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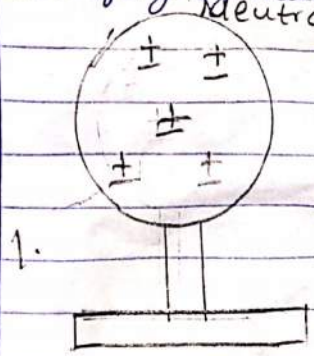
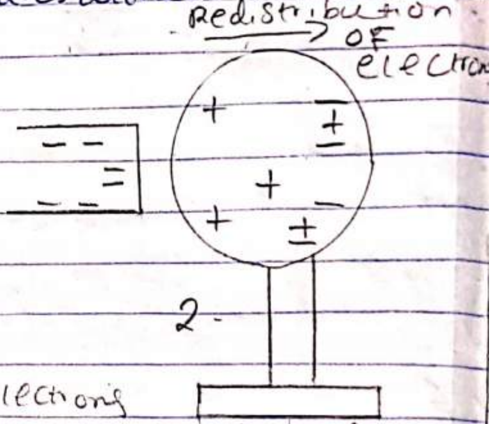
Covid-19 Holiday Assignment

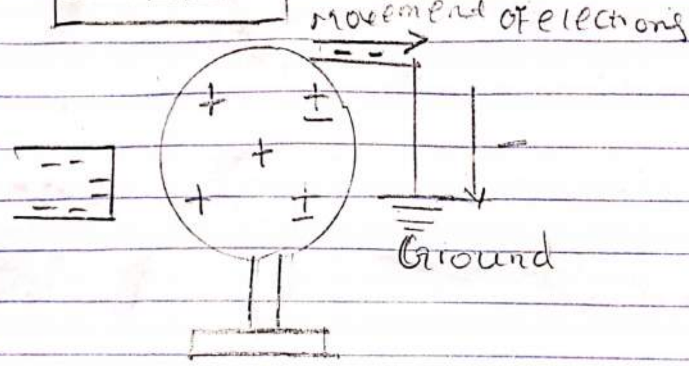
Section A

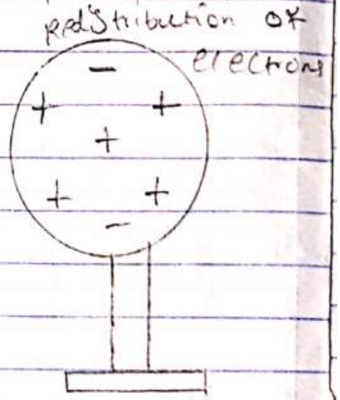
1a Charging by Induction:

When an uncharged object is placed very close to a charged conductor without touching, the nearer end aquires a charge opposite to the charge on the charged conductors and the two bodies attract. This is called Charging by induction.









1b $q_1 + q_2 = 5\times10^{-5}C$

$F = 1N$

$d = 2m$

Calculate the charge on each spehere?

$K = 9\times10^9$

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

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

$4 = 9\times10^9\times5\times10^{-5} q_1 + 9\times10^9 q_2$

$4 = 4.5\times10^5 q_1^2 + 9\times10^9 q_2$

It is a quadratic equation

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

$q_1 = 0.0000111C$

$q_2 = 0.000038C$

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

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

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

$d = 0.5m$

determine Q if electric field at a point p is zero

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

$\tan\theta = \frac{1}{0.5} = 2$

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

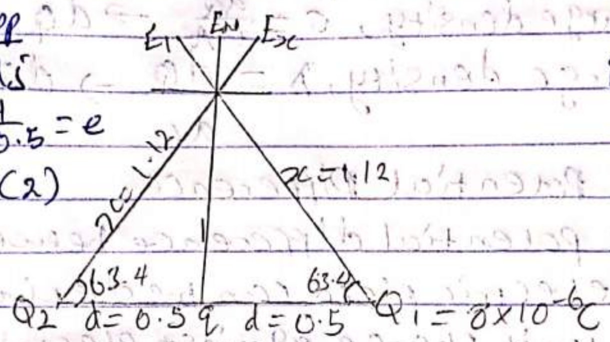
$\theta = 63.4$

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

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

$x = \sqrt{1.25}$

$x = 1.12$



$E_1 = \frac{kq_1}{r_1^2} = \frac{9\times10^{9}\times8\times10^{-6}}{(1.12)^2} = 5739.795918$

$E_2 = \frac{kq}{r^2} = \frac{9\times10^{9}\times8\times10^{-6}}{1.12^2} = 5739.795918$

