

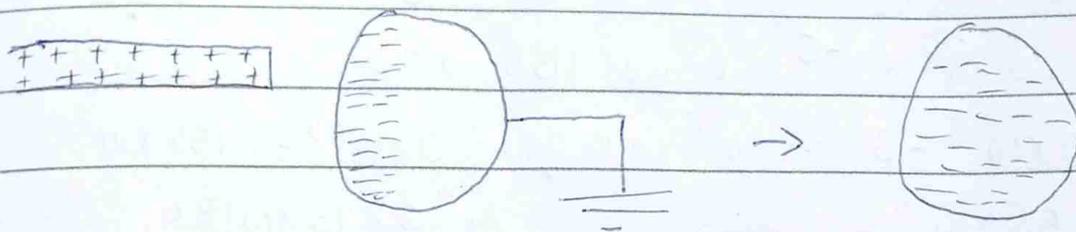
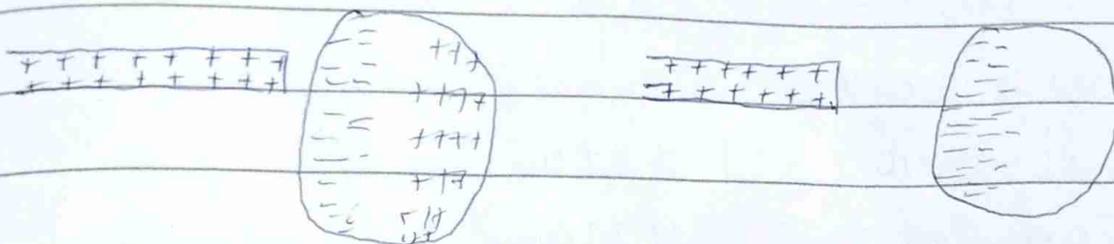
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191MHS01101

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 charges can be obtained on an object without touching it by a process called electrical induction

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

Solution

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

$$F = \frac{kq_1q_2}{r^2}$$

$$1 = \frac{9 \times 10^9 \times q_1q_2}{2^2}$$

Cross multiply

$$4 = \frac{9 \times 10^9 \times q_1q_2}{9 \times 10^9}$$

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

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

$$q_1 = 5.0 \times 10^{-5} - q_2 \text{ -- equ (2)}$$

Put equ (2) in equ (1)

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

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

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

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

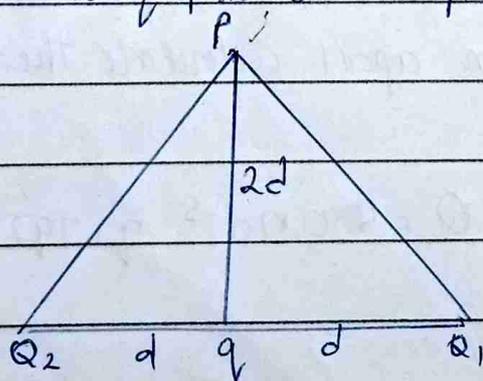
$$q_1 = 5.0 \times 10^{-5} - 3.845 \times 10^{-5} \text{ or } q_1 = 5.0 \times 10^{-5} - 1.155 \times 10^{-5}$$

$$= 1.155 \times 10^{-5} \text{ C}$$

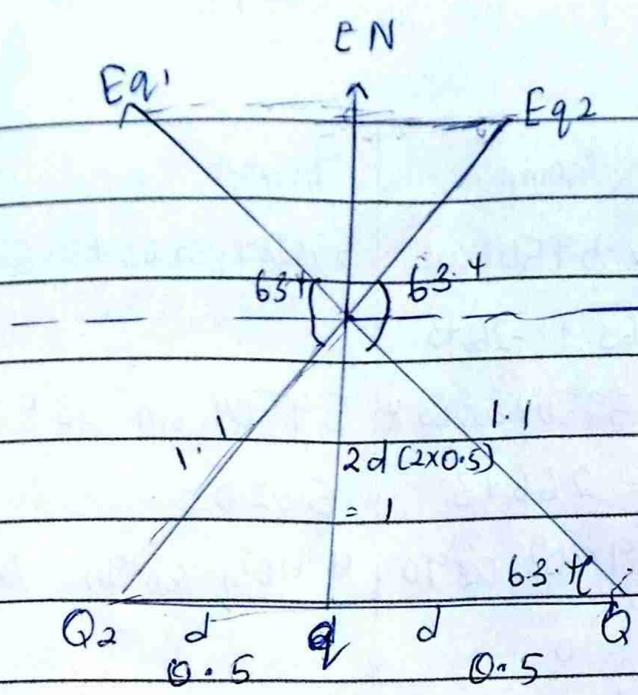
$$= 3.845 \times 10^{-5} \text{ C}$$

$$\therefore q_2 = 3.845 \times 10^{-5} \text{ C} \quad q_1 = 1.155 \times 10^{-5} \text{ C}$$

