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MATRIC NO: 19/sci01/007

DEPARTMENT: Computer science

PHY102 HOLIDAY ASSIGNMENT

1a. Charging by induction:

Electric charges can be obtained on an object without touching it, by a process called electrostatic induction. Consider a negatively 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 electrons in the rod, and those in the sphere causes a redirection of charges on the sphere so that some electrons move to the side of the sphere farthest away from the rod (fig 1.3a). The region of sphere nearest the negatively charged rod has an excess of positive charge because of the migration of electrons away from the location. If a grounded conducting wire is then connected to the sphere as in (fig 1.3b), some of the electrons leave the sphere and travel to the earth. If the wire to the ground is then removed (fig 1.3c), the conducting sphere is left with an excess of induced positive charge. Finally, when the rubber rod is removed from the vicinity of the sphere (fig 1.3d), the positive charge remains on the underground sphere and becomes uniformly distributed over the surface of the sphere.

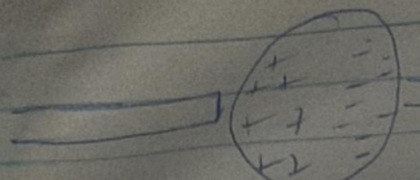


Fig 1.3a

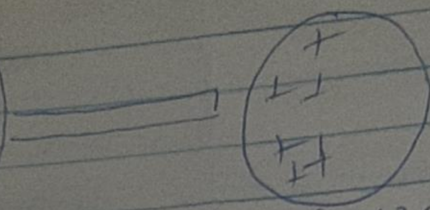


Fig 1.3c

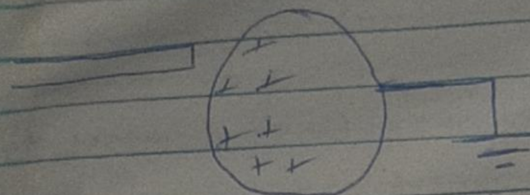


Fig 1.3b

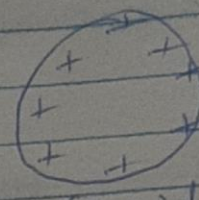


Fig 1.3d

15) $k = 9\times10^{9}$

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

$F = 1N$

$d = 2m$

Charge on each sphere =

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

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

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

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

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

$q_1 = 0.0000111\,c \Rightarrow 1.11\times10^{-5}\,c$

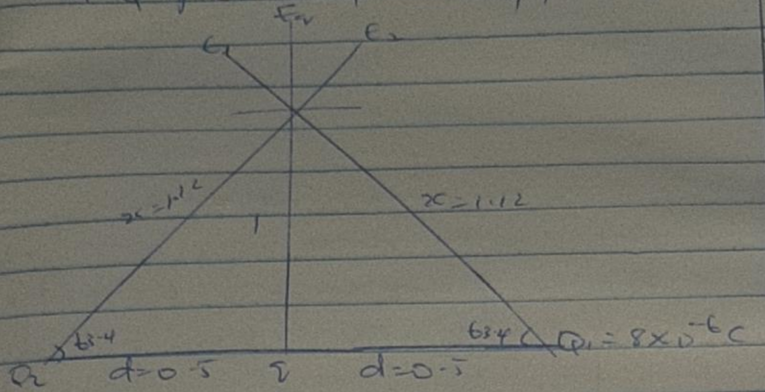
$q_2 = 3.8\times10^{-5}\,c$

1c

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

$d = 0.5m$

Find Q if electric field at a point $p = 0$



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

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

$x = 1.12$

$\tan\theta = opp/adj$

$\tan\theta = 1/0.5$

$\theta = \tan^{-1}(1/0.5)$

$\theta = 63.4$

$$E_1 = \frac{kq_1}{r^2} = \frac{9\times10^9 \times 8\times10^{8}}{(1.12)^2} = 57397.95918$$

$$E_2 = \frac{kq_2}{r^2} = \frac{9\times10^9 \times 8\times10^{-6}}{(1.12)^2} = 57397.95918$$

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

Vector	Angle	x-component	y component
$E_1 = 57397.95918$	$63.4°$	$E_1\cos\theta =$ 2570.045785	$E_1\sin\theta =$ 5132.262839
$E_2 = 57397.95918$	$64.3°$	2570045785	5132.262839
$E_q = 9\times10^9 q$	$90°$	$E_q\cos\theta = 0$ $Ex = 0$	$9\times10^9 q$ $Ey = 10264.5258$

magnitude

1c.

$$\text{magnitude} = \sqrt{(E_x)^2 + (E_y)^2}$$

$$E_q = \sqrt{(0)^2 + (10264.525682)^2} \quad , \quad E_q = 0$$

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

$$q = \frac{10264.52568}{19\times10^9}$$

$$q = 1.140502858\times10^{-16}$$

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

2a. Electric field is a region of space in which electric charges will experience an electric force while electric intensity is the force per unit charge.

