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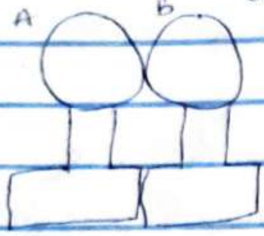
MATRIC NO: 19/MHS01/041

DEPARTMENT: MBBS

SECTION A: 1 & 2

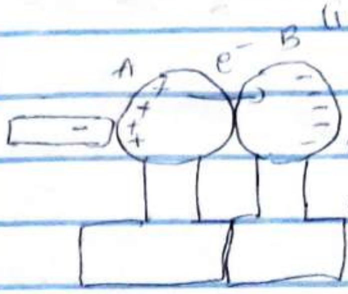
(i)

1.a.

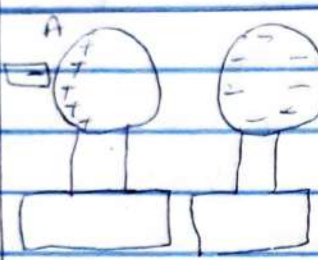


Two metal spheres are mounted on insulating stands

(ii)

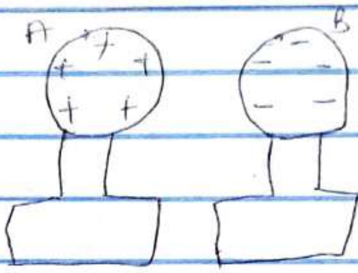


The presence of a -charge induces e^- to move from sphere A to B



Sphere B is separated from A using the insulating stand.

(iii)



The excess charge distributes itself uniformly over the surface of the spheres

(iv)

1.b. $q_1 + q_2 = 5.0\times10^{-5}C$, $F = 1.0N$, $r = 2.0m$, $q_1 = ?$, $q_2 = ?$

soln.

$$F = \frac{Kq_1q_2}{r^2}, \quad q_1q_2 = \frac{Fr^2}{K} = \frac{1\times2^2}{9\times10^9} = 4.4\times10^{-10}C^2$$

$$q_1 = 5.0\times10^{-5} - q_2$$

$$(5.0\times10^{-5} - q_2)q_2 = 4.4\times10^{-10}C^2$$

$$5.0\times10^{-5}q_2 - q_2^2 = 4.4\times10^{-10}C^2$$

$$q_2^2 - 5.0\times10^{-5}q_2 + 4.4\times10^{-10}C^2 = 0$$

$$q_2 = \frac{-b \pm \sqrt{b^2-4ac}}{2a} = \frac{5.0\times10^{-5} \pm \sqrt{(5.0\times10^{-5})^2 - 4(1)(4.4\times10^{-10})}}{2(1)}$$

$$q_2 = 5.0\times10^{-5} \pm 4.99\times10^{-5}/2$$

$$q_2 = 5.0\times10^{-5} \pm 2.49\times10^{-5}$$

$$q_2 = 2.51\times10^{-5} \text{ or } 7.49\times10^{-5}$$

$$q_1 = 5.0\times10^{-5} - 2.51\times10^{-5} \text{ or } 5.0\times10^{-5} - 7.49\times10^{-5}$$

$$= 2.49\times10^{-5} \text{ or } -2.49\times10^{-5}$$

q_1 & $q_2 = 2.49\times10^{-5}$ & 2.51×10^{-5}, since the 2 spheres are both positively charged.

1(c) $Q_1 = Q_2 = 8\mu C$, $d = 0.5m$, $q = ?$, $P = 0$

$F = \frac{KQ_1Q_2}{r^2} = \frac{9\times10^9 \times (8\times10^{-6})^2}{(0.5+0.5)^2} = 0.576N$

$F = \frac{KQ_1q}{r^2} = \frac{9\times10^9 \times 8\times10^{-6} \times q}{(0.5)^2} = 2.88\times10^5 q N$

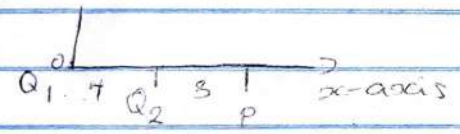
$\therefore 0.576N = 2.88\times10^5 q N$

$q = \frac{0.576N}{2.88\times10^5 N}$

$q = 2\times10^{-6} \approx \underline{2\mu C}$

2(a) Electric field is a region of space in which an electric charge will experience an electric force while electric field intensity is the force per unit charge at a point in an electric field.

