(fig 1.3d) The induced positive charge remains on the ungrounded sphere and becomes uniformly distributed over the surface of the sphere.

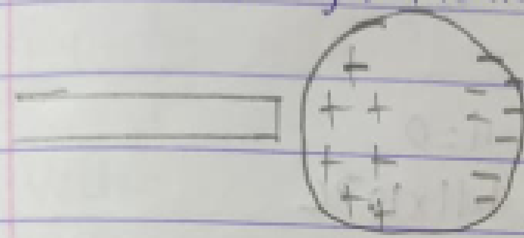


fig 1.3a

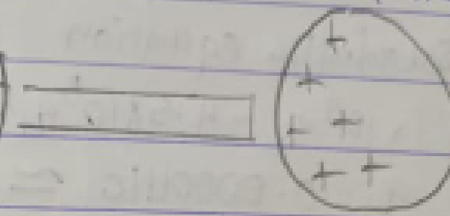


fig 1.3c

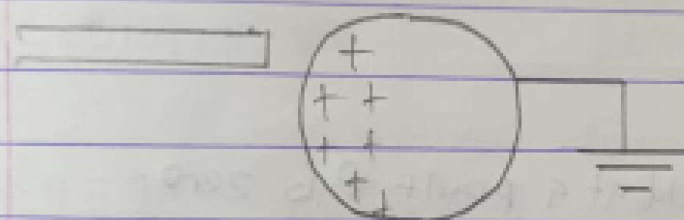


fig 1.3b

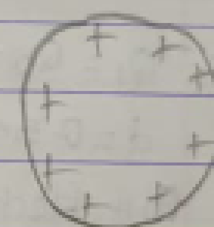


fig 1.3d

16, $K = 9 \times 10^9$

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

$F = 1N$

$d = 2m$

Charge on each sphere = ?

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

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

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

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

Quadratic equation

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

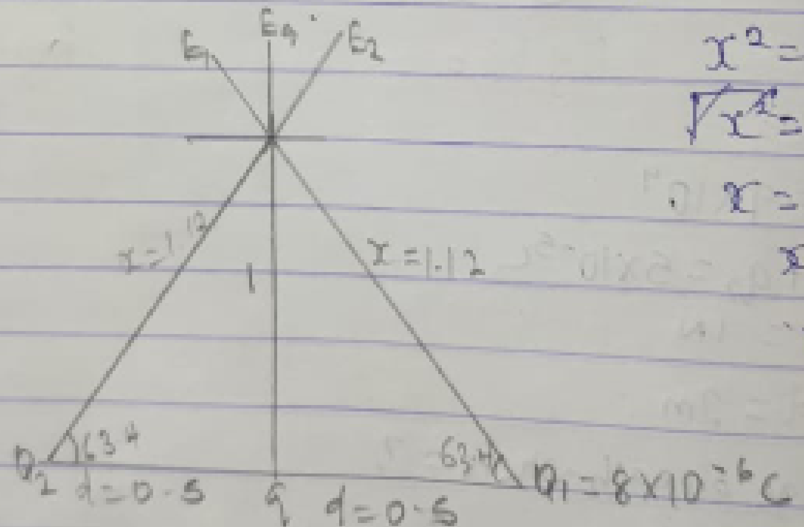
$q_1 = 0.0000111C \simeq 1.11\times10^{-5}C$

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

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

$d = 0.5m$

Q) if Electric field at a point P is zero.



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

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

$x = \sqrt{1.25}$

$x = 1.12$

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

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

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

$\theta = 63.4$

$E_1 = \frac{Kq_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-6}}{(1.12)^2} = 57397.9598$

Recall $dl = dy$

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

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

Using special integrals: $\int \frac{dy}{(x^2+y^2)^{3/2}} = \frac{1}{x^2} \cdot \frac{y}{(x^2+y^2)^{1/2}}$

Equation (3) becomes $B = \frac{\mu_0 I x}{4\pi}\left[\frac{y}{x^2(x^2+y^2)^{1/2}}\right]_{-a}^{a}$

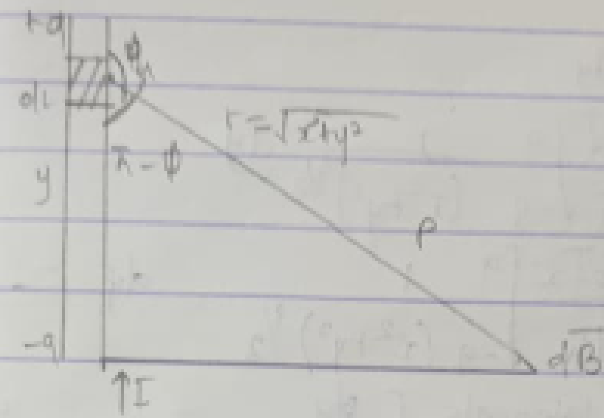
$$B = \frac{\mu_0 I x}{4\pi}\left(\frac{2a}{x^2(x^2+a^2)^{1/2}}\right)$$

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

When the length $2a$ of the conductor is very great in comparison to its distance x from point P, we consider it infinitely long. That is, when a is much larger than x, $(x^2+a^2)^{1/2} \simeq a$, as $a \to \infty$

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

- 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: $B = \frac{\mu_0 I}{2\pi r}$ --- # (magnitude of the magnetic field of flux density B near a long, straight current carrying conductor)



A section of a straight current carrying conductor

Applying the Biot-savart law, we find the magnitude of the field dB

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

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

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

From diagram, $r^2 = x^2+y^2$ (pythagoras theorem) $\therefore$

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

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

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

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

3a i, Volume charge density, $\rho = \frac{dQ}{dV}$ 'n $dQ = \rho dV$.

ii, Surface charge density, $\sigma = \frac{dQ}{dA}$ 'n $dQ = \sigma dA$

iii, Linear charge density, $\lambda = \frac{dQ}{dL}$ in $dQ = \lambda dL$

3b, <u>Electric potential difference</u>

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. It is measured in Volt (V) or Joules per coulomb (J/C). It is a scaler quantity.

Elemental work done dW is given as:

$$dW = F \cdot dL \quad --① $$

But $$F = -q_0 E \quad --②$$

Substituting equation ② in ① $= dW = -q_0 E dL \quad --③$

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

$$W(A \text{ 'n } B)_{ag} = -q_0 \int_A^B E dL \quad --④$$

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

$V_B - V_A = \frac{-h l (A' n B) A q}{q_0}$ --- ⑤

putting equation ④ in ⑤ yields $V_B - V_A = -\int_A^B E\,dl$ --- ⑥

SECTION B

4a 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. Mathematically given as $\phi_B = dA$

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

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

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

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

4c mass of electron $= 9.11 \times 10^{-31}$ Kg

$$E_2 = \frac{Kq_2}{r^2} = \frac{9\times10^9\times8\times10^{-6}}{(1.12)^2} = 57397.95918$$

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

Vector	Angle	X-component	Y-component
$E_1 = 57397.95918$	63.4°	$E_1\cos\theta =$ 2570.045785	$E_1\sin\theta =$ 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 $E_q = 0$

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

Making q subject of formula

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

$$q = 1.140502853\times10^{-16}$$

$$q = 11.4\mu C$$