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1a.

CHARGING BY INDUCTION.

Electric charges can be obtained on an object without touching it, by a process called electrostatic induction. Consider a positively charged rubber rod brought near a neutral (uncharged) conducting sphere that is insulated so that there is no conducting path to ground as shown below. The repulsive force between the protons in the rod and those in the sphere causes a redistribution of charges on the sphere so that some protons move to the side of the sphere farthest away from the rod (e.g in the figure 1·3a below). The region of the sphere nearest the positively charged rod has an excess of negative charge because of the migration of protons away from this location.

If a grounded conducting wire is then connected to the sphere as in (fig 1·3b below), some of the protons leave the sphere and travel to the earth. If the wire to ground is then removed, (fig 1·3c) the conducting sphere is left with an excess of induced negative charges. Finally, when the rubber rod is removed from the vicinity of the sphere (fig 1·3d below), the induced negative charge remains on the ungrounded sphere and becomes uniformly distributed over the surface of the sphere

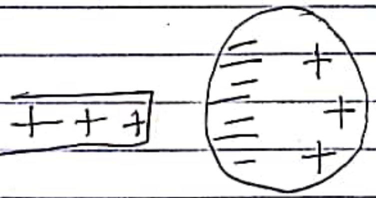


fig 1·3a

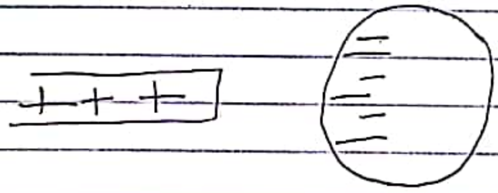


fig 1·3c

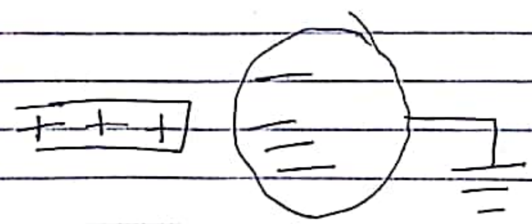


fig 1·3b.

fig 1·3d.

(b)

$K = 9 \times 10^9$

$F = 1N$

$d = 2m$

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

charge on each sphere = ?

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

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

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

$4 = 4.5 \times 10^5 q_1 + 9 \times 10^9 q_2$

Quadratic equation :

$9 \times 10^9 q_2 = 4.5 \times 10^5 q_1 + 4 = 0$

$q_1 = 0.0000111C \simeq 1.11 \times 10^{-5} C$

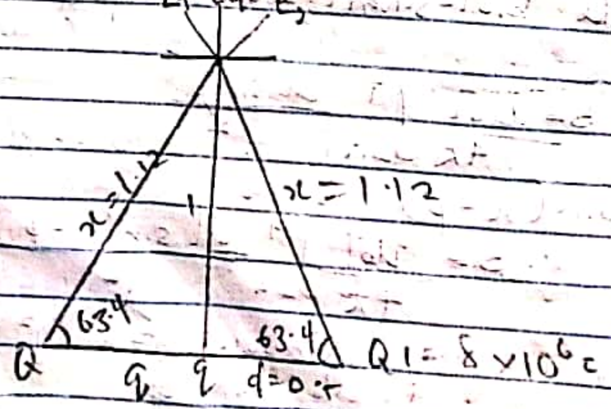
$q_2 = 0.0000038C \simeq 3.8 \times 10^{-5} C$ //

1c.

$Q_1 = Q_2 = 84 c$

$d = 0.5m$

Q. If Electric field at a point P is zero.



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

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

$x = \sqrt{1.25}$

$x = 1.12$

$\tan\theta = \frac{opp}{Adj}$ $\quad \tan\theta = \frac{1}{0.5}$

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

$\theta = 63.4$

$E_1 = \frac{Kq_1}{r^2} = \frac{9 \times 10^9 \times 8 \times 10^{-6}}{(1.12)^2}$

$= 57394.9598$

$E_2 = \frac{Kq_2}{r^2} = \frac{9 \times 10^9 \times 8 \times 10^{-6}}{(1.12)^2}$

