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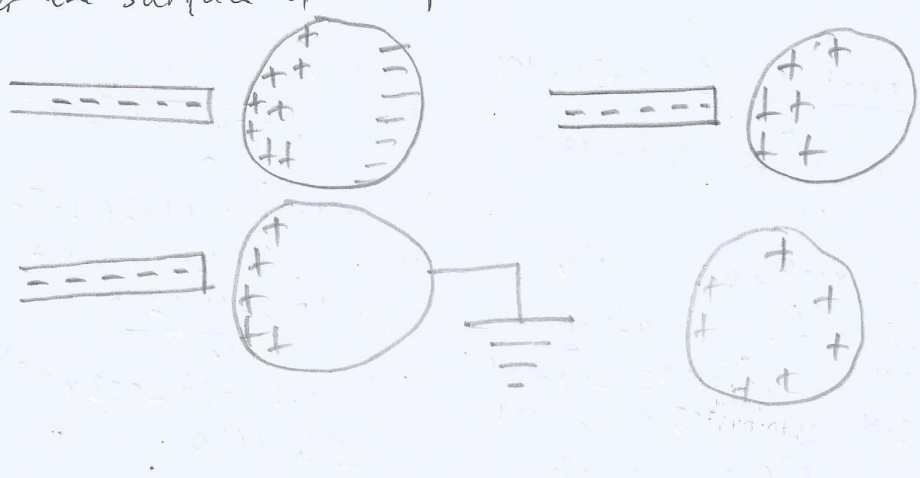
PHY 102 ASSIGNMENT

Section A

① a) Consider a negatively charged rubber rod brought near an uncharged (neutral) conducting sphere, that is insulated so that there is no conducting path to ground as. The repulsive force between the electrons in the rod and those in the Sphere causes a redistribution of charges on the sphere so that some electrons move to the side of the sphere farthest away from the rod. The region of the sphere nearest the negatively charged rod has an excess of positive charge because of the migration of electrons away from this location. If a grounded conducted wire is then connected to the sphere, some of the electrons leave the sphere and travel to the earth. If the wire to the ground is then removed, the conducting sphere is left with an excess of induced positive charge. Finally, when the rubber rod is removed from the vicinity of the Sphere, the induced positive charge remains on the ungrounded sphere and becomes uniformly distributed over the surface of the sphere



b.) $K = \frac{1}{4\pi\varepsilon_0} = 8.98 \times 10^9 Nm^2/C^2 \simeq 9.0 \times 10^9 Nm^2/C^2$

$q_1 + q_2 = 5.0 \times 10^{-5} C$

$F = 1.0 N$

$d = 2.0 m$

Charge on either sphere = ??

$F = \frac{K q_1 q_2}{r^2}$ | $1 = \frac{(9\times10^9 Nm^2/C^2)(q_1 q_2\ 5\times10^{-5})}{2^2}$

$4 = 9\times10^9 \times 5\times10^{-5}\ q^1 + 9\times10^9 q_2$

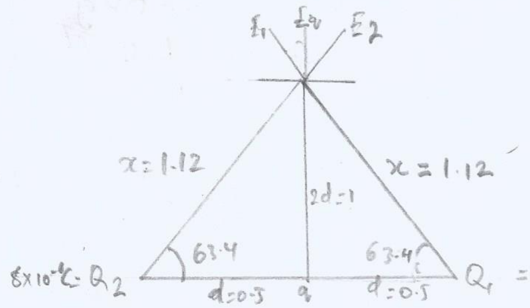
$4 = 4.5 \times 10^5 q_1 + 9\times10^9 q_2$

$9\times10^9 q_2 - 4.5\times10^5 q_1 + 4 = 0$

$q_1 = 1.11 \times 10^{-5} C$

$q_2 = 3.8 \times 10^{-5} C$

c.)



