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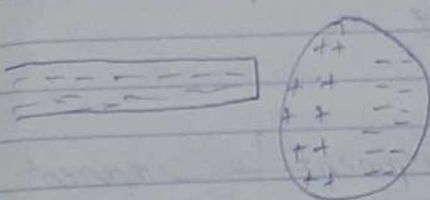
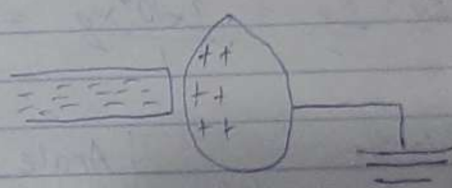
19/MHS01/434
MBBS
Phy 102

(a) Charging by Induction
Electric charges can be obtained on an object without contact by the process of Electrostatic induction if a positively charged rubber is brought near an uncharged conducting shere that is insulated, the replusive force between the electrons in the rod and the sphere causes a redistribution of charges. The electrons move to the side closer to it has an excess of positive charges, if a grounding wire is then connected to the sphere, the electron will flow to the earth having the sphere with induced positive charges, Finally when the rod is removed the induced charges become, uniformly distributed around the space.

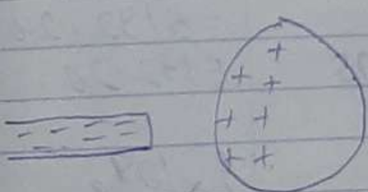
a)



(b)



(c)



(d)

(b) $K = 9\times10^{9}$

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

$F = 1N$

$F = \frac{Kq_1q_2}{d^2} = \frac{9\times10^{9}\times(5\times10^{-5} - q_2)\times q_2}{2^2}$

$4 = \frac{9\times10^{9}\times(5\times10^{-5} - q_2)\times q_2}{2^2}$

$9\times10^9 q^2 - 4.5\times10^{-5} q^2 + 4 = 0$

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

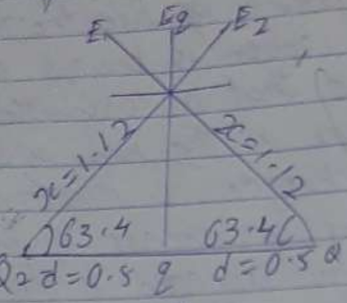
$q_2 = 0.000038C = 3.8\times10^{-6}C$

10) $Q_1 = Q_2 = 84C$

$d = 0.5m$

Q, if electric field is at point P is zero

2(a)



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

$x^2 = (0.25)^2$

$x = \sqrt{1.25}$

$x = 1.12$

$\tan\theta = opp/adj$

$\tan\theta = 1/0.5$

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

$\theta = 63.4^\circ$

$E_1 = \frac{kq_1}{r^2} = \frac{9\times10^9 \times 8\times10^8}{(1.12)^2}$

$= 57397.9598$

$E_2 = \frac{kq_2}{r^2} = \frac{9\times10^9\times8\times10^8}{(1.12)^2} = 57397.95918$

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

b) Vector	Angle	x-component	y-component
$E_1 = 57397.95918$	63.4°	$E\cos\theta = -2570.05$	$E = \sin\theta$ $= 5132.26$
$E_2 = 57397.95918$	63.4°	2570.05	5132.26
$E_q = 9\times10^9 q$	90	0	$9\times10^9 q$
		$E_x = 0$	$E_y = 10264$

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

$E_q = \sqrt{0^2 + (10264.52)^2}$

Since $E_q = 0$

$0 = 9\times10^9 q + 10264.52$

$q = \frac{10264.52}{9\times10^9}$

$q = 1.140502853$

$q = ~~4~~\ 11.4\mu C$

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

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

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

(b) Electric potential difference: This is the work done per unit charge against electrical forces when a charge is transported from one point to another. It is measured in volts (V) or Joules per coulomb (J/C). It is a scalar quantity.

$$dW = F \cdot dl \quad --(1)$$
$$\text{But } F = -q_0 E \quad --(2)$$
$$\therefore dW = -q_0 E \cdot dl \quad --(3)$$

Total work done in moving the rest of the charges

$$W(A \cap B) A_g = -q_0 \int_A^B E dl \quad --(4)$$

$$V_B - V_A = \frac{W(A \cap B) A_g}{q_0}$$

$$\therefore V_B - V_A = \frac{-q_0 \int_A^B E dl}{q_0}$$

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

4(a) Magnetic flux is defined as the strength of the magnetic field which is represented by line of forces. It is represented by the symbol ϕ. Mathematically

$$\phi = B \cdot dA$$

(b) $m = 9 \times 10^{-31} kg$

$r = 1.4 \times 10^{-1} m$

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

cyclotron frequency = angular speed

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

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

$$w = 6.22 \times 10^{10} T$$

4(b) $w = V/r = qB/m$

$= \frac{1.6\times10^{-19}\times3.5\times10^{-1}}{9\times10^{-31}}$

$w = 6.22\times10^{10}\,T$

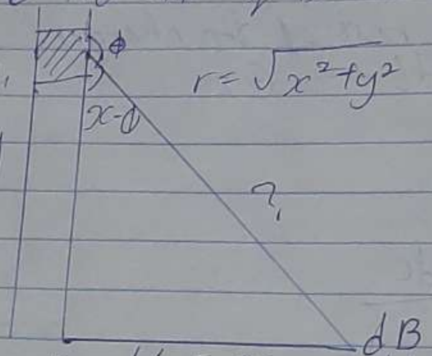
The unit of cyclotrom freqeency is equal to unit frequency dimensionally

5(a) Biot-savart law also states that the magnetic field is directly proportional to the product of permeability of free space (μ_0), the current (I), the change in length and inversely proportional to the square of radius

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

where μ_0 is a constant called permeability of free space. The unit of B is weber/metre^2

(b) d_1



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

From the diagram above $r^2 = x^2 + y^2$

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

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

Using special integrals

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

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

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

When the length $2a$ of the conductor is very great in comparison to its distance x from the 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 $a \longrightarrow \alpha$

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

In a physical situation, we have axial symetry about the y-axis, That, 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 is near a long straight current carrying conductor.)