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MATRIC NUMBER: 19/MHS01/132

DEPARTMENT: MBBS

COURSE: PHY102 ASSIGNMENT

COVID-19 HOLIDAY ASSINGMENT.

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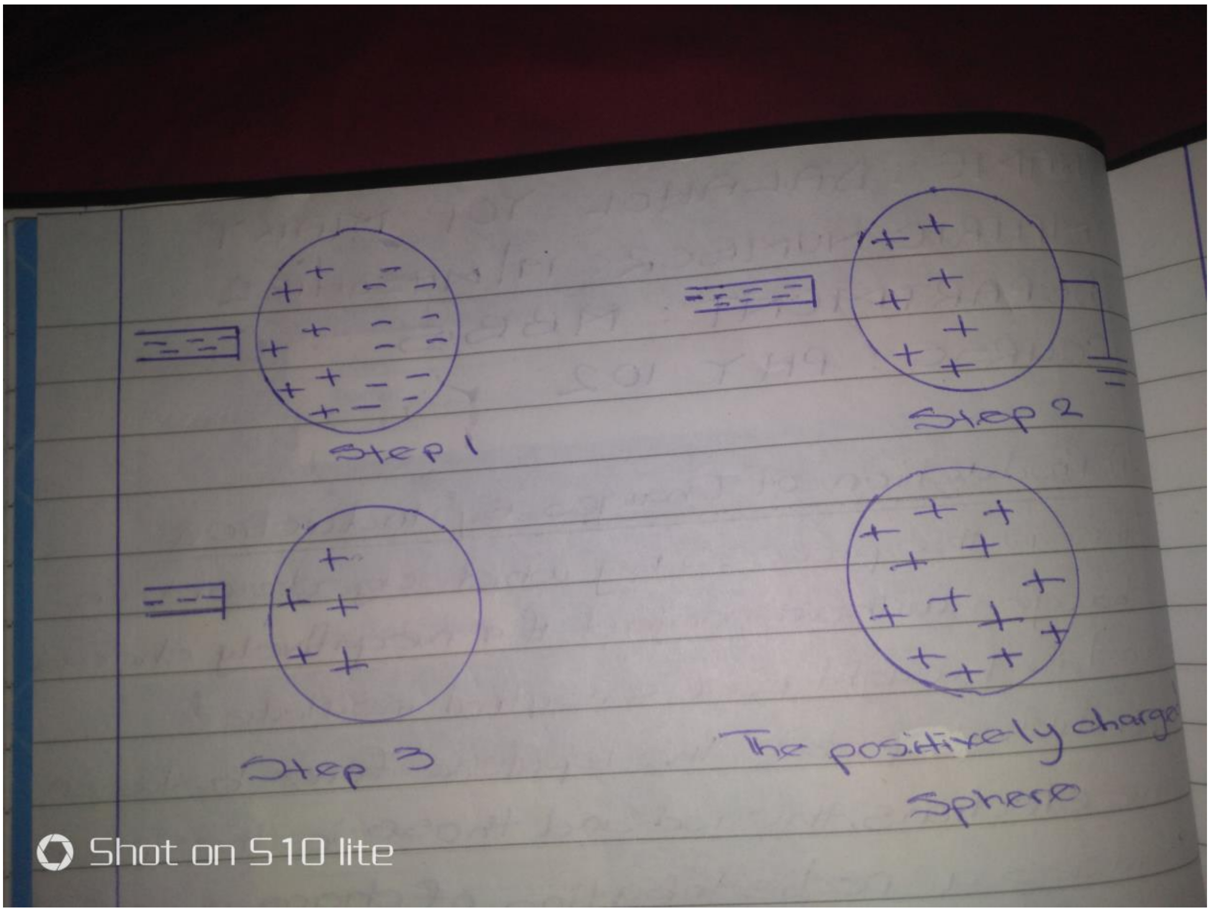
1) Production of Charges By Induction

