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COLLEGE/DEPARTMENT: MHS/MBBS

COURSE TITLE: ELECTRICITY, MAGNETISM AND MODERN PHYSICS

COURSE CODE: PHY 102 2019/2020 SESSION

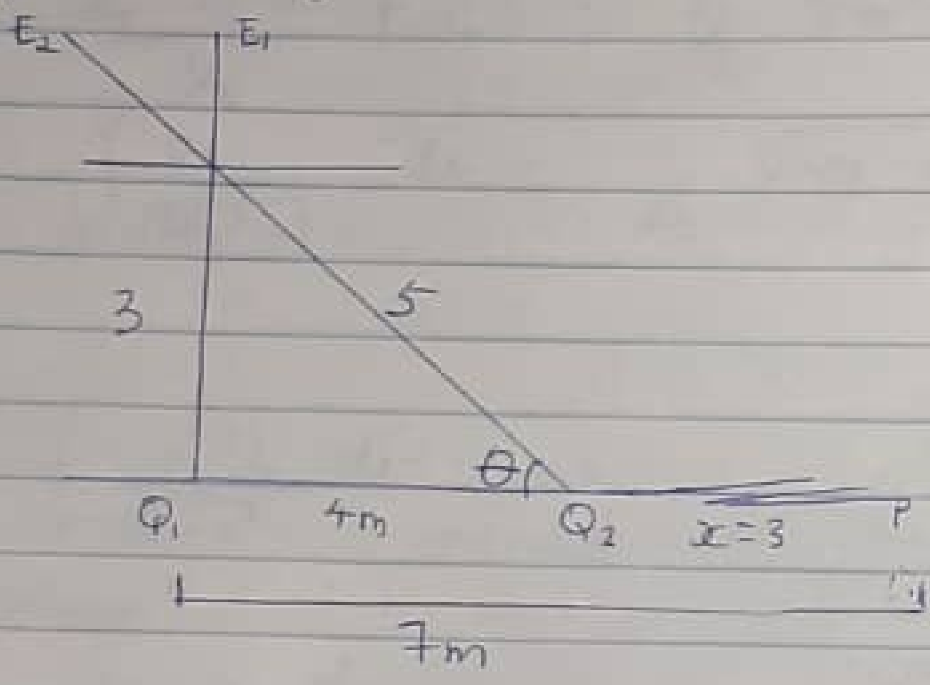
PHY 102 COVID-19 HOLIDAY ASSIGNMENT

Instruction: Answer four questions in all - 2 from Section A and 2 Section B.

Question 2

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

b.



$\tan\theta = \frac{Opp}{Adj} = \frac{3}{4}$

$\theta = \tan^{-1}\left(\frac{3}{4}\right)$

$\theta = 36.9°$

$E_{net} = E_1 + E_2$

$E_1 = \frac{kq_1}{r^2} = \frac{9\times10^9 \times 3\times10^{-9}}{7^2} = 1.469\ N/C$

$E_2 = \frac{kq_2}{r^2} = \frac{9\times10^9 \times 12\times10^{-9}}{3^2} = 12N/C$

$\therefore E_{net} = 12 + 1.469 = 13.469\ N/C$

$E_{net} \simeq 13.5 N/C$

ii. $E_1 = \frac{Kq_1}{r^2} = \frac{9\times10^9 \times 12\times10^{-9}}{5} = 4.32\ N/C$

Vector	Angle	X-comp	Y-comp
$E_1 = 8\ N/C$	$90°$	0	8
$E_2 = 4.32\ N/C$	$36.9°$	-3.45	2.59
		$\Sigma x = -3.45$	$\Sigma y = 10.59$

$E_{net} = \sqrt{\Sigma E_x^2 + \Sigma E_y^2}$

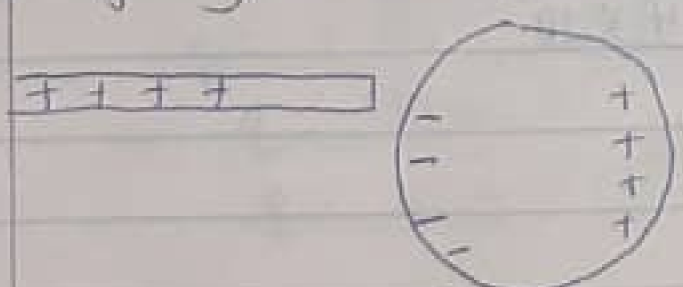
$E_{net} = \sqrt{(-3.45)^2 + (10.59)^2}$