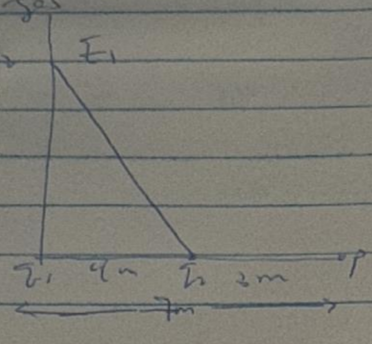
2b.

2b) $q_1 = 8nc$ as origin, $q_2 = 12nc$ on x-axis at $x = 4m$

i) no electric field at point P on the x-axis at $x = 9m$.

ii) Electric field at point Q on the y-axis at $y = 3m$ due to like charges

i) E_2 E_1

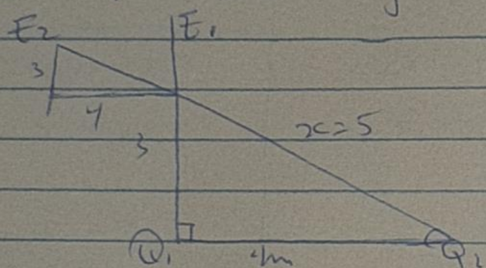


$E_1 = \frac{kQ_1}{r^2} = \frac{9 \times 10^9 \times 8 \times 10^{-9}}{7^2} = 1.5\ N/C$

$E_2 = \frac{kQ_2}{r^2} = \frac{9 \times 10^9 \times 12 \times 10^{-9}}{2} = 12\ N/C$

$w = E_n = E_1 + E_2 = 1.5 + 12 = 13.5\ N/C$

(ii) E at point Q on the y axis at y = 8m due to like charges.



$c^2 = a^2 + b^2$

$c^2 = 4^2 + 3^2$

$c = \sqrt{25} = 5$

$E_1 = \frac{kQ_1}{r^2} = \frac{9 \times 10^9 \times 8 \times 10^{-9}}{3^2} = 8N/C$

$E_2 = \frac{kQ_2}{r^2} = \frac{9 \times 10^9 \times 12 \times 10^{-9}}{5^2} = 4.3N$

Vector	angle	x-component	y-component
$E_1 = 8N/C$	90	$0N/C$	$8N/C$
$E_2 = 4.32N/C$	36.87°	$-3.45N/C$	$2.59N/C$
		$\Sigma E_x = -3.45N/C$	$\Sigma E_y = 10.59N/C$

$$E_{net} = \sqrt{\Sigma E_x^2 + \Sigma E_y^2}$$
$$= \sqrt{(-3.45)^2 + (10.59)^2}$$
$$= 11.14N/C$$

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 ᶲ. Mathematically given as ᶲ=β-Da

4b/c.

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

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

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

Cyclotron frequency = angular speed, angular speed $\omega = \frac{v}{r} = \frac{qB}{m}$

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

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

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

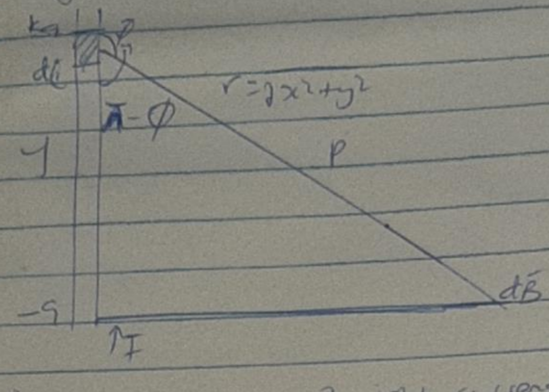
5a. Biot-savart law states that the magnetic field is directly proportional to the proportional to the product permeability of free space (μ), the current (I), the change in length, the radius and inversely proportional to the square of radius (r^2). It can be represented mathematically by:

$\alpha\beta = \mu_0 Idlxr/4\pi r^2$

unit of β is weber/meter square

5b.

5) 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 $d\vec{B}$

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

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

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

from the diagram, $r^2 = x^2+y^2$

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

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

Substituting ② into ①

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

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

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

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

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

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

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

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

- 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 magnetic field of flux density B near a long straight current carrying conductor.