This is the process by which objects obtain charges without contact. If a negatively charge rod is brought near a neutral insulated conducting sphere, the repulsive force between the electrons, the rod and those in the sphere causes a redistribution of charges on the sphere. The electrons on the side closest to the rod move away to the side farthest from the rod. The result is that the side closest to the negatively charged rubber rod is dominated by positive charges. A grounded conducting wire is then connected to the sphere and most of its electrons move into the earth. The wire is removed, leaving the sphere with an excess of positive charges. Lasty, the negatively charged rubber rod is removed leaving the sphere with uniformly distributed positive charges.


Step 1
Step 2
Step 3
The positively charge
Sphere
Shot on S10 lite

1b) let the two charges be q_1 and q_2

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

$F = 1.0$ N

$r = 2.0$m $r^2 = 4.0$ m^2

recall $F = \frac{kq_1q_2}{r_2}$

$$1.0 = \frac{9 \times 10^9 \times q_1q_2}{4.0}$$

$4.0 = 9 \times 10^9 \times q_1q_2$

$$q_1q_2 = \frac{4.0\,\cancel{Nm^2}}{9 \times 10^9\,\cancel{Nm^2}\,C^{-2}}$$

$q_1q_2 = 4.44 \times 10^{-10}\,C^2$

recall that

$x^2 - (\text{sum of roots})x + (\text{product of roots}) = 0$

$x^2 - (5.0 \times 10^{-5}\,c)x + (4.44 \times 10^{-10}\,c^2) = 0$

$x^2 - 3.887 \times 10^{-5}\,Cx + 1.113 \times 10^{-5}\,Cx + 4.44 \times 10^{-10}_{c} = 0$

$x(x - 3887 \times 10^{-5}\,c)\,\cancel{ax} + 1.113 \times 10^{-5}\,c\,(x + 3.989 \times 10^{-9}) = 0$

But 3.887×10^{-5} and 3.989×10^{-9} are approx equal

$\therefore$ using 3.887×10^{-5}C

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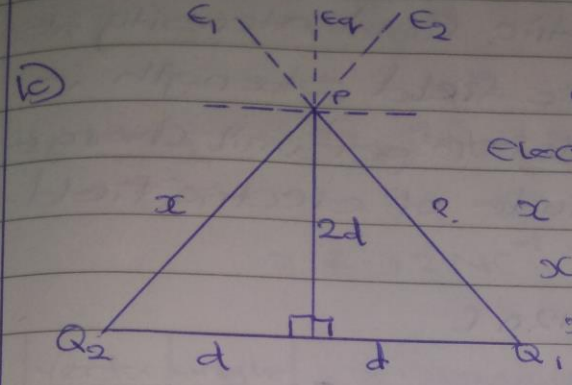
roots are: $3.89 \times 10^{-5} C$ and $1.110 \times 10^{-5} C$
where these roots are the charges.

(c)



