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MATRIC NO: 19/MHS~~01~~/048

~~PHY101102~~ MBBS/MHS

COURSE: PHY102 ASSIGNMENT ANSWERED: 2, 3, 4 and 5

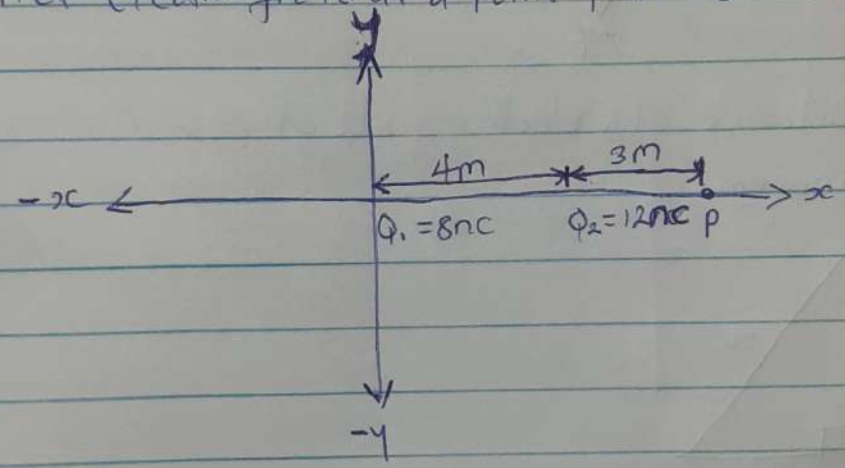
2a) Distinguish between the terms: electric field and electric field intensity

An electric field is a region of space in which an electric charge will experience an electric force.

Electric field intensity E, can be defined as the force per unit charge.

2b) A positive Charge $Q_1 = 8nC$ is at the origin, and a second positive charge $Q_2 = 12nC$ is on the x-axis at $x = 4m$. find

i) The net electric field at a point P on the x axis at $x = 7m$.



$$E_1 = \frac{kq_1}{r_1^2} = \frac{9\times10^9 \times 8\times10^{-9}}{7^2} = 1.4694 N/C$$

$$E_2 \ \frac{Kq_2}{r_2^2} = \frac{9\times10^9\times12\times10^{-9}}{3^2} = 12 N/C$$

Vector	Angle	x-comp	y-comp
$E_1 = 1.4694 N/C$	0	$1.4694\cos 0 = 1.4694$	0
$E_2 = 12 N/C$	0	$12\cos 0 = 12$	0
		13.4694	

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

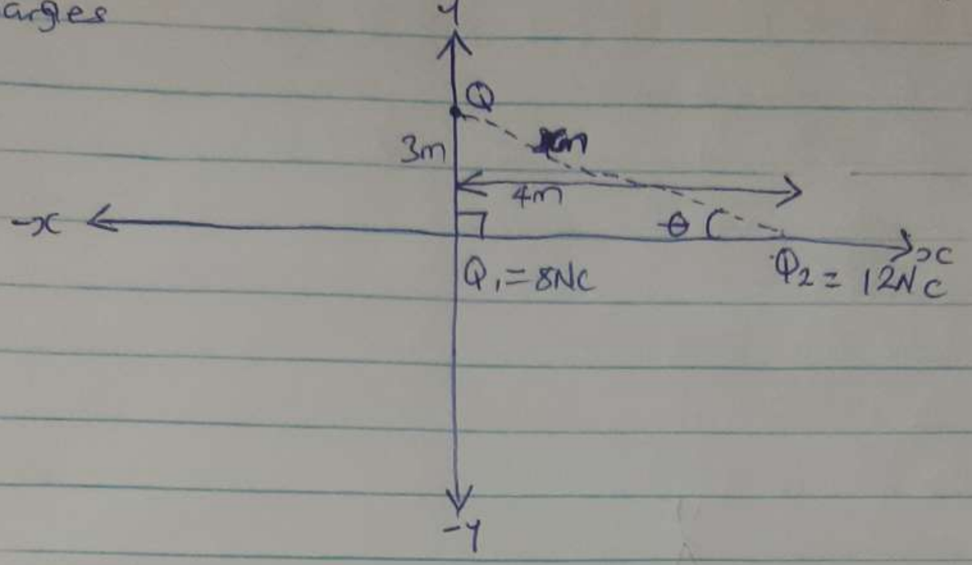
$$E = \sqrt{\Sigma E_x^2}$$

$$E = \sqrt{13.4694^2}$$

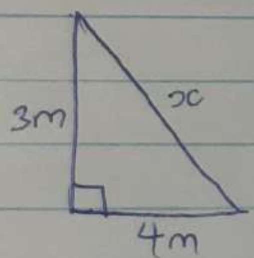
$$E = 13.4694$$

$$E = 13.5 N/C$$

ii) The electric field at a point Q on the y axis at y = 3m due to the charges

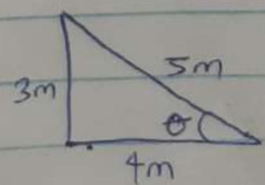


To find the distance btw electric field at point P and Q_2 use Pythagoras theorem



