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MATIC NO: 14/MHC01/275

PHY 102 COVID-19 ASSIGNMENT

1) How to produce a negatively charged sphere by method of induction.

A positively charged rubber rod is brought near a neutral (uncharged) conducting sphere that is insulated so there is no conducting path to the ground. The repulsive force between the positive charge on the upper side of the sphere causes a redistribution of charges on the sphere so that some electrons move to the side of the sphere furthest from the rod and the region nearest the positively charged rod has an excess of positive charges. A

grounded conducting wire which is connected to the sphere and the positive charges leave the sphere and travel to the ground. If the wire is then removed, the conducting sphere is left with an excess of electrons. Then the rubber rod is removed from the vicinity of the sphere and the electrons remain on the ungrounded sphere becoming uniformly distributed over the surface of the sphere.



neutral sphere



$$k = 9 \times 10^9$$

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

$$F = 1 \text{ N}$$

$$d = 2 \text{ m}$$

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

$$1 = \frac{9 \times 10^9 \times (q_1 q_2 \times 5 \times 10^{-5})}{2^2}$$

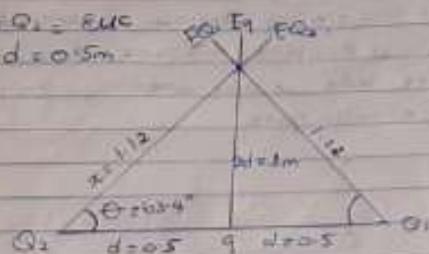
$$4 = 9 \times 10^9 \times 5 \times 10^{-5} q_1 q_2 + 9 \times 10^9 q_1^2$$

$$q = 4.5 \times 10^{-5} q_1 + 9 \times 10^9 q_1^2$$

$$9 \times 10^9 q_1^2 - 4.5 \times 10^{-5} q_1 + 4 = 0$$

$$q_1 = 1.11 \times 10^{-8} \text{ C}, \quad q_2 = 3.5 \times 10^{-8} \text{ C}$$

c) $Q_1 = Q_2 = 8 \mu\text{C}$
 $d = 0.5 \text{ m}$



$$\tan \theta = \frac{\text{opp}}{\text{adj}} = \frac{1}{0.5} = 2$$

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

$$x = \sqrt{1.25}$$

$$x = 1.12$$

$$\theta = \tan^{-1}(2) = 63.4^\circ$$

$$F_1 = \frac{k q_1}{r^2} = \frac{9 \times 10^9 \times 8 \times 10^{-6}}{(1.12)^2} = 5739.795918$$

$$F_2 = \frac{k q_2}{r^2} = \frac{9 \times 10^9 \times 8 \times 10^{-6}}{(1.12)^2} = 5739.795918$$

$$F_q = \frac{k q}{r^2} = \frac{9 \times 10^9 \times q}{1} = 9 \times 10^9 q$$

Value	Angle	x-comp	y-comp
$E_1 = 5739.795918$	63.4°	$E_1 \cos \theta$ $= 2570.075215$	$E_1 \sin \theta$ $= 5132.264339$
$E_2 = 5739.795918$	63.4°	$E_2 \cos \theta$ $= 2570.075215$	$E_2 \sin \theta$ $= 5132.264339$
$E_q = 9 \times 10^9 q$	90°	$E_q \cos 90 = 0$ $\Sigma x = 0$	$9 \times 10^9 q$ $\Sigma y = 10264.52568$

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

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

$$\text{and } E = 0$$

$$0 = 9 \times 10^9 q + 10264.52568$$

$$q = -\frac{10264.52568}{9 \times 10^9}$$

$$q = 1.14 \mu\text{C}$$

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

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) Electric potential difference

This can be defined as the work done per unit charge against electrical forces when a charge q is transported from one point to the other. It is measured in volt (V).

