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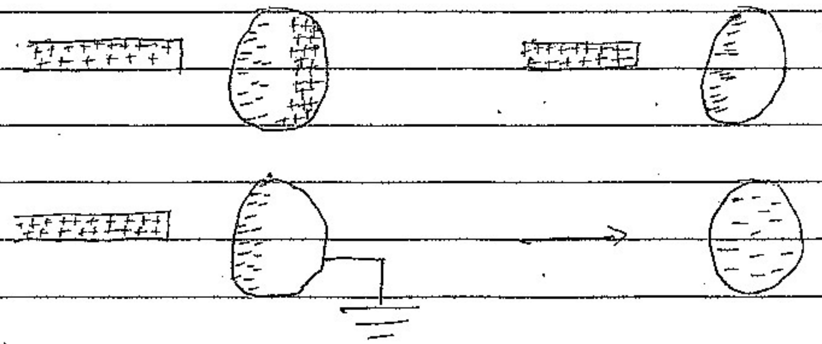
19/MHS11/064
PHY 102 COVID-19 ASSIGNMENT

1a Explain with the aid of a diagram how you can produce a negatively charged Sphere by method of induction



Electric charge can be obtained on an object without touching it by a process called electrical Induction

1b Each of two small sphere is charged positively, the combined charge being 5.0×10^{-5} c. If each sphere is repelled from the other by a force of 1.0N when the sphere are 2.0m apart calculate the charge on each sphere

sol

$F = 1.0N \quad r = 2.0m \quad Q = 5.0 \times 10^{-5} \quad q_1 + q_2 \quad Q = 5.0 \times 10^{-5}$

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

$$1 = \frac{9 \times 10^9 \times q_1 q_2}{2^2}$$

cross multiply

$$\frac{4}{9 \times 10^9} = \frac{9 \times 10^9}{9 \times 10^9} \times q_1 q_2$$

$q_1 q_2 = 4.44 \times 10^{-10}$ — equ (1)

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

$q_1 = 5.0 \times 10^{-5} - q^2$ —— (2)

Put equ (2) in (1)

$q_2 \times [5.0 \times 10^{-5} - q^2] = 4.44 \times 10^{-10}$

$5.0 \times 10^{-5} q_2 - q_2^2 = 4.44 \times 10^{-10}$

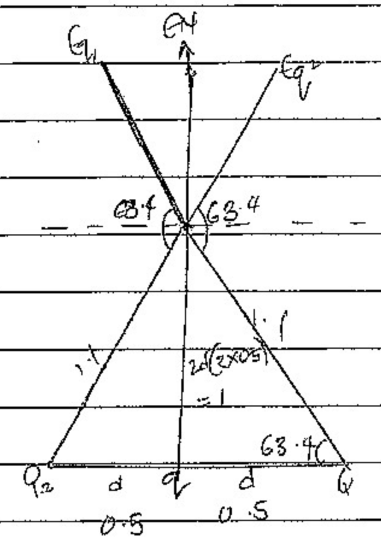
$-q_2^2 + 5.0 \times 10^{-5} q_2 - 4.44 \times 10^{-10} = 0$

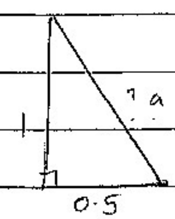
$q_2 = 3.845 \times 10^{-5}$ c or $q_2 = 1.155 \times 10^{-5}$ c

$q_1 = 5.0\times10^{-5} - 3.845\times10^{-5}$ or $q_1 = 5.0\times10^{-5} - 1.155\times10^{-5}$

$= 1.155\times10^{-5}\,C$ $\qquad$ $= 3.845\times10^{-5}\,C$

$q_2 = 3.845\times10^{-5}\,C$ $\qquad$ $q_1 = 1.155\times10^{-5}\,C$





Using pythagoras theorem

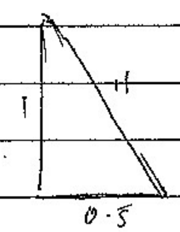
$a^2 = 1^2 + 0.5^2$

$a^2 = 1 + 0.25$

$a^2 = 1.25$

$a = \sqrt{1.25}$

$a = 1.1$



$\tan\theta = \frac{1}{0.5}$

$\theta = 63.4$

$E_p = E_{q_1} + E_{q_2} + E_q$

$E_{q_1} = \frac{kQ_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-6}}{1.1^2} = 59504\ N/C$

$E_{q_2} = \frac{kQ_2}{r^2} = 9\times10^9\times8\times10^{-6} = 59504\ N/C$

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

Vector	Angle	X comp	Y comp
$E_{q_1} = 59504$	63.4	$-59504\cos 63.4$ $= -26643$	$59504 \sin 63.4 = 53205$
$E_{q_2} = 59504$	63.4	$59504 \cos 63.4$ $= 26643$	$59504 \sin 63.4 = 53205$
$E_q = 9\times10^9 q$	90	$9\times10^9 q \cos 90$ $= 0$	$9\times10^9 q \sin 90 = 9\times10^9 q$

$\Sigma f_x = 0$ $\qquad$ $\Sigma f_y = 106410 + 9\times10^9 q$

$\mathcal{E}_p = \sqrt{0^2 + (106410 + 9\times10^9 q)^2}$

$\mathcal{E}_p = \sqrt{(106410 + 9\times10^9 q)^2}$

$\mathcal{E}_p = 106410 + 9\times10^9 q$

- at $\mathcal{E}_p$ 0.

