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Medicine & Surgery
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PHY 102 COVID-19 HOLIDAY ASSIGNMENT

1a). 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 (fig. 1.3a). 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), some of the protons leave the sphere and travel to the Earth. If the wire ~~is~~ to ground is then removed (fig 1.3c), the conducting sphere is left with an excess of induced negative charge.

Finally, when the rubber rod is removed from the vicinity of the sphere (fig. 1.3d), the induced negatively charge remains on the ungrounded sphere and becomes uniformly distributed over the surface of the sphere.

Diagrams

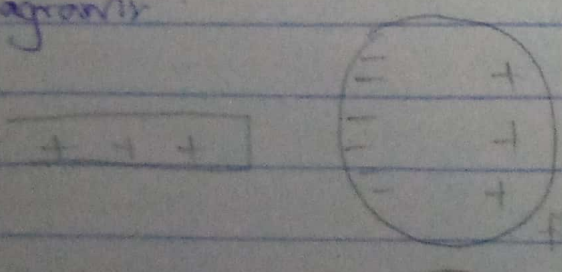


fig 1.3a

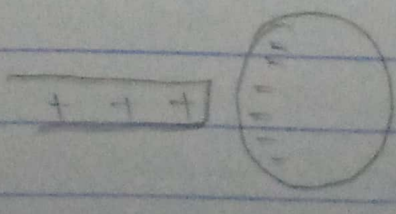


fig 1.3c

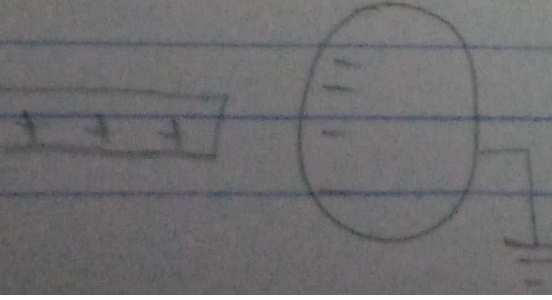


fig 1.3b

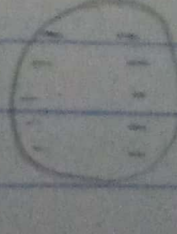


fig 1.3d

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

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

$F = 1N$

$r = 2m$

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

$$1 = \frac{(9\times10^{9})(q_1 q_2\, 5\times10^{-5})}{2^2}$$

$4 = 9\times10^{9} \times 5\times10^{-5} q_1 + 9\times10^{9} q_2^{2}$

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

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

$q_1 = 0.000011C$

$q_2 = 0.000038C$

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

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

c). $Q_1 = Q_2 = 8\mu C$, $d = 0.5\,m$

$\tan\theta = opp/adj$

$\tan\theta = 1/0.5 = 2$

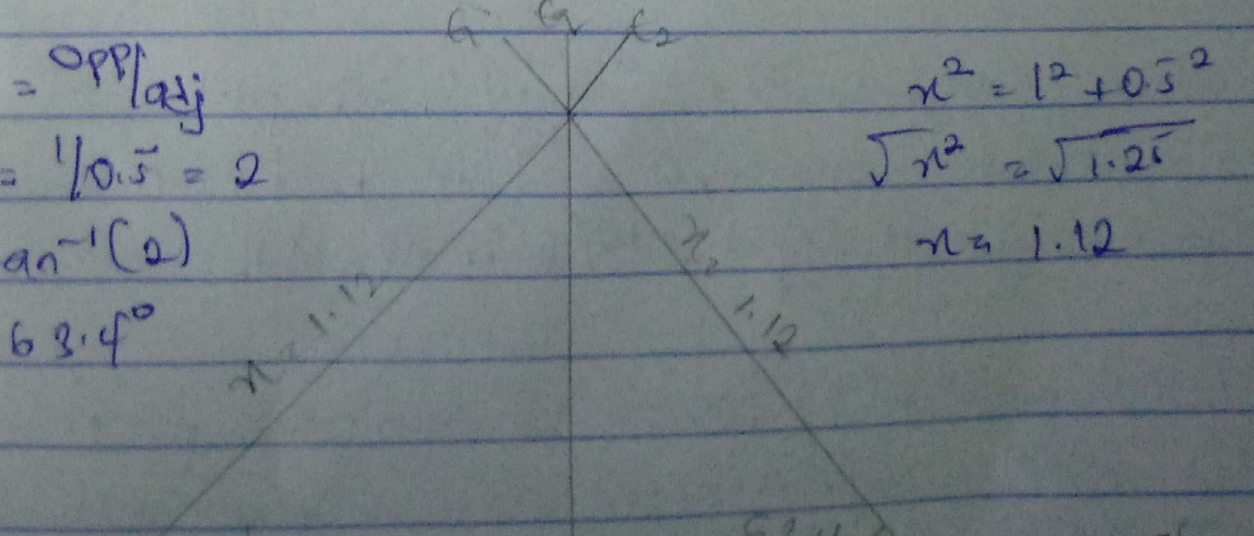
$\theta = \tan^{-1}(2)$

$\theta = 63.4^\circ$

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

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

$x = 1.12$



$= 5739.795918$

$E_1 = \frac{Kq_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-6}}{(1.12)^2} = 5739$ $E_2 = \frac{Kq_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-6}}{1.12^2} = 5739.7959$

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

Vector	Angle	x comp	y comp
$E_1 = 5739.795918$	$63.4°$	-2570.045785	5132.262839
$E_2 = 5739.795918$	$63.4°$	2570.045785	5132.262839
$E_q = 9\times10^9 q$	$90°$	0	10264.52568

Magnitude $= \sqrt{(\Sigma x)^2 + (\Sigma y)^2}$

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

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

$q = -\frac{10264.5268}{9\times10^9}$

$q = 1.140502853\times10^{-6}$

$q = \cancel{1.14}$ $11.4\mu C$

3a) i). Volume charge density, $\rho = dQ/dV$ 'n $dQ = \rho dV$

ii). Surface charge density, $\sigma = dQ/dA$ 'n $dQ = \sigma dA$

iii). Linear charge density, $\lambda = dQ/dL$ 'n $dQ = \lambda dL$

b). 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 the other. It is measured in volt (V) or Joule

per coulomb (J/C). Electric potential difference is a scalar quantity.
