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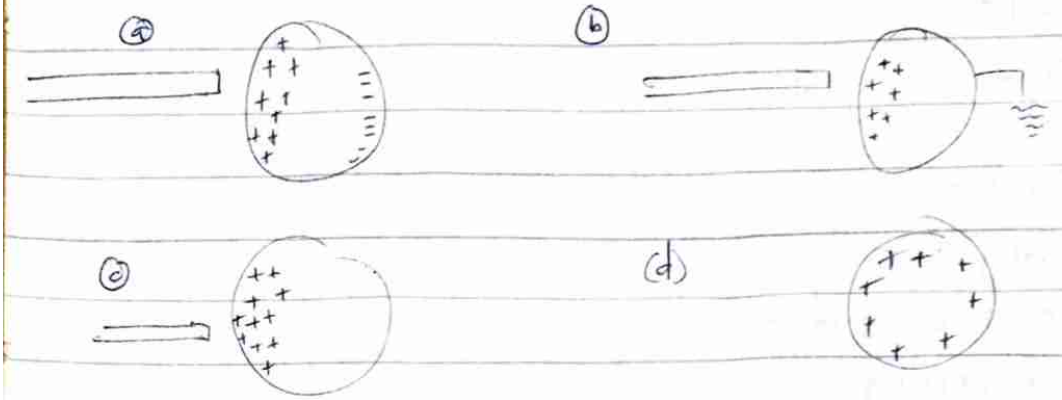
Physics Assignment 102

1) A negatively charged rod is brought near a neutral conducting sphere that is insulated. the repulsive force between the electrons in the rod and those in the sphere causes a re distribution of charge some electrons move to the side of the sphere far from the rod . the region and the the positive charge near the rod. If a grounded conducting wire is connected to the sphere; electrons leaves the sphere and travels to the earth. If the wire is removed, sphere is left with positive charge Finally, when the rubber rod is removed from the sphere, the induced positive ~~per~~ charge remains on the ungrounded sphere and ~~formally~~ uniformly distributed over the surface of the sphere.



2) $q_1+q_2 = 5\times10^{-5}C$, $F = 1N$, $r = 2$

$F = \frac{k q_1 q_2}{r^2}$. $1 = \frac{9\times10^{9}\times(5\times10^{-5} - q_2)\times q_2}{2^2}$

$4 = 4.5\times10^{-5} q_2 - 9\times10^{9} q_2^{2}$

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

$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$ $q_2 = \frac{-4.5\times10^{-5} \pm \sqrt{(4.5\times10^{-5})^2 - 4(-9\times10^{9})(4)}}{2(-9\times10^{9})}$

$q_2 = \frac{4.5\times10^{-5} \pm \sqrt{5.8\times10^{10}}}{-18\times10^{9}}$

$q_2 = 1.156\times10^{-5}$ or $3.84\times10^{-5}C$

$q_1 = 1.156\times10^{-5}$, $q_2 = 3.84\times10^{-5}$

c) $\sqrt{2d}$

$\sqrt{2d^2 + d^2} = d\sqrt{5}$

$\tan\theta = \frac{2d}{d}$

$\tan^{-1}(2) = 63.43^\circ$

$E_1 = \frac{kQ_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-6}}{(d\sqrt{5})^2}$

$= \frac{9\times10^9 \times 8\times10^{-6}}{(\sqrt{5}/2)^2}$

$= \cancel{590}\ 57600\ N/C$

$E_2 = \frac{kQ_2}{r^2} = \frac{9\times10^9 \times q}{2d^2}$

$= 9\times10^9\ N/C$

vector	θ	x comp	y comp
$E_1 = 57600\ N/C$	63.43°	$57600\cos 63.43$ $= -25764$	$57600\sin 63.43$ $= 51516.8$
$E_2 = 57600\ N/C$	63.43	$57600\cos 63.43$ $= 25764$	$57600\sin 63.43$ $+ 51516.8$
$E_q = -9\times10^9\ N/C$	90°	$9\times10^9 q\cos 90$ $= 0$	$9\times10^9\sin 90^\circ$ $= 9\times10^9$
		$E_{fx} = 0$	$E_{fy} = 103033.6 + 9\times10^9 q$

