25°$

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Question 03:-

$$\Phi = \frac{\text{total charge}}{\varepsilon_0}$$

For S1 :-

$$\Phi = \frac{-2Q + Q}{\varepsilon_0} = \frac{-Q}{\varepsilon_0} \text{ Vm}$$

FOR S2 :-

$$\Phi = \frac{Q - Q}{\varepsilon_0} = 0 \text{ vm}$$

FOR S3 ⇒

$$\Phi = \frac{-2Q + Q - Q}{\varepsilon_0} = \frac{-2Q}{\varepsilon_0} \text{ vm}$$

FOR S4 ⇒

$$\Phi = \frac{0}{\varepsilon_0} \Rightarrow 0 \text{ vm}$$

Question: 04:

$r = 3.2 \times 10^{-2}$ m

$a_1 = 7 \text{ m/s}^2$

$a_2 = a \text{ m/s}^2$

$m_1 = 6.3 \times 10^{-7}$ kg

Sol :

∵ Acc to Newton's Second law of motion

$F = ma$

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$F_1 = m_1 a_1 \quad F_2 = m_2 a_2$

∵ both charges are equal

$m_1 a_1 = m_2 a_2$

$m_2 = \frac{m_1 a_2}{a_2}$

$m_2 = \frac{(6.3 \times 10^{-7})\ 7}{9}$

$\boxed{m_2 = 4.9 \times 10^{-7}\ kg}$

Acc to ~~Column~~ Coulomb's law:-

$F = k_e \frac{q_1 q_2}{r^2} \quad \because q_1 = q_2$

$F = \frac{k q^2}{r^2}$

but $F = ma$

$ma = \frac{kq^2}{r^2}$

$q^2 = \frac{ma r^2}{k}$

$q = \sqrt{\frac{ma r^2}{k}} \Rightarrow \sqrt{\frac{(6.3 \times 10^{-7})(7)(3.2 \times 10^{-3})^2}{9 \times 10^9}}$

$\boxed{q = \pm 7.1 \times 10^{-11}\ C}$

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Question: 05

$q_1 + q_2 = 5 \times 10^{-5}\ C$

$F = 1N \quad , \quad r = 2m$

Sol:-

$$F = \frac{k q_1 q_2}{r^2}$$

$$q_1 q_2 = \frac{F r^2}{k}$$

$$q_1 q_2 = \frac{(1)(2)^2}{9 \times 10^9}$$

$$q_1 q_2 = 4.45 \times 10^{-10}$$

$\because q_1 + q_2 = 5 \times 10^{-5}$

let $q_1 = x$ & $q_2 = 5 \times 10^{-5} - x$

substitute value

$$x(5 \times 10^{-5} - x) = 4.45 \times 10^{-10}$$

$$x^2 - 5 \times 10^{-5} x + 4.45 \times 10^{-10} = 0$$

by quadratic formula

$x_1 = 3.84 \times 10^{-5}\ C$ ~~$x_1 = 4.025 \times 10^{-5}$~~

$x_2 = 1.16 \times 10^{-5}\ C$ ~~$x_2 = 7.5 \times 10^{-6}$~~

smaller charge

$1.16 \times 10^{-5}\ C$ ~~4.5×10^{-6}~~ C