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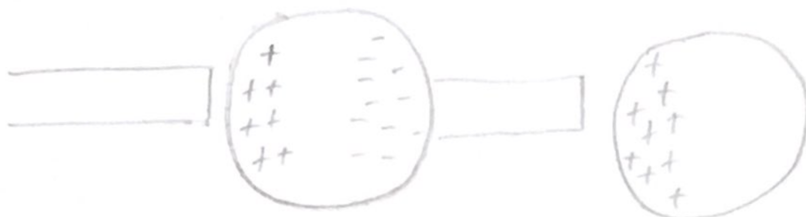
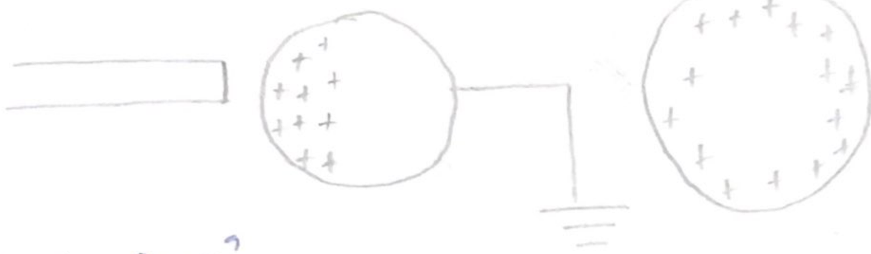
PHY 102 ASSIGNMENT

1a. Charging by induction

Electric charges can be obtained on an object without touching it by a process called electrostatic induction. Consider a negatively charged rubber rod brought near a neutral (uncharged) conducting sphere that's insulated so that there is no conducting path to ground as found below. The repulsive force between the electrons in the rod and those in the sphere causes a redistribution of charges in the sphere so that some electrons move to the side of the sphere farthest away from the rod. The region of the sphere nearest to the negatively charged rod has an excess of positive charge because of the migration of electrons away from the location. If a grounded conducting wire is then connected to the sphere, some of the ~~elect~~ electrons leave the sphere and travel to the earth. If the wire to the ground is then removed, then 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.





1b) $K = 9\times10^9$

$q_1 + q_2 = 5\times10^{-5}C$

$F = 1N$

$d = 2m$

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

$$1 = \frac{9\times10^9 \times (q_1 q_2 \times 5\times10^5)}{2^2}$$

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

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

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

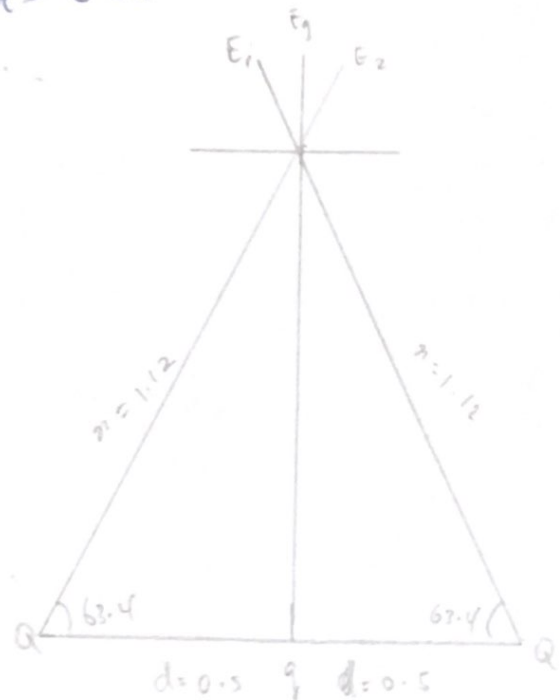
$q_1 = 0.0000111C \simeq 1.11\times10^{-5}C$

$q_2 = 0.000038C \simeq 3.8\times10^{-5}C$

2

1c. $Q_1 = Q_2 = 8\mu C$

$d = 0.5m$



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

$x = \sqrt{1.25}$

$x = 1.12$

$\tan\theta = \frac{opp}{adj}$

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

$\theta = \tan^{-1} 2$

$\theta = 63.4$

$E_1 = \frac{Kq_1}{r_1^2} = \frac{9\times10^9 \times 8\times10^{-6}}{(1.12)^2}$

$= 57397.95918$

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

$= 57397.95918$

$E_q = \frac{Kq}{r^2} = \frac{9\times10^9 \times q}{1} = 9\times10^9 q$

3

Vector	Angle	X component	Y component
$E_1 = 57397.95918$	63.4°	$E_1 \cos\theta$. $= 2570.04585$	$E_1 \sin\theta$ $= 5132.262839$
$E_2 = 57397.95918$	63.4°	2570.045785	5132.262839
$E_q = 9\times10^9 q$	90°	$E_q \cos\theta = 0$	$9\times10^9 q$
		$E_x = 0$	$E_y = 10264.52568$