$106410 + 9\times10^9 q = 0$

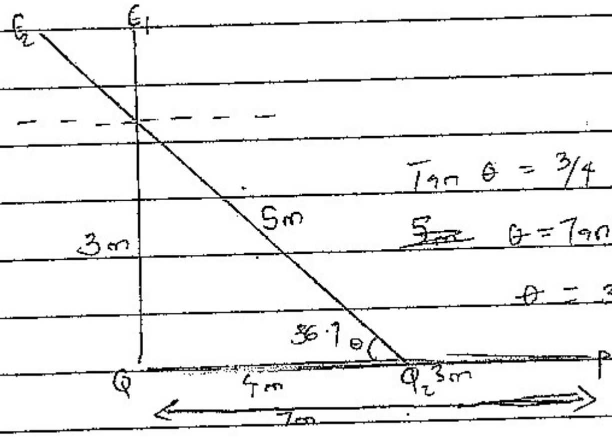
$\frac{9\times10^9 q}{9\times10^9} = \frac{-106410}{9\times10^9}$

$q = -1.18\times10^{-5} C$

$\simeq 12\mu C$

2a ~~Electric~~ field: It is a region of space in which an electric charge will experience an electric force while electric field intensity can be defined as the force per unit charge

b



$\tan\theta = 3/4$

$\theta = \tan^{-1} 0.75$

$\theta = 36.7$

$\mathcal{E}_p = \mathcal{E}Q_1 + \mathcal{E}Q_2$

$\mathcal{E}Q_1 = \frac{KQ}{r^2} = \frac{9\times10^9\times8\times10^{-9}}{7^2} = 1.469 N/c$

$\mathcal{E}Q_2 = \frac{KQ}{r^2} = \frac{9\times10^9\times12\times10^{-9}}{3^2} = 12 N/c$

$\mathcal{E}p_{net} = 1.469 + 12 = 13.469 \simeq 13.5 N/c$

ii $\mathcal{E}_{net}\ Q = \vec{\mathcal{E}_1} + \vec{\mathcal{E}_2}$

$\mathcal{E}_1 = \frac{KQ_1}{r^2} = \frac{9\times10^9\times8\times10^{-9}}{3^2} = 8 N/c$

$\mathcal{E}_2 = \frac{KQ_2}{r^2} = \frac{9\times10^9\times12\times10^{-9}}{5^2} = 4.32 N/c$

Vector	Angle	X comp	Y comp
$\varepsilon_1 = 8N/c$	90^0	$8\cos 90$	$8\sin 90$
		$=0$	$=8$
$\varepsilon_2 = 4.32N/c$	36.9	$-4.32\cos 36.9$	$4.32\sin 36.9$
		$=-3.45$	2.59
		$\Sigma f_x = -3.45$	$\Sigma f_y = 10.59$

$\varepsilon_{net_Q} = \sqrt{(-3.45)^2 + (10.59)^2}$

$= 11.14 N/c$

4a Magnetic flux is defined as the strength of the magnetic field represented by lines of force. It is represented by the Symbol ϕ

4b $M = 9.11\times10^{31}kg$ $r = 1.4\times10^{-7}m$ $B = 3.5\times10^{-1} w/m^2$ $\theta = 90^0$ $w = ?$

$q = -1.60\times10^{-19}c$

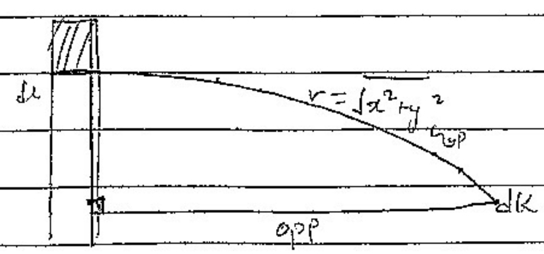
$W = \frac{qB}{m_e}$

$W = \frac{1.6\times10^{-19}\times3.5\times10^{-1}}{9.11\times10^{31}} = -6.15\times10^{10} rad/sec$

c Since the Cyclotron frequency is negative it means that the charge particle electron circulates in a negative direction at the angular frequency

5a Biot-Savart law is an equation that describes the magnetic field created by a current carrying wire and allows us to calculate its strength at various forms

5b



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

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

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

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

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

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

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

Substituting (**) into (*), we have

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

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

Recall $dl = dy$

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

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

Using special integral

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

Eqn (***) therefore becomes

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

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

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

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

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

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

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

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

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