Phy 102 Assignment

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Level: 100
Matric no: 19/MHS01/437

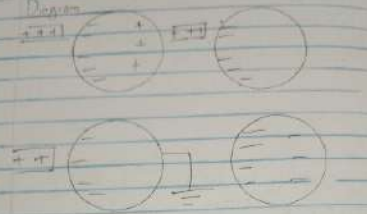
Answer 4 questions in all - two from section A and two from section B

1a Explain with aid of a diagram how you can produce a negatively charged sphere by method of induction

Charging by Induction

Electrostatic induction is a process of charging a body by introducing a charged body to a neutral body. If a positively charged rubber is brought near a neutral conducting sphere that's insulated, the repulsive between the rod and the sphere causes a redistribution of charges so that protons move further away from the rod in the sphere which causes the region of sphere closest to the rod to have excess negative charge. If a conducting wire is connected to the sphere, some protons leave the sphere to the earth and when the wire is removed the sphere is left with excess induced negative charge and when the rod is finally removed from the sphere the induced negative charge becomes uniformly distributed round the sphere.

Diagram



b Each of two small spheres is charged positively, the combined charge being 5.0×10^{-5}C. If each sphere is repelled from the other by a force of 1.0N when the spheres are 2m apart. Calculate charge on each sphere

Solution

$k = 9 \times 10^9$

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

$F = 1N$

$d = 2m$

Recall that $F = \frac{kq_1 q_2}{r^2}$

so $q_1 = Q - q_2 = q_1 = 5 \times 10^{-5} - q_2$ --- (1)

$1 = \frac{9\times10^{9} \times q_1 q_2}{2^2}$

$\frac{4}{9\times10^9} = \frac{9\times10^9 \times q_1 q_2}{9\times10^9}$ divide thru by 9×10^9

$q_1 q_2 = 4.44\times10^{-10}$ ... (ii)

Since $q_1 = 5\times10^{-5} - q_2$ equate into eq (ii)

$(5\times10^{-5} - q_2)q_2 = 4.44\times10^{-10}$

$5\times10^{-5}q_2 - q_2^2 - 4.44\times10^{-10} = 0$

$-q_2^2 + 5\times10^{-5}q_2 - 4.44\times10^{-10} = 0$

use quadratic equation

$q = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

$\therefore q_1 = 1.155\times10^{-5}C$

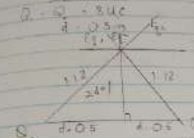
$q_2 = 3.845\times10^{-5}C$

C Three charges were positioned as shown in the figure below. If $Q_1 = Q_2 = 8\mu C$ and $d = 0.5m$, determine q if the electric field P is at zero.

Solution

$Q_1 = Q_2 = 8\mu C$

$d = 0.5m$



tan θ = opp/adj

tan θ = 1/0.5

θ = 63.43

$E_{q_1} = \frac{kq_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-6}}{1.12^2} = 57397.96$ N/C

$E_{q_2} = \frac{kq_2}{r^2} = \frac{9\times10^9 \times 8\times10^{-6}}{1.12^2} = 57397.96$ N/C

$E_q = \frac{kq}{r_2^2} = \frac{9\times10^9 \times q}{1} = 9\times10^9 q$

Vector	Angle	x-comp	y-comp
E_1	63.43	$E_1 \cos 63.43$ = -25673.6	$E_1 \sin 63.43$ 51336
			51336
E_2	63.43	25673.6	$9\times10^9 q$
E_q	90	$E_q \cos 90 = 0$	
		$\Sigma x = 0$	$\Sigma y = 102672 + 9\times10^9 q$

$EP = \sqrt{(\Sigma x)^2 + (\Sigma y)^2}$ but $E_P = 0$

$0 = 0 + 102672 + 9\times10^9 q$

$-9\times10^9 q = 102672$

$q = \frac{-102672}{9\times10^9}$

$= -1.14\times10^{-5} = -11.4\times10^{-6}$

$q = -11.4\ \mu C$

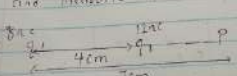
2 a A positive ~~q~~

Electric field is the region of space around a charge where the force of attraction is felt

While

Electric field intensity is force per unit charge and measured in Newton per coloumb

2b i)



$E_1 = \frac{kq_1}{r_1^2} = \frac{9\times10^9 \times 8\times10^{-9}}{7^2} = 1.469$