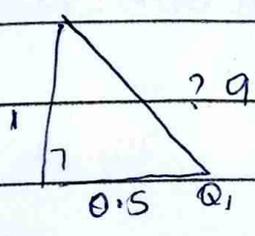
C Three charges were positioned as shown in the figure below. If $Q_1 = Q_2 = 8 \mu\text{C}$ and $d = 0.5 \text{ m}$ determine q if the electric field at P is zero



Solution



$$E_q = \frac{kq}{r^2} = \frac{9 \times 10^9 \times q}{1^2} = 9 \times 10^9 \frac{q}{mC}$$



Using pythagoras theorem

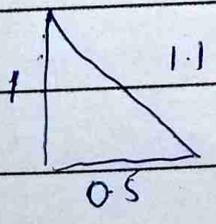
$$q^2 = 1^2 + 0.5^2$$

$$q^2 = 1 + 0.25$$

$$q^2 = 1.25$$

$$q = \sqrt{1.25}$$

$$q = 1.1$$



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

$$\theta = 63.4$$

$$E_p = E_{q1} + E_{q2} + E_q$$

$$E_{q1} = \frac{kQ_1}{r^2} = \frac{9 \times 10^9 \times 8 \times 10^{-6}}{1.1^2} = 59504 \frac{N}{C}$$

$$E_{q2} = \frac{kQ_2}{r^2} = \frac{9 \times 10^9 \times 8 \times 10^{-6}}{1.1^2} = 59504 \frac{N}{C}$$

$$1 = 10^{-6} \frac{1}{4\pi\epsilon_0} = +2\mu\text{C} \text{ i.c.}$$

Vector	Angle	X comp	Y comp
$E_{q1} = 59504$	63.4°	$x = 59504 \cos$	$59504 \sin 63.4 = 53205$
$E_{q2} =$		$63.4 = -26643$	
$E_{q2} = 59504$	63.4°	$59504 \cos 63.4$	$59504 \sin 63.4$
		$= 26643$	53205
$E_q = 9 \times 10^9 q$	90	$9 \times 10^9 q \cos 90$	$9 \times 10^9 q \sin 90 = 9 \times 10^9 q$
		$= 0$	
		$E_{fx} = 0$	$E_{fy} = 106410 + 9 \times 10^9 q$

$$E_p = \sqrt{0^2 + (106410 + 9 \times 10^9 q)^2}$$

$$E_p = \sqrt{(106410 + 9 \times 10^9 q)^2}$$

$$E_p = 106410 + 9 \times 10^9 q$$

$$\text{at } E_p = 0$$

$$106410 + 9 \times 10^9 q = 0$$

$$\frac{9 \times 10^9 q}{9 \times 10^9} = \frac{-106410}{9 \times 10^9}$$

$$q = -1.18 \times 10^{-5} \text{ C}$$

$$q = \approx 12 \mu\text{C}$$

29. Distinguish between the terms: Electric field and electric field intensity.

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. A positive charge $Q_1 = 8 \text{ nC}$ is at the origin and a second positive charge $Q_2 = 12 \text{ nC}$ is on the x-axis at $x = 4 \text{ m}$. find

$$E_p = E_{Q_1} + E_{Q_2}$$

$$E_{Q_1} = \frac{kQ}{r^2} = \frac{9 \times 10^9 \times 8 \times 10^{-9}}{7^2} = 1.469 \text{ N/C}$$

$$E_{Q_2} = \frac{kQ}{r^2} = \frac{9 \times 10^9 \times 12 \times 10^{-9}}{3^2} = 12 \text{ N/C}$$