$x^2 = 1^2 + 0.5^2$

$\sqrt{x^2} = \sqrt{1.25}$

$x = 1.12$

$\tan\theta = \frac{1}{0.5}$

$\theta = \tan^{-1}(1/0.5)$

$\theta = 63.4$

$E_1 = \frac{Kq_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-6}}{(1.12)^2} = 57397.959$

$E_2 = \frac{Kq_2}{r^2} = \frac{9\times10^9 \times 8\times10^{-6}}{(1.12)^2} = 57397.959$

$E_q = \frac{Kq}{r^2} = \frac{9\times10^9 \times q}{r^2} = 9\times10^9 q$

Vector	Angle	x – Component $E_1 \cos\theta$ =	y – Component $E_1 \sin\theta$
$E_1 = 57397.959$	63.4	25670.045785	5132.262839
$E_2 = 57397.959$	63.4	25670.045785	5132.262839
$E_q = 9\times10^9 q$	90	$E_q \cos\theta$ .0	$9\times10^9 q$
		$E_x = 0$	$E_y = 10264.52568$

Magnitude $= \sqrt{(E_x)^2 + (E_y)^2}$

$E_q = \sqrt{(0)^2 + (10264.52568)^2}$

Since $E_q = 0$

$0 = 9\times10^{-9} q + 10264.52568$

Making q the subject of formula

$q = \frac{10264.52568}{9\times10^9}$

$q = 1.140502853 \times 10^{-16}$

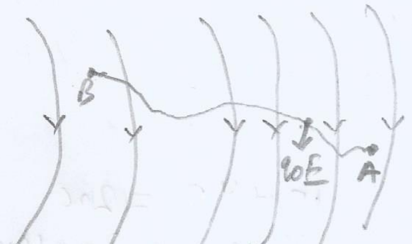
$\simeq 11.4 MC$

③ a) (i) Volume Charge density, $\rho = \frac{dQ}{dv} \rightarrow dQ = \rho dv$

(ii) Surface charge density; $\sigma = \frac{dQ}{dA} \rightarrow dQ = \sigma dA$

(iii) Linear Charge density, $\lambda = \frac{dQ}{dL} \rightarrow dQ = \lambda dL$

b.) The electric potential difference between two points in an electric field can be defined as the work done per unit charge against electrical forces when a charge is transported from one point to the other. It is measured in Volt (v) or joules per Coulomb (J/C).



Consider the diagram above, suppose a test charge q_0 is moved from point A to point B along an arbitrary path inside an electric field E. The Electric field E exerts a force $F = q_0E$ on the charge. To move the test charge from A to B at constant velocity, an external force of $F = -q_0E$ must act on the charge, therefore, the elemental work done dW =:

$$dW = F \cdot dl \quad — (1)$$

Recall $\vec{F} = -q_0E \quad — (2)$

Substituting 2 into 1

$$dW = -q_0 E dl \quad — (3)$$

Then the total work done in moving the test charge from A to B

$$W(A \rightarrow B)_{Ag} = -q_0 \int_A^B E\, dl \quad — (4)$$

From the definition of electric potential difference, it follows that:

$$V_B - V_A = \frac{W(A \rightarrow B)_{Ag}}{q_0} \quad — (5)$$

Putting (4) in (5)

$$V_B - V_A = -\int_A^B E\, dl \quad — (6)$$

3c.) $Q_1 = 10\mu C$

$Q_2 = -2\mu C$

$x = 0$

$x = 4m$

$$V_{(A-B)} = \frac{1}{4\pi\mathcal{E}_0}\left(\frac{Q_1}{y} + \frac{Q_2}{4-y}\right)$$

$$\cancel{0} = \frac{1}{\cancel{4\pi\mathcal{E}0}}\left(\frac{Q_1}{y} + \frac{Q_2}{4-y}\right)$$