b(i)



$\therefore E_1 = \frac{Kq_1}{r_1^2} = \frac{9\times10^9 \times 8\times10^{-9}}{7^2} = 1.47 N/C$

$E_2 = \frac{Kq_2}{r_2^2} = \frac{9\times10^9 \times 12\times10^{-9}}{3^2} = 12 N/L$

Vector	Angle	x-comp	Y-comp
$E_1 = 1.47N/C$	90°	0	1.47
$E_2 = 12N/C$	90°	0	12

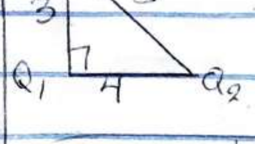
$\therefore E_x = 0$, $E_y = 13.47$

$E_{net} = \sqrt{E_x^2 + E_y^2}$

$E_{net} = \sqrt{13.47^2} = 13.47 \approx 13.5N/C$

$\therefore$ Ans $= \underline{13.5N/C}$

(ii)



$\therefore E_1 = \frac{Kq_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-9}}{3^2} = 8N/C$, $E_2 = \frac{9\times10^9 \times 8\times10^{-9}}{5^2} = 4.32N/C$

Vector	Angle	x-comp	Y-comp
$E_1 = 8N/C$	90°	0	8
$E_2 = 4.32N/C$	45°	3.0547	3.0547

$\therefore E_x = 3.0547$, $E_y = 11.055$

$\therefore \vec{E}_{net} = \sqrt{E_x^2 + E_y^2} = \sqrt{131.54}$

$\vec{E}_{net} = 11.7 \approx 11.5N/C$

$\therefore$ Ans: $\underline{11.5N/C}$

SECTION B : 4 & 5

4(a) Magnetic flux is defined as the strength of magnetic field reresented by lines of force.

(b) $m = 9.11 \times 10^{-31}$ Kg, $r = 1.4 \times 10^{-?}$ m, $B = 3.5 \times 10^{-1}$ weber/m²

⊥ to speed means $\theta = 90°$, charge on an electron $= 1.6 \times 10^{-19}$ C

∴ cyclotron frequency = ?

Soln.

$$\text{Period} = T = \frac{2\pi m}{qB}$$

$$F = \frac{1}{T} = \frac{qB}{2\pi m} = \frac{1.6 \times 10^{-19} \times 3.5 \times 10^{-1}}{2 \times \pi \times 9.11 \times 10^{-31}} = 9{,}783{,}399{,}356$$

∴ cyclotron frequency $= f = 9783399356 \simeq 9.8 \times 10^{9}$ Hz

5(a) Biot-savart Law: States that the magnetic intensity at any Point due to a steady current in an infinitely long straight wire is directly Proportional to the current and inversely Proportional to the distance from Point to wire. It is an equation that describes the magnetic field created by a current carrying wire, and allows calculation of its strength at various Points.

(b) from: $d\vec{B} = \frac{\mu_0 I \, d\vec{L} \times \hat{r}}{4\pi \, r^2} \rightarrow \vec{B} = \frac{\mu_0}{4\pi} \int \frac{I \, dL \sin\theta}{r^2}$

$$\therefore B = \frac{\mu_0 I}{4\pi} \int_{-a}^{a} \frac{dL \sin(\pi - \theta)}{r^2}$$

note: $\sin(\pi - \theta) = \sin\theta = x/(x^2+y^2)^{1/2}$

$r^2 = x^2 + y^2$, $dL = dy$

$$\therefore B = \int \frac{dy}{(x^2+y^2)^{3/2}} = \frac{1}{x^2} \frac{y}{(x^2+y^2)^{1/2}}$$

$$B = \frac{\mu_0 I x}{4\pi} \left[\frac{y}{x^2(x^2+y^2)^{1/2}} \right]_{-a}^{a} = \frac{\mu_0 I x}{4\pi} \left(\frac{2a}{x^2(x^2+a^2)^{1/2}} \right)$$

$$B = \frac{\mu_0 I}{4\pi x} \left(\frac{2a}{(x^2+a^2)^{1/2}} \right), \quad (x^2+a^2)^{1/2} \cong a, \text{ as } a \rightarrow \infty.$$

$$\therefore B = \frac{\mu_0 I}{2\pi x}$$