Suppose a test charge q_0 is moved from point A to point B along an arbitrary path inside an electric field $\bar{E}$, the electric field exerts a force $\bar{F} = q_0 \bar{E}$ on the charge. To move the test charge from A to B at constant velocity, an external force of $F = q_0 E$ must act on the charge.
Therefore, the elemental work done dW is given as:

$$dW = F \cdot dL \quad \text{— (i)}$$

But,

$$F = -q_0 E \quad \text{— (ii)}$$

Substituting equation (ii) in (i) yields

$$dW = -q_0 E dL \quad \text{— (iii)}$$

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

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

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

$$V_B - V_A = \frac{W(A \to B)_{Ag}}{q_0} \quad \text{— (v)}$$

Putting eqn (iv) in (v)

$$V_B - V_A = -\int_A^B E dL \quad \text{— (v)}$$

4(a). Magnetic flux is defined as the strength of the magnetic ~~field~~ field which can be represented by lines of forces. It is represented by the symbol Φ & is mathematically given as $\Phi = B \cdot dA$

(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

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

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

~~$\omega = 6.2\ T^{-1}\ 6\times$~~

$\omega = 6.2\times10^{10}\ T^{-1}$

c). Cyclotron frequency is the same as angular speed.
Angular speed is given as $\omega = v/r = qB/m$
Substituting, we have $v/r = qB/m = \frac{1.6\times10^{-19}\times3.5\times10^{-1}}{9\times10^{-31}} = 6.2\times10^{10}T^{-1}$

Since cyclotron frequency = angular speed
∴ The cyclotron frequency ~~is~~ $= 6.2\times10^{10}\ T^{-1}$

5a). Biot-savart law states that the magnetic field is directly proportional to the product permeability of free space (μ), the current (I), the ~~change to~~ change in length, the radius and inversely proportional to the square of radius (r^2). ~~It can be represented mathematically by b)~~. The unit of B is weber/metre square

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

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

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

$r^2 = x^2+y^2$ (Pythagoras theorem)

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

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

Substituting (ii) into (i), we have

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

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

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

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

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 (iii) therefore 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,

$$(x^2+a^2)^{1/2}$$

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

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

$$B = \frac{\mu_0 I}{2\pi r} \quad -(iv)$$

Equation (iv) defines the magnitude of the magnetic field of flux density B near a long, straight current carrying conductor