Multiply through by $\cancel{4\pi\mathcal{E}0}$ $\frac{1}{4\pi\mathcal{E}_0}$

$$0 = \frac{Q_1}{y} + \frac{Q_2}{4-y}$$

$$0 = \frac{10\cancel{\times 10^{-6}}}{y} - \frac{2\cancel{\times 10^{-6}}}{4-y}$$

$$\frac{2}{4-y} = \frac{10}{y}$$

$$10(4-y) = 2 \cdot y$$

$$40 - 10y = 2y$$

$$\frac{40}{12} = \frac{12y}{12}$$

$$y = 3.33$$

$$V_{(A-B)} = \frac{1}{4\pi\mathcal{E}_0}\left(\frac{Q_1}{x} + \frac{Q_2}{x+4}\right)$$

multiply through by $1/4\pi\mathcal{E}_0$

$$0 = \frac{Q_1}{x} + \frac{Q_2}{x+4}$$

$$\frac{2\cancel{\times 10^{-6}}}{x+4} = \frac{10\cancel{\times 10^{-6}}}{x}$$

$$\frac{10}{x} = \frac{2}{x+4}$$

$$10x + 40 = 2x$$

$$\cancel{10}40 = 2x - 10x$$

$$\frac{40}{-8} = \frac{-8x}{-8}$$

$$x = -5m$$

$\therefore$ The positions along the x-axis where $V=0$ are $x = -5m$, $3.33m$

Section B

(4)a Magnetic flux is defined as the strength of the magnetic field which can be represented by line of forces. It is represented by the symbol Φ and mathematically given as $\Phi B \cdot dA$

4b. $m = 9 \times 10^{-31}$ Kg
$r = 1.4 \times 10^{-9}$ m
$B = 3.9 \times 10^{-1}$ weber/metre^2
Cyclotron frequency = angular speed

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

$$W = \frac{qB}{m} = \frac{1.6 \times 10^{-19} \times 3.5 \times 10^{-1}}{9 \times 10^{-31}}$$

$$W = 6.22 \times 10^{10}\ T^{-1}$$

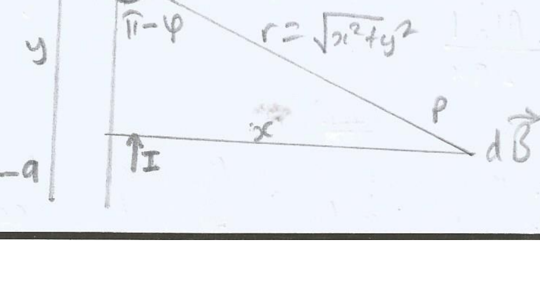
4c. Cyclotron frequency of moving electron = angular speed
Recall that angular speed = $W = \frac{V}{r} = \frac{qB}{m}$

So cyclotron frequency = $6.22 \times 10^{10}\ T^{-1}$, the unit is equal to the unit of frequency dimensionally. The angular speed w is often referred to as the cyclotron frequency because the charge particle circulates at ~~their~~ this angular frequency or angular speed in the type of an accelerator called cyclotron.

(5.) Biot-Savart Law states that the magnetic field is directly proportional to the product permeability of free space (μ_0) the current (I) the change in length (dl), the radius (r) and inversely proportional to the square of the radius (r^2)

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

b.)



Applying the Biot-Savart law, we find the magnitude of the field $d\vec{B}$

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

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

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

From diagram, $r^2 = x^2+y^2$ (Pythagoras theorem)

$$B = \frac{\mu_0 I}{4\pi}\int\frac{dl \sin(\pi-\varphi)}{x^2+y^2} \quad \text{— (I)}$$

But $\sin(\pi-\varphi) = \dfrac{x}{\sqrt{x^2+y^2}} = \dfrac{x}{(x^2+y^2)^{1/2}}$ — (II)

substituting (II) into (I)

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

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

Recall $dl = dy$

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

using special integrals

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

Equ (III) becomes

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

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

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

When the length $2a$ of the conductor is very great in comparison to its distance x from point P, we consider it infinitely long.

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

$$B = \frac{\mu_0 I}{2\pi r} \quad \text{— Equ (IV)}$$

Equ (IV) defines the magnitude of the magnetic field of flux density B near a long, straight current carrying conductor