$Q_1 = Q_2 = 8\ \mu C$

Electric field at $P = 0$

$x = \sqrt{2d^2 + d^2}$

$x = \sqrt{(1)^2 + 0.5^2}$

$x = \sqrt{1 + 0.25}$

$x = \sqrt{1.25}$

$\therefore x = 1.12\ m$

$\sin\theta = \frac{2d}{1.12} = 63.43^\circ$

$\cos\theta = \frac{d}{1.12} = 26.56^\circ$

$E = \frac{kq}{r^2}$ $\quad Q_1 = Q_2$ Note $E_1 = E_2$

$E_1 = E_2 = \frac{9 \times 10^9\ Nm^2C^{-2} \times 8 \times 10^{-6} C}{1.12^2}$

$\therefore E_1 = E_2 = 5.74 \times 10^4\ NC^{-1}$

$E_q = \frac{9.0 \times 10^9\ Nm^2C^{-2} \times q}{1^2}$

$= 9.0 \times 10^9 q\ C$

$\therefore E_q = 9.0 \times 10^9 q\ C$

Forces (NC^{-1})	Angles	X-component	Y-component
5.74×10^4	63.43°	$5.74 \times 10^4 \cos 63.43$ $= -2.57 \times 10^4$	$5.74 \times 10^4 \sin 63.43$ $= 5.13 \times 10^4$
5.74×10^4	63.43	$5.74 \times 10^4 \cos 63.43$ $= -2.57 \times 10^4$	$5.74 \times 10^4 \sin 63.43$ $= 5.13 \times 10^4$
$9 \times 10^9 q$	90°	$9 \times 10^9 q \cos 90^\circ$ $= 0$	$9 \times 10^9 q \sin 90$ $= 9 \times 10^9 q$
		$\Sigma x = 0 NC$	$\Sigma y = 1.026 \times 10^5 NC^{-1} + 9 \times 10^9 q NC^{-1}$

$$\Sigma q = \sqrt{\Sigma x^2 + \Sigma y^2}$$

$$= \sqrt{(0.9 + [(1.026 \times 10^5)]^2 + (9.0 \times 10^9 q)^2]}$$

$$= \sqrt{1.053 \times 10^{10} + (9.0 \times 10^9 q)^2}$$

But $\Sigma q = 0$

$$\therefore 0 = \sqrt{1.053 \times 10^{10} + (9.0 \times 10^9 q)^2}$$

$$0 = 1.053 \times 10^{10} + (9.0 \times 10^9 q)^2$$

$$(9.0 \times 10^9 q)^2 = 1.053 \times 10^{10}$$

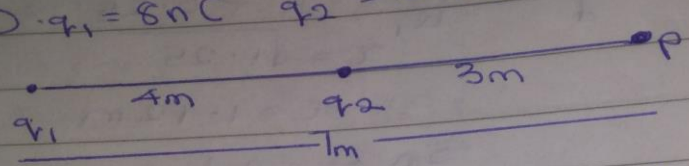
$$\therefore q^2 = \frac{1.053 \times 10^{10}}{9.0 \times 10^9} = 1.2996 \times 10^{-10}$$

$$\therefore q = \sqrt{1.2996 \times 10^{-10}}$$

$$q = 11.4 \, MC$$

2a) Electric field is the region in which an electric charge will experience an electric force while Electric field intensity also known as electric field strength is defined as the force per unit charge. it is the magnitude of electric field.

b) $q_1 = 8nC \quad q_2 = 12nC$



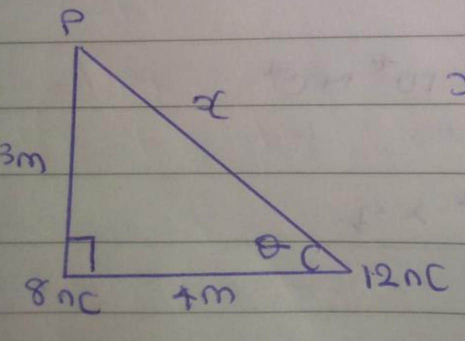
$$E_1 = \frac{kq_1}{r_1^2} = \frac{9\times10^9 Nm^2C^{-2} \times 8\times10^{-9}C}{7^2} = 1.469NC^{-1}$$

$$E_2 = \frac{kq_2}{r_2^2} = \frac{9\times10^9 Nm^2C^{-2}\times 12\times10^{-9}C}{3^2} = 12NC^{-1}$$

$$F_{net} = E_1 + E_2 = 1.469NC^{-1} + 12NC^{-1}$$

$$E_{net} = 13.469NC^{-1} \simeq 13.5NC^{-1}$$

(ii)



$$x^2 = 3^2 + 4^2$$

$$x = \sqrt{25}$$

$$x = 5m$$

$$\theta = \sin^{-1}(3/5)$$

$$\theta = 36.9^\circ$$

$E_1 = \frac{kq_1}{r_1^2} = \frac{9 \times 10^9 Nm^2C^{-2} \times 8 \times 10^{-9} C}{3^2}$