Torlonka per coulomb (J/C). A test charge moving from a given point A to a point B along an arbitrary path inside an Electric field E . The electric field exerts a force $F = q_0 E$ on the charge. To move the test charge from A to B at constant velocity, an external force of $E = -q_0 E$ must act on the charge. Therefore the elemental work done dW is given by:

$$dW = F \cdot dl$$

$$\text{where } F = -q_0 E$$

$$\therefore dW = -q_0 E \cdot dl$$

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

$$W(A \rightarrow B) = -q_0 \int_A^B E \cdot dl$$

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

$$V_B - V_A = \frac{1}{q_0} W(A \rightarrow B)$$

$$V_B - V_A = \int_A^B E \cdot dl$$

$$E = \frac{kQ}{r^2}$$

Testing three cases: to the left of Q_1 , to the right of Q_2 and in between.

To the left of Q_1 , ($x < 0$)

$$V = \frac{k \times 10}{x} - \frac{k \times 2}{4+x}$$

where $V = 0$.

$$0 = \frac{10}{x} - \frac{2}{4+x}$$

$$\frac{40}{x} = \frac{2}{4+x}$$

$$x = -5 \text{ m}$$

In between

$$V = \frac{k \times 10}{x} - \frac{2 \times k}{4-x}$$

where $V = 0$

$$0 = \frac{10}{x} - \frac{2}{4-x}$$

$$\frac{40}{x} = \frac{2}{4-x}$$

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

which is not in between the points.

To the right of Q_2 , ($x > 0$)

$$V = \frac{10k}{x} - \frac{2k}{x-4}$$

where $V = 0$.

$$0 = \frac{10}{x} - \frac{2}{x-4}$$

$$\frac{40}{x} = \frac{2}{x-4}$$

$$x = 5 \text{ m}$$

$V = 0$ at points $x = -5 \text{ m}$, $x = 5 \text{ m}$ and $x = \frac{40}{12}$.

4) Magnetic Flux.

This is defined as the amount of magnetic field represented by the lines of force. It is usually represented by the symbol Φ . Mathematically, it is represented by $\Phi = \int \vec{B} \cdot d\vec{A}$.

where B = the magnetic field.

dA = change in element of area.

for cyclotron frequency $\omega = \frac{V}{r}$

$$V = 3.0 \times 10^6 \text{ m/s}$$

$$r = 1.4 \times 10^{-2} \text{ m}$$

$$\omega = 2.143 \times 10^{15} \text{ rad/s}$$

3c) Cyclotron frequency ω can be solve or get by angular speed ω . It can be solve or get by $\omega = \frac{v}{r}$ or $\omega = \frac{qB}{m}$

where v = speed of the moving electron.
 r = radius of the circular orbit.
 q = charge of the electron.
 B = magnetic field.
 m = mass of the electron

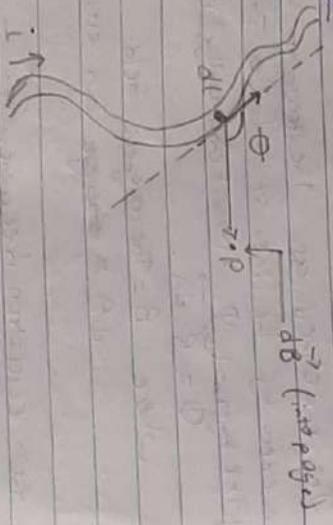
The speed of the moving electron is $3 \times 10^6 \text{ m/s}$ and radius of the circular orbit is $1.4 \times 10^{-2} \text{ m}$.
 \therefore the cyclotron frequency is equal to $2.143 \times 10^{15} \text{ rad/s}$

3a. Biot-Savart Law

It states that it is a mathematical expression which illustrates the magnetic field produced by a stable electric current in the particular electromagnetic of physics.

b) From the Biot-Savart experiment, the following will be observed.

~~The vector~~



- 1) The vector \vec{dB} is perpendicular to \vec{B} both dl and \vec{r} to the unit vector \hat{r} directed from dl towards P .
- 2) The magnitude of \vec{dB} is inversely proportional to r^2 , where r is the distance from dl to P .
- 3) The magnitude of \vec{dB} is proportional to the current I and to the magnitude of the length element dl .
- 4) The magnitude of \vec{dB} is proportional to $\sin \theta$, where θ is the angle between \vec{r} and dl .

These observations are summarized in the mathematical expression known as Biot-Savart law.

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

But after finite integration, it gives $B = \frac{\mu_0 I}{4\pi r}$