$= 57397.95918.$

$E_q = \frac{Kq}{r^2} = \frac{9 \times 10^9 \times q}{1} = 9 \times 10^9 q$

Vector	Angle	X-component	Y-component
$E_1 = 51397.95918$	$63.4°$	$E_1 \cos\theta = 2570.04578$	$E_1 \sin\theta = 5132.26283$
$E_2 = 51397.95918$	$63.4°$	$E_2 \cos\theta = 2570.04578$	$E_2 \sin\theta$ 5132.26283
$E_3 = 9 \times 10^9 q$	$90°$	$E_q \cos\theta = 0$	$9 \times 10^9 q$
		$Ex = 0$	$Ey = 1024.5256$

$\text{Magnitude} = \sqrt{(Ex)^2 + (Ey)^2}$

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

Since $Eq = 0$

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

Making q the subject of the formula.

$$q = \frac{10264.52568}{9 \cdot 10^{9}}$$

$$= 1.14050 \times 10^{-6}$$

$$q = 11.4\,\mu C$$

3a)

(a) Volume Charge Density

$$\rho = \frac{dQ}{dv} \quad \text{'n } dQ = \rho\, dv$$

(b) Surface charge Density

$$\sigma = \frac{dQ}{dA} \quad \text{'n } dQ = \sigma\, dA$$

(c) Linear Charge Density

$$\lambda = \frac{dQ}{dl} \quad \text{in } dQ = \lambda\, dl.$$

3b)

Electric Potential Difference

The electric potential difference between two points in an electric field can be defined as the workdone 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 Coulumb (J/C) and it is a scalar quantity.

Elemental workdone dW is given as

$$dW = F \cdot dl \quad \text{.... (i)}$$

But $F = -q_0 E$ .... (ii)

Substituting equation 2 and 1 = $dW = -q_0 E\, dl$ — (3)

Total workdone in moving the test charge from A to B is

$$W(A \to B)_{Ag} = -q_0 \int_A^B E\, dl \quad \text{—— (4)}$$

From the definition of electric p.d it follows that.

$$V_B = \frac{W(A' \to B)_{Ag}}{q_0} \quad --- (5)$$

Substituting eq (4) in (5) yields

$$V_B - V_A = -\int_A^B E\,dl \quad --- (6)$$

4a.

Magnetic Flux is
The strength of the magnetic field which can be represented by line of forces. It is represented by the symbol ϕ and mathematically given as $\oint B \cdot dA$.

4(b).

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

$r = 1.4 \times 10^{-7} m$

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

Cyclotron frequency = angular speed

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

$$\omega = \frac{qB}{m} = \frac{1.6 \times 10^{-19} \times 3.5 \times 10^{-1}}{.9 \times 10^{-3}}$$

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

4c.

Mass of electron $= 9.11 \times 10^{-31} kg$

$r = 1.4 \times 10^{-7} m$

magnetic field $= 3.5 \times 10^{-1}$ weber/meter

cyclotron frequency = angular speed

! Angular speed $\omega = \frac{v}{r} = \frac{qB}{m}$

Substitution we have $\omega = \frac{v}{r} = \frac{qB}{m} = \frac{1.6 \times 10^{-19} \times 3.5 \times 10^{-1}}{9.11 \times 10^{-31}}$

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

Therefore, cyclotron frequency $= 6.22 \times 10^{10} T^{-1}$, the unit is equal to the unit of frequency dimensionally.

PHY102 ASSIGNMENT.

5a

Biot - Savart Law

States that the magnetic field is directly proportional to the product of permeability of free space (μ), the current (I), the change in length, the radius and inversely proportional to the square of radius (r^2). It can be represented as:

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

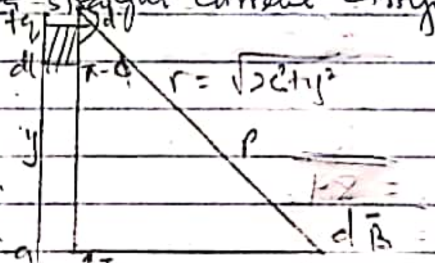
where μ_0 = constant <permeability of free space>

$$\mu = 4\pi \times 10^{-3}\ T.\frac{m}{A}$$

the unit of B is weber/metre square.

5b

Magnetic field of a straight current carrying conductor



A section of a straight current carrying conductor. Applying the biot-savart law, we find the magnitude of the field.

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

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

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

From the diagram above, $r^2 = x^2 + y^2$ (pythagoras theorem).

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

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

Substituting eq (ii) into (i)

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

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

Recall $dl = dy$

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

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

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

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

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

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