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

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

Since $E_q = 0$

$$0 = 9\times10^9 q + 10264.52568$$

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

$$q = 1.140502853\times10^{-6}$$

$$q = 1.14\,\mu C$$

3a.) i) Volume charge density $\rho = \frac{dQ}{dV}$ In $dQ = \rho dv$

ii) Surface charge density $\sigma = \frac{dQ}{dA}$ in $dQ = \sigma dA$

iii) Linear charge density $\lambda = \frac{dQ}{dL}$ In $dQ = \lambda dL$

3b) Electric potential difference

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 p~~ one point to another. It is measured in joules per coulomb (J/C) or ~~v~~ volts (V). It is a scalar quantity.

Elemental work done dW is given by:

$$dW = F \cdot dl \quad \text{—— (1)}$$
$$F = -q_0 \bar{E} \quad \text{—— (2)}$$

Subst (2) in (1)

$$dW = -q_0 E \, dL \quad \text{—— (3)}$$

Total work done in moving the test charge from A to B is:

$$W(A \text{ in } B)_{Ag} = -q_0 \int_A^B E dL \quad \text{—— (4)}$$

from the definition of electric potential difference, follows that:

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

Putting (4) in (5).

$$V_B - V_A = \int_A^B E\,dL \quad \text{—— (6)}$$

SECTION B

4a.) Magnetic flux is defined as the strenght of the magnetic field which can be represented by the of forces. It is represented by the symbol ϕ. Mathematically given as

$\phi = B \cdot dA$

4b.) $M = 9 \times 10^{-31}$ kg

$r = 1.4 \times 10^{-7}$ m

$B = 3.5 \times 10^{-1}$ weber/meter^2

Cyclotron frequency = angular speed

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

$$\omega = \frac{qB}{m} = \frac{1.6\times10^{-19}\times 3.5\times10^{-1}}{9\times10^{-31}}$$

$$\omega = 6.22\times10^{10}\,T^{-1}$$

4c.) Mass of electron $= 9.11\times10^{-31}$ kg

Radius $= 1.4\times10^{-7}$ m

Magnetic field $= 3.5\times10^{-1}$ weber/meter^2

cyclotron frequency can be placed can be called angular speed

Angular speed, $\omega = \frac{v}{r} = \frac{qB}{m}$

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

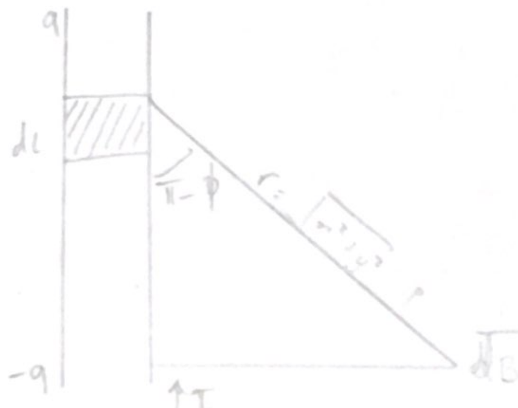
$$= 6.22\times10^{10}\,T^{-1}$$

So cyclotron frequency $= 6.22\times10^{10}\,T^{-1}$, the unit is equal to unit of frequency dimensionally.

5a.) Bio - Savart law states that the magnetic field is directly proportional to the product pameability of free space (μ), the current (I), the change in lenght, the radius are inversely proportional to the square of radius (r^2). It can be represented mathematically by:

$$dB = \frac{\mu_0 I \, dl \times r}{4\pi r^2}$$

5b. Magnetic field of straight current carrying conductor



A section of a straight current carrying conductor

Applying the Biot - Savart law, we find the magnitude of the field.

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

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

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

from diagram, $r^2 = x^2 + y^2$ (pythagoras theorem)

$$B = \frac{\mu_0 I}{4\pi} \int_{-a}^{a} \frac{dl \sin(\pi - \phi)}{x^2 + y^2} \quad \text{——} \; (1)$$

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

Substituting eqtn (2) into (1),

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

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

Recall $dl = dy$

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

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