$E_{net} = 11.14\ N/C$

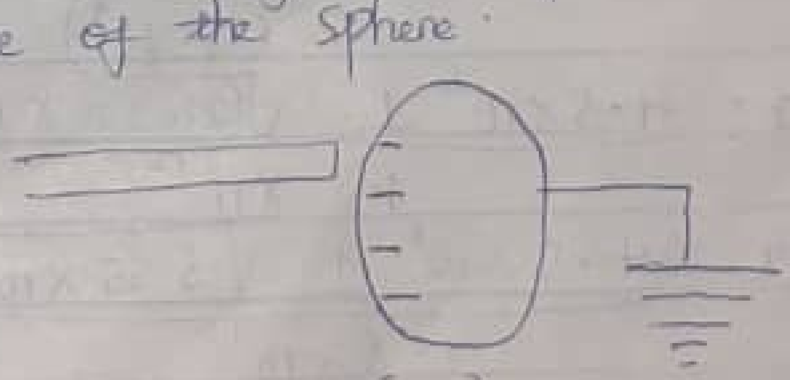
Question 1

a. Consider a positively charged rubber rod brought near a neutral (uncharged) conducting sphere that is insulated so that there is no conducting path to the ground. The repulsive force between the positive charges in the rod and those in the sphere causes a redistribution of charges on the sphere so that some of the positive charges move to the side of the sphere farthest away from the rod. The region of the sphere nearest to the positively charged rod has an excess of negative charges because of the migration of positive charges away from this location. If a grounded conducting wire is then connected to the sphere, some of the positive charges leave the sphere and travel to the ground. If the wire is then removed, the conducting sphere is left with excess of induced negative charge.

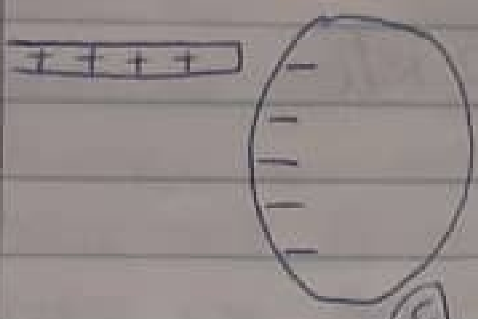
Finally, when the rubber rod is removed from the vicinity of the sphere, the induced negative charge remains on the ungrounded sphere and becomes uniformly distributed over the surface of the sphere.



(a)



(b)



1(b) $q_1 + q_2 = Q_{total} = 5.0 \times 10^{-5}$ C

$F = 1.0N$

$r = 2.0m$

$q_1 = ?$ $q_2 = ?$

from Coulomb's law, $f = \frac{K q_1 q_2}{r^2}$

$q_1 + q_2 = 5.0 \times 10^{-5}$ C

$q_1 = 5.0 \times 10^{-5} C - q_2$

$k = 9 \times 10^9 Nm^2/C$

$$1.0 = \frac{(9 \times 10^9)(5 \times 10^{-5} - q_2)(q_2)}{2^2}$$

$(9 \times 10^9)(5.0 \times 10^{-5} - q_2)(q_2) = 4$

$(4.5 \times 10^5 - 9 \times 10^9 q_2)(q_2) = 4$

$4.5 \times 10^5 q_2 - 9 \times 10^9 q_2^2 = 4 \implies 9 \times 10^9 q_2^2 - 4.5 \times 10^5 q_2 + 4 = 0$

Quadratically,

$a = 9 \times 10^9$, $b = -4.5 \times 10^5$, $c = 4$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$x = \frac{-(-4.5 \times 10^5) \pm \sqrt{(-4.5 \times 10^5)^2 - 4(9 \times 10^9)(4)}}{2(9 \times 10^9)}$$

$$x = \frac{4.5 \times 10^5 \pm \sqrt{(2.025 \times 10^{11}) - 1.44 \times 10^{11}}}{1.8 \times 10^{10}}$$

$$x = \frac{4.5 \times 10^5 \pm \sqrt{5.85 \times 10^{10}}}{1.8 \times 10^{10}}$$

$$x = \frac{4.5 \times 10^5 \pm 2.42 \times 10^5}{1.8 \times 10^{10}}$$

$x = \frac{4.5 \times 10^5 + 2.42 \times 10^5}{1.8 \times 10^{10}}$ or $x = \frac{4.5 \times 10^5 - 2.42 \times 10^5}{1.8 \times 10^{10}}$

$x = 3.84 \times 10^{-5}$ $\quad$ $x = 1.16 \times 10^{-5}$

$\therefore q_1 = 3.84 \times 10^{-5}$ C

$q_2 = 1.16 \times 10^{-5}$ C

c $\cancel{K =}$ $\tan\theta = \frac{opp}{adj}$

$\theta = \tan^{-1}\left(\frac{1}{0.5}\right)$

$\theta = 63.43^\circ$

$E_2 = \frac{Kq_2}{r^2} = \frac{9 \times 10^9 \times 8 \times 10^{-6}}{(1.12)^2} = 57397.95918$