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

Vector	angle	x-comp	y-comp
$E_1 = 5739.795918$	63.4°	$E_1 \times \cos\theta$	
	$E_1 =$	-2570.045785	5132.262839
$E_2 = 5739.795918$	63.4°	2570.045785	5132.262839
$E_q = 9\times10^{9}q$	90°	$E_q\cos\theta = 0$ $Ex = 0$	$9\times10^{9}q$ $\Sigma y =$ 10264.52568

magnitude $= \sqrt{(\Sigma x)^2 + (\Sigma y)^2}$

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

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

~~making~~ $q = \frac{-10264.52568}{9\times10^{9}}$

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$q = 1.1405028 53 \times 10^{-6}$

$\simeq q = 11.44C$ //

2. The electric field is a region around a charge in which it exerts electrostatic force on another charge. While electric field intensity is the strength of the electric field at any point in space.

3a) i) Volume charge density, $\rho = \frac{dQ}{d_V} \Rightarrow dQ = \rho dv$

ii) Surface Charge density, $\sigma = \frac{dQ}{d_A} \Rightarrow dQ = \sigma dA$

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

3) 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 point to another.

$dw = F \cdot dL \ldots (i)$

But

$F = -q_0 E \ldots (2)$

substituting equation (2) in (i) yields

$dw = -q_0 E dL \ldots (3)$

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

$W(A \rightarrow B)_{ag} = -q_0 \int_A^B E dL \ldots (4)$

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

$V_B - V_A = \frac{W(A \rightarrow B)_{ag}}{q_0} \ldots (5)$ Putting equation (4) in (5) yields

$V_B - V_A = -\int_A^B E dL \ldots (6)$

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Section B

4a ~~magene~~ magnetic flux is defined as the number of magnetic field lines passing through a given closed surface. It gives the measurement of the total magnetic field that passes through a given surface area.

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

$w = \frac{v}{r} = \frac{eB}{m}$

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

$w = 622.2222.22222\ T^{-1}$

4c In the question we were given parameters such as

i mass of the electron = ~~9 x~~ 9.11×10^{-31} kg

ii A radius of 1.4×10^{-7} m

iii magnetic field of 3.5×10^{-1} weber/meter ~~qu~~ square.

and ~~you are~~ we were, asked to find the cyclotron frequency which is equal or the same thing as angular speed. It is called cyclotron frequency because it is a frequency of an accelerator called cyclotron.

Angular speed is given as ~~w =~~ $\frac{v}{r} = \frac{qB}{m}$

substituting we have $w = \frac{v}{r} = \frac{qB}{m} = \cancel{\frac{1.6 \times 10^{-10} \times 3.5}{\times 10^{-1}}}$

$\frac{1.6 \times 10^{-10} \times 3.5 \times 10^{-10}}{9.11 \times 10^{-31}}$

$\frac{qB}{m} = \frac{1.6 \times 10^{-19} \times 3.5 \times 10^{-1}}{9.11 \times 10^{-31}} = 6.222222.22222\ T^{-1}$

So since cyclotron frequency is equal to angular speed the cyclotron frequency is equal to = 6222222.22222 T^{-1}, having a unit as $1/T$ which is equal to the unit of frequency dimensionally.

4. The Bio-savart Law states that the magnetic field is directly proportional to the product permeability of free space (μ), the current (I), the change in length, the radius and inversely proportional to square of radius (r^2). It can be represented mathematically by

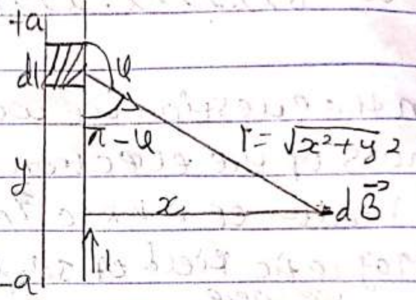
$$dB = \frac{\mu_0 I \, dl \times r}{4\pi r^2}$$

Where μ_0 is a constant called permeability of free space.

$\mu = 4\pi \times 10^{-7} \, T.\frac{m}{A}$

The unit of B is weber/metre square.

B. Magnetic field of a straight current carrying conductor



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

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

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

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

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

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

Substituting (2) into (1) we have

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

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

using special integrals:

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

Equation (3) becomes

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

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

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

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

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

6. It's a basic rule of physics called Faraday's law that a change in magnetic field produces electricity so a guitar string will produce ~~electricity~~ sound only for as long as the magnetic field is changing.

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