$= 8 NC^{-1}$

$E_2 = \frac{kq_2}{r_2^2} = \frac{9 \times 10^9 Nm^2C^{-2} \times 12 \times 10^{-9} C}{5^2}$

$= 4.32 NC^{-1}$

vector	angle	x - component	y - component
$8NC^{-1}$	90°	$8NC^{-1}\cos 90^\circ = 0NC^{-1}$	$8\sin 90^\circ = 8NC^{-1}$
	36.9°	$4.32NC^{-1}\cos 36.9 = 3.45$	$4.32\sin 36.9 = 2.60NC^{-1}$
		$\Sigma x = 3.45 NC^{-1}$	$\Sigma y = 10.60NC^{-1}$

$E_{net} = \sqrt{\Sigma fx^2 + \Sigma fy^2}$

$E_{net} = \sqrt{(3.45)^2 + (10.60)^2}$

$E_{net} = \sqrt{124.2625}$

$E_{net} = 11.147NC^{-1} \simeq 11.5 NC^{-1}$

4a) Magnetic flux refers to the number of magnetic lines of force passing through a given closed surface which is the magnetic field. It is what generates the field around a magnetic material. Its S.I unit is Weber (wb).

b) $m_e = 9.11 \times 10^{-31}$ Kg, $r = 1.4 \times 10^{-7}$ m, $\theta = 90^0$

$B = 3.5 \times 10^{-1}$ Wb/m^2, $q = 1.6 \times 10^{-19}$ C.

cycloton frequency $= \omega = \frac{qB}{m_e} = v/r$

$$\omega = \frac{1.6 \times 10^{-19} C \times 3.5 \times 10^{-1} wbm^{-2}}{9.11 \times 10^{-31} kg}$$

$$\omega = \frac{5.6 \times 10^{-20}}{9.11 \times 10^{-31}} = 6.47 \times 10^{10}$$

$\omega = 6.15 \times 10^{10}$ rad/s

c) The cycloton frequency is the inverse of the period which is the time taken for the accelerated electron to complete a cycle in the magnetic field. The cycloton frequency is also known as the angular speed of the particle.

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

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

The unit of $\vec{B}$ is Weber/m² (Wb/m²)

b)

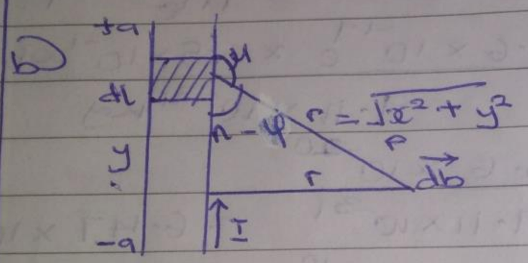


Diagram of a section of a straight current carrying conductor.

applying Biot-Savart law, find the magnitude of the field $\vec{db}$

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

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

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

from the diagram $r^2 = x^2 + y^2$

$$B = \frac{\mu_0 I}{4\pi}\int_{-a}^{a} \frac{dl \sin(\pi - u)}{r^2} \quad \text{----} (*)$$

but $\sin(\pi - u) = \frac{x}{\sqrt{x^2+y^2}} = \frac{x}{(x^2+y^2)^{1/2}} \quad \text{----} (**)$

substitute (**) into (*)

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

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

recall that $dl = dy$

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

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

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

Equation (***) becomes

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

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

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

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

$(x^2+a^2)^{1/2} \cong a$, as $a \longrightarrow \infty$

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

In a physical situation, we have axial symmetry about the y-axis. Thus at all points in a circle of radius r, around the conductor, the magnitude of B is

$$B = \frac{\mu_0 I}{2\pi r} \quad ----[*]$$

Equation [*] defines the magnitude of the magnetic field of flux density B near a long, straight current carrying conductor.