(i) The net electric field at a point

P on the x-axis at $x = 7 \text{ m}$

$$E_{\text{net}} = 1.469 + 12$$

$$= 13.469 \approx 13.5 \text{ N/C}$$

(ii) The electric field at a point

Q on the y-axis at $y = 3 \text{ m}$ due to the charges

$$E_{\text{net}} = \vec{E}_1 + \vec{E}_2$$

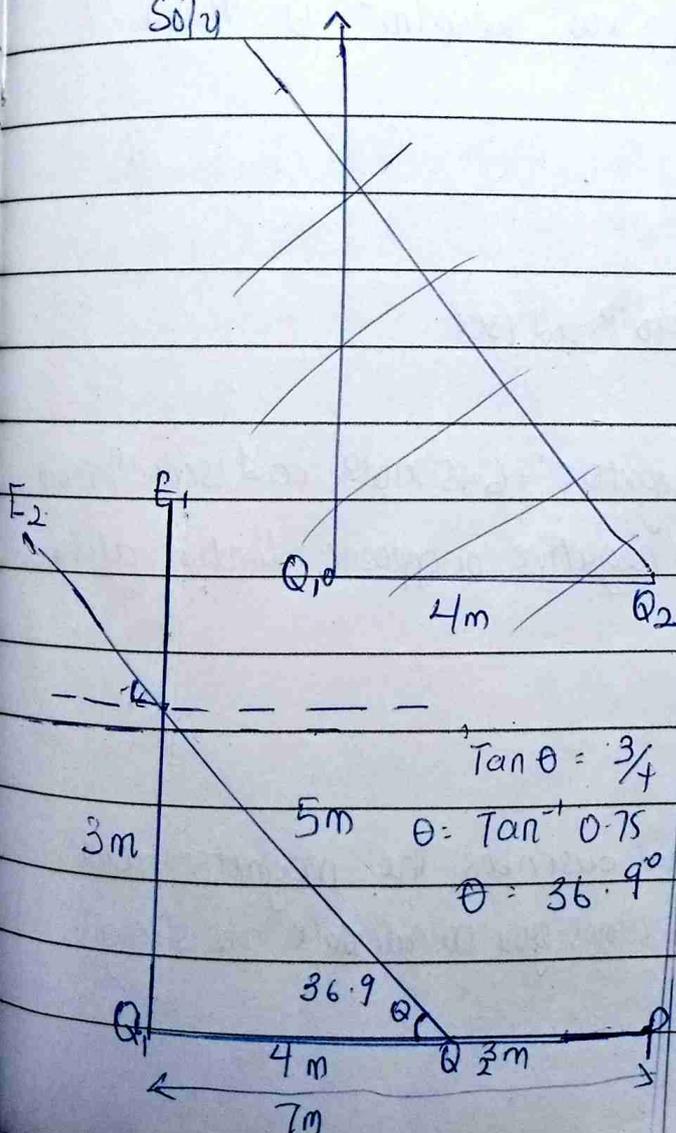
$$E_1 = \frac{kQ_1}{r^2} = \frac{9 \times 10^9 \times 8 \times 10^{-9}}{3^2}$$

$$= 8 \text{ N/C}$$

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

$$= 4.32 \text{ N/C}$$

Solu



Vector	Angle	x com	y com
$E_1 = 8 \text{ N/C}$	90°	$8 \cos 90$ $= 0$	$8 \sin 90$ $= 8$
$E_2 = 4.32 \text{ N/C}$	36.9°	$-4.32 \cos 36.9$ -3.45	$4.32 \sin 36.9$ 2.59
		$E_{fx} = -3.45$	$E_{fy} = 10.59$

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

$$= 11.14 \text{ N/C}$$

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 An electron with a rest mass of $9.11 \times 10^{-31} \text{ kg}$ moves in a circular orbit of radius $1.4 \times 10^{-7} \text{ m}$ in a uniform magnetic field of $3.5 \times 10^{-1} \text{ Weber/m}^2$ square perpendicular to the speed with which electron moves. Find the cyclotron frequency of the moving electron.

(c) Discuss your answer in 4b above.

Solu

$$M = 9.11 \times 10^{-31} \text{ kg} \quad r = 1.4 \times 10^{-7} \text{ m} \quad B = 3.5 \times 10^{-1} \text{ weber/m}^2 \quad \theta = 90^\circ \quad \omega = ?$$
$$q = -1.60 \times 10^{-19} \text{ C}$$

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

$$\omega = \frac{-1.60 \times 10^{-19} \times 3.5 \times 10^{-1}}{9.11 \times 10^{-31}} = -6.15 \times 10^{10} \text{ rad/sec}$$

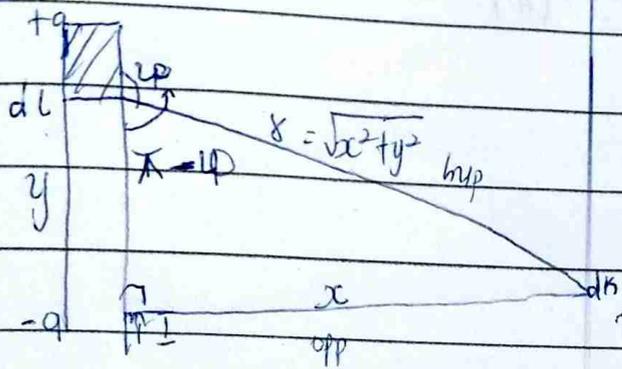
4c. Since our cyclotron frequency is negative, $-6.15 \times 10^{10} \text{ rad/sec}$. It means that the charge particle electron circulates in a negative or opposite direction at the angular frequency.

5a State the Biot-Savart law.

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

5b. Using the Biot-Savart law, show that the magnitude of the magnetic field of a straight current carrying conductor is given as $B = \frac{\mu_0 I}{2\pi x}$

Solution



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

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

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

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

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

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

$$\text{but } \sin(\pi - \alpha) = \frac{x}{\sqrt{x^2 + y^2}} = \frac{x}{(x^2 + y^2)^{1/2}} \dots (2)$$

Substituting equation 2 into 1 we have

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

Using law of indices

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

Recall $dl = dy$

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

Using special integrals

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

Equation 3 therefore becomes

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

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

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

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

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

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

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

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