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19/ENG03/022

CIVIL ENGINEERING

Section A

1) 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 conducting sphere that is insulated so that there is no conducting path to ground. The repulsive force between the electrons in the rod and those in the sphere causes a redistribution of charges on the sphere so that some electrons move to the side of the sphere farthest away from the and rod. The region of the sphere nearest to the negatively charged rod has an excess of positive charge because of the migration of electrons away from this location. If a grounded conducting wire is then connected to the sphere, some of the electrons leave the sphere and travel to the earth. If the wire to ground is then removed the conducting sphere is left with an excess of induced positive charge. When the rubber rod is removed from the vicinity of the sphere, the induced positive charge remains on the ungrounded sphere and becomes uniformly distributed over the surface of the sphere.

1b) $K = 9 \times 10^9$ $\quad r = 2$

$F = 1N$ $\quad q_1 + q_2 = 5 \times 10^{-5} C$

$F = \frac{Kq_1q_2}{r^2}$; $q_1q_2 = F\left(r^2/K\right)$

$q_1q_2 = 1\left(2^2/9\times10^9\right)$

$q_1q_2 = 4/9\times10^9$

$q_1q_2 = 4.44\times10^{-10} C^2$

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

$q_2 = (5\times10^{-5} - q_1) = 4.44\times10^{-10}$

$5\times10^{-5} q_1 - q_1^2 = 4.44\times10^{-10}$

$q_1^2 - (5\times10^{-5} C)q_1 + 4.44\times10^{-10} = 0$

$B = \frac{\mu_0 I}{2\pi x}$ ... we have axial symmetry abo...

In a physi...

all points

$B =$

Equation ...

a long st...

Using quadratic equation

$$q_1 q_2 = \frac{(5\times10^{-5}) + \sqrt{(5\times10^{-5})^2 - 4(4.44\times10^{-10})}}{2}$$

Or

$$\frac{(5\times10^{-5}) - \sqrt{(5\times10^{-5})^2 - 4(4.44\times10^{-10})}}{2}$$

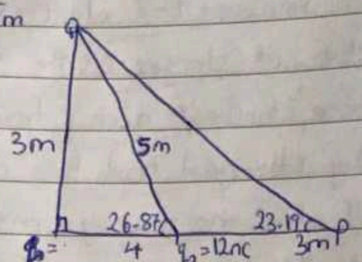
$q_2 = 1.16\times10^{-6}\,C$

$q_1 = 3.84\times10^{-5}\,C$

$q_1 + q_2 = 3.84\times10^{-5}\,C + 1.16\times10^{-6}\,C = 5.0\times10^{-5}\,C.$

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

$d = 0.5m$



i) $E_1 = \frac{KQ_1}{r^2} = \cancel{9\times10^9\times10}\ \frac{9\times10^9\times8\times10^{-9}}{7^2} = 1.47$

ii) $E_2 = \frac{KQ_2}{r^2} = \frac{9\times10^9\times8\times10^{-9}}{3^2} = 128$

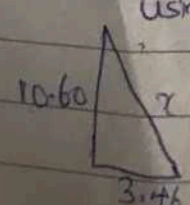
$1.47 + 8 = 9.47\,N/C$

ii) $E_1 = \frac{9\times10^9\times8\times10^{-9}}{9} = 8$

$E_2 = \frac{9\times10^9\times12\times10^{-9}}{25} = 4.32$

x	y
$8\times\cos(90)$	$8\times\sin 90$
$= 0$	8
$4.32\times\cos(36.87)$	$4.32\times\sin(36.87)$
$= 3.46$	2.60
3.46	10.60

Using pythagoras theorem



$x = \sqrt{10.60^2 + 3.46^2}$

$= 11.15\,N/C$

3a) Volume charge density, $\rho = \frac{dQ}{dv} \rightarrow dQ = \rho dv$

Surface charge density $\sigma = dQ/dA \longrightarrow dQ = \sigma dA$

linear charge density $\lambda = dQ/dl \rightarrow dQ = \lambda dl$

b) $dW = F.dl$ ---(i)

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

$dW = -q_0 E dl$ ---(iii)

$W(A \rightarrow B)_{Ag} = -q_0 \int_A^B E dl$ ---(iv)

$V_B - V_A = \frac{W(A \rightarrow B)_{Ag}}{q_0}$ ---(v)

sub equ 4 into 5

$V_B - V_A = -\int_A^B E dl$ ---(vi)

3c)

$Q_1 = 10\mu C$ 4m $Q_2 = -2\mu C$

$Q_1 = 10\mu C$; $Q_2 = 2\mu C$

$V = 1/4\pi\varepsilon_0 \left[Q_1/r_1 \times Q_2/r_2 \right]$

$\frac{0}{9\times10^9} = \frac{10\times10^{-6}}{r_1} - \frac{2\times10^{-6}}{r_2}$

$2r = 10r_2$; $r_1 = 5r_2$

Section B

4) A magnetic flux is defined as the strength of the magnetic field which can be represented by lines of forces. It is represented by the symbol Φ ; $\Phi = B.dA$

4b) $m = 9\times10^{-31}$ kg $B = 3.5\times10^{-1}$ weber/meter^2

$r = 1.4\times10^{-7}$ m

Cyclotron frequency = angular speed

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

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

$$\omega = 62222.2222T^{-1}$$

c) We were given

i) mass of the electron = 9.11×10^{-31} kg

ii) A radius of 1.4×10^{-7} m

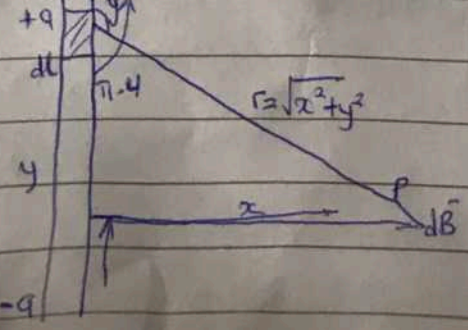
iii) Magnetic field of 3.5×10^{-1} weber/meter square and were asked to find the cyclotron frequency which is equal or the same as the angular speed. It is called Cyclotron frequency because it is the frequency of an accelerator called cyclotron

recall angular speed is given as $\omega = \frac{v}{r} = \frac{qB}{m}$

substituting we have $\omega = v/r = qB/m = \frac{1.6\times10^{-10}\times3.5\times10^{-10}}{9.11\times10^{-31}}$

$$\frac{qB}{m} = 62222.2222T^{-1}$$

5a) The Biot-Savart law states that the magnetic field is directly proportional to the product permeability of free space (μ), the current (I), the change in length, the radius and inversely proportional to square of radius (r^2). It can be represented mathematically by $dB = \frac{\mu_0 I dl \times r}{4\pi r^2}$



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

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

$$(x^2+a^2)^{1/2} = a, \text{ as } a \to \infty$$

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

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

$$B = \frac{\mu_0 I}{2\pi r} \quad \text{---(1)}$$

Equation (1) defines the magnitude of the magnetic field of flux density B near a long straight ~~element~~ current carrying conductor.