$E_1 = E_2 = 57397.95918$

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

Vector	Angle	x - Comp	y - comp
$E_1 = 57397.95918$	63.4	25700.45785	51322.62839
$E_2 = 57397.95918$	63.4	-25700.45785	51322.62839
		$\Sigma x = 0$	$\Sigma y = 102645.2568$

$E_q = \sqrt{\Sigma E_x^2 + \Sigma E_y^2}$

$E_q = \sqrt{0^2 + (102645.2568)^2}$

$E_q = 0 + 102645.2568$

$q = \frac{E_q}{9 \times 10^9} = \frac{102645.2568}{9 \times 10^9}$

$q = 1.14 \times 10^{-5}$ C

$q = 11.4 \times 10^{-6}$ C

$q = 11.4\ \mu C$

Question 4

a. Magnetic flux is defined as the strength of magnetic field represented by lines of force. It is represented by the symbol ϕ.

b. $m = 9.11 \times 10^{-31}$ kg
$r = 1.4 \times 10^{-9}$ m
$B = 3.5 \times 10^{-1}$ weber/m^2
$q = 1.6 \times 10^{-19}$ C
The cyclotron frequency is also called angular speed (ω)

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

$$\omega = \frac{1.6 \times 10^{-19} \times 3.5 \times 10^{-1}}{9.11 \times 10^{-31}} = \frac{5.6 \times 10^{-20}}{9.11 \times 10^{-31}}$$

$$\omega = 6.15 \times 10^{10} \text{ rad s}^{-1}$$

$\therefore$ Cyclon frequency $= 6.15 \times 10^{10}$ rad s^{-1}

c. In the question, we were given
i mass of electron $(m) = 9.11 \times 10^{-31}$ kg
ii a radius of 1.4×10^{-1} m
Magnetic field of 3.5×10^{-1} weber/meter^2
and asked to find the cyclotron frequency which is often referred to a angular speed (ω). It is called cyclotron frequency because it is a frequency of an accelerator called cyclotron.
And cyclotron frequency = angular speed (ω). Using the formula $\omega = \frac{v}{r} = \frac{qB}{m}$ we can derive the cyclon frequency

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

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

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

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 i a is much larger than x

$$(x^2+a^2)^{1/2} \simeq a \quad \text{as} \quad a \longrightarrow \infty$$

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

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

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

This equation defines the magnetic field of flux density B near a long, straight current carrying conductor.

Question 5

a. 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 (dl) and the radius and inversely proportional to the square of the radius (r^2)

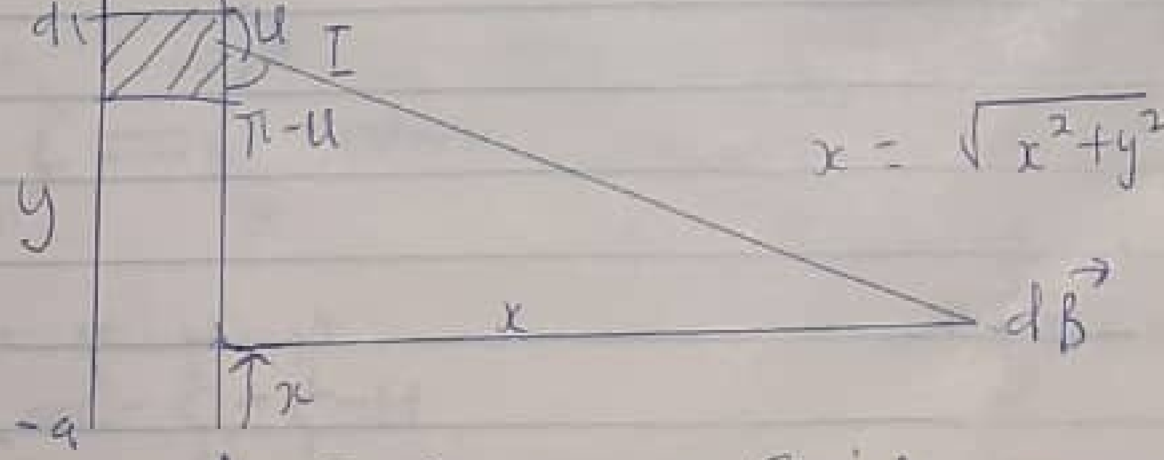
Mathematically,

$$d\vec{B} = \frac{\mu_0}{4\pi} \frac{I\, d\vec{l} \times \hat{r}}{r^2}$$

where μ_0 is a constant called ~~per~~ permeability of free space

$$\mu_0 = 4\pi \times 10^{-7}\ T.m/A$$

b



A Section of a Straight current carrying conductor

Applying the Biot-Savart law we find the magnitude of the field dB

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

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

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

from the diagram above $r^2 = x^2 + y^2$ (pythagoras theorem)

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

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

By substitution 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 that $dl = dy$

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

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

Using special integrals:

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