$E_2 = \frac{kq_2}{r^2} = \frac{9\times10^9 \times 12\times10^{-9}}{3^2} = 12$

$E_{net} = E_1 + E_2 = 1.469 + 12 = 13.5$ N/C

$E_{net} = 13.5\,N/c$

ii)

$\tan\theta = 3/4$

$\tan^{-1} 0.75 = 36.87$

$E_1 = \frac{kq_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-9}}{3^2} = 8N$

$E_2 = \frac{kq_2}{r^2} = \frac{9\times10^9 \times 12\times10^{-9}}{5^2} = 4.32$

Vector	Angle	y comp	x comp
E_1	90	$8\sin 90 = 8$	$8\cos 90 = 0$
E_2	36.87	$4.32\sin 36.87 = 2.59$	3.455
		$= 10.59$	3.455

$E\ Net = \sqrt{(10.59)^2 + (3.455)^2}$

$= 11.2\,N/c$

(iii) $\tan\theta = \frac{E_y}{E_x}$ $\quad \theta = \tan^{-1}\frac{10.59}{3.455} = 71.93°$

4 a. Magnetic flux is the strength of a magnetic field represented by lines of force. Represented by B

b. $m = 9.11\times10^{-31}kg$

$r = 1.6\times10^{-19}$

$B = 3.5\times10^{-1}T$

Cyclotron frequency

$W = \frac{v}{r} = \frac{qB}{m}$

$W = \frac{1.6\times10^{-19} \times 3.5\times10^{-1}}{9.11\times10^{-31}}$

$= 6.147\times10^{10}\ rad\,s^{-1}$

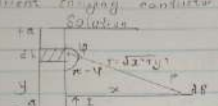
c. It states that an electron mass of 9.11×10^{-31} kg and charge $1.6\times10^{-19}C$ in motion in a magnetic field of 3.5×10^{-1} Tesla perpendicular to the field will have a cyclotron frequency of 6.147×10^{10} rad s^{-1}

5 a. Biot - Savart law is based on observation of magnetic field $d\vec{B}$ at Point P associated with length dl of a wire carrying steady current I

$d\vec{B} = \frac{\mu_0}{4\pi}\frac{I\,d\vec{l}\times\hat{r}}{r^2}$

b. Use the Biot - Savart law and show the magnitude of magnetic field of a straight current carrying conductor is given as $B = \frac{\mu_0 I}{2\pi r}$

Solution



$B = \frac{\mu_0}{4\pi}\int \frac{I\,d\vec{l}\times\hat{r}}{r^2}$

$B = \frac{\mu_0}{4\pi}\int \frac{I\,dl\sin\theta}{r^2}$

$B = \frac{\mu_0 I}{4\pi}\int_{-a}^{a} \frac{dl\sin\varphi}{r^2}$

$\sin(\pi - \varphi) = \sin\theta$

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

From diagram $r^2 = x^2 + y^2$ $\ldots\ldots$ (*)

$B = \frac{\mu_0 I}{4\pi}\int_{-a}^{a} \frac{dl\sin(\pi-\varphi)}{x^2+y^2}$

But $\sin(\pi - \theta) = \frac{x}{\sqrt{x^2+y^2}} = \frac{x}{(x^2+y^2)^{1/2}}$ ...... (**)

Sub (**) into (*)

$$B = \frac{\mu_0 I}{4\pi}\int_{-\infty}^{\infty} \frac{dl \; x}{(x^2+y^2)(x^2+y^2)^{1/2}}$$

$$B = \frac{\mu_0 I}{4\pi}\int_{-a}^{a} \frac{dl \; x}{(x^2+y^2)^{3/2}}$$

Recall $dl = dy$

$$B = \frac{\mu_0 I}{4\pi}\int_{-a}^{a} \frac{x}{(x^2+y^2)^{3/2}}\,dy$$

$$B = \frac{\mu_0 I x}{4\pi}\int_{-a}^{a} \frac{1}{(x^2+y^2)^{3/2}}\,dy$$

$$B = \frac{\mu_0 I x}{4\pi}\int_{-a}^{a} \frac{1}{(x^2+y^2)^{3/2}}\,dy \quad \text{...... (***)}$$

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

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

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

Lenght of 2a is compared to distance x from [illegible]

$(x^2+a^2)^{1/2} \Rightarrow a$ as $a \to \infty$

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

At all points of circle of radius around around

the conductor should make magnitude $B = \frac{\mu_0 I}{2\pi x}$