$E_{net} = \sqrt{E_{fx}^2 + E_{fxy}^2}$

but E_{net} at point $p = 0$

$0 = \sqrt{0^2 + (103033.6 + 9\times10^9 q)^2}$

$0 = 103033.6 + 9\times10^9 q$

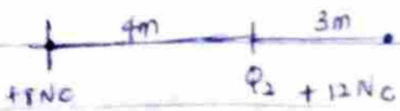
$q = \frac{-103033.6}{9\times10^9}$

$q = -1.14481\times10^{-5}$

$q = -11.4\ NC$

2) An electric field is a region of space in which an electric charge will experience an electric force while electric field intensity is the per unit change unexperienced by a charge in an electric field.

b)



$E_1 = \frac{kQ_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-9}}{7^2} = 1.47 N/C$

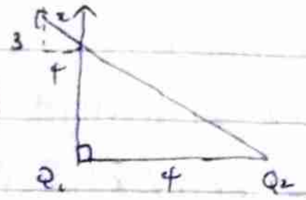
$E_2 = \frac{kQ_2}{r^2} = \frac{9\times10^9 \times 12\times10^{-9}}{7} = 12 N/C$

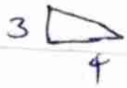
$E_{net} = E_1 + E_2$

$1.47 + 12$

$E_{net} = 13.47 N/C$

4, E at point P on the x-axis at y = 3m due to charge.





$c^2 = a^2 + b^2$
$= 4^2 + 3^2$
$16 + 9$
$= 25$
$c = \sqrt{25}$
$= 5$ //

$E_1 = \frac{kQ_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-9}}{3^2} = 8 N/C$

$E_2 = \frac{kQ_2}{r^2} = \frac{9\times10^9 \times 12\times10^{-9}}{5^2} = 4.32 N/C$

Vector	angle	x component	y component
E_1 8N/C	90°	$8\cos 90^\circ$	$8\sin 90^\circ$
		$= 0$	$+8$
$E_2 = 4.32$N/C	37°	$4.32 \cos 37^\circ$	$4.32 \sin 37^\circ$
		$= -3.45$	$= +2.6$
		$E_{fx} = -3.45$N/C	$E_{fy} = 10.6$N/C

Resultant $= \sqrt{E_{fx}^2 + E_{fy}^2}$

$= \sqrt{(-3.45)^2 + (10.6)^2}$

$= \sqrt{124.263}$

$= 11.147 N/C$

SECTION B.

f) The magnetic flux is defined as the strength of a magnetic field represented by lines of force. It is usually represented by the symbol ϕ

ϕ = $M_e = 9.11 \times 10^{-21}$ kg $r = 1.4 \times 10^{-9}$ m $\theta = 90°$

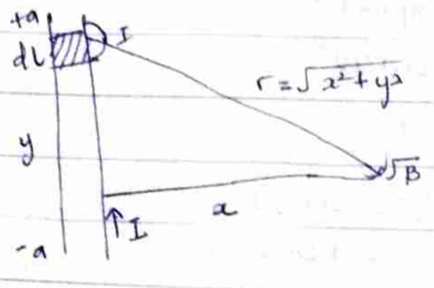
magnetic field $= 3.5 \times 10^{-1}$ Wb/m2 $\sin\theta = 1$

$$W = \frac{qB}{m} \qquad W = \frac{1.6 \times 10^{-19} \times (3.5 \times 10^{-1})}{9.11 \times 10^{-21}}$$

$W = 6.115 \times 10^{10}$ rad/s

4c) An electron of mass 9.11×10^{21} kg and charge 1.6×10^{-19}C in motion in a magnetic field of 3.5×10^{-1} tesla perpendicular with the field will have an angular frequency of 6.115×10^{10} r/s

5) Biot-savart law 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 radius but inversely proportional to the square of the radius.

b) 

Apelying the biot-savart law, we find the magnitude of the field $d\vec{B}$

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

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

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

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

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

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

Substituting (II) into (I) we have;

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

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

recall $dl = dy$.

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

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

$B = \cancel{\frac{\mu_0 I x}{4\pi}\int_{-a}^{a}}$ using special integrals:

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

equation $\overline{\text{III}}$ becomes

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

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

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

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

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

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