$$x^2 = 3^2 + 4^2$$
$$x^2 = 9 + 16$$
$$\sqrt{x^2} = \sqrt{25}$$
$$x = 5m$$

To find the angle between the horizontal and E_2, do this



$$\sin\theta = \frac{3}{5}$$
$$\theta = \sin^{-1} 3/5$$
$$\theta = 36.87^\circ$$

$$E_1 = \frac{Kq_1}{r_1^2} = \frac{9\times10^9 \times 8\times10^{-9}}{3^2} = 8N/C$$

$$E_2 = \frac{Kq_2}{r_2^2} = \frac{9\times10^9 \times 12\times10^{-9}}{5^2} = 4.32N/C$$

Vector	Angle	x-Component	y-Component
$E_1 = 8N/C$	$90°$	$8\cos 90 = 0$	$8\sin 90 = 8$
$E_2 = 4.32N/C$	$36.87°$	$4.32\cos 36.87 = 3.455995$	$4.32\sin 36.87 = 2.592$
		3.455995	10.592

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

$$E = \sqrt{3.455995^2 + 10.592^2}$$

$$E = 11.2N/C$$

3a) State the formulation of the following identities of charge:
i) Volume charge density ii) Surface charge density
iii) Linear charge density

Solution: i) Volume charge density, $\rho = \frac{dQ}{dV} \rightarrow dQ = \rho dV$

ii) Surface charge density, $\sigma = \frac{dQ}{dA} \rightarrow dQ = \sigma dA$

iii) Linear charge density, $\lambda = \frac{dQ}{dL} \rightarrow dQ = \lambda dL$

b) Explain with appropriate equations, the electric potential difference

Electric potential difference between two points in an electric field can be defined as the work done per unit charge against forces when a charge is transported from one point to another.

We have different formulas for electric potential difference depending on how the case may be.

i) We have electric potential in a uniform electric field which is

$$V_B - V_A = \frac{W_{cA \rightarrow B2Ag}}{q_0}$$

2) We can also defined potential difference as the potential energy per unit charge

$$V_B - V_A = \frac{\Delta U}{q_0}$$

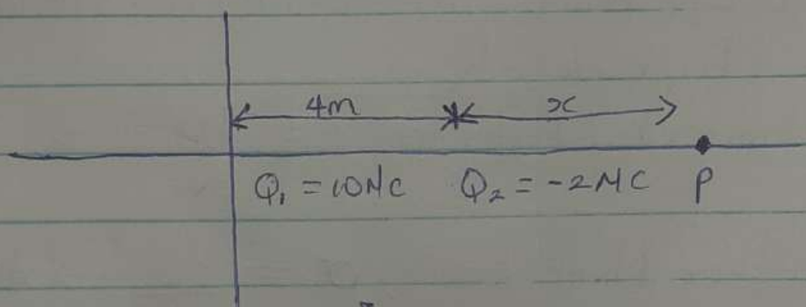
3) We also have electric potential due to single point charge

$$V_B - V_A = \frac{Q}{4\pi\varepsilon_0}\left(\frac{1}{r_B} - \frac{1}{r_A}\right)$$

4) We also have electric potential due to several point charges.

$$V_P = \frac{1}{4\pi\varepsilon_0}\left[\frac{Q_1}{r_1} + \frac{Q_2}{r_2} + \frac{Q_3}{r_3} + \frac{Q_4}{r_4}\right]$$

3c) Two point charges $Q_1 = 10\mu C$ and $Q_2 = -2\mu C$ are arranged along the x-axis at $x = 0$ and $x = 4m$ respectively. Find the position along the x-axis where $V = 0$



$$V_P = \frac{1}{4\pi\varepsilon_0}\left[\frac{Q_1}{r_1} + \frac{Q_2}{r_2}\right]$$

let $V_P = 0$

$$0 = 9\times10^9\left[\frac{10\times10^{-6}}{4+x} + \frac{(-2\times10^{-6})}{x}\right]$$

$$0 = 9\times10^9\left[\frac{10\times10^{-6}}{4+x} - \frac{2\times10^{-6}}{x}\right]$$

$$0 = \frac{90000}{4+x} - \frac{18000}{x}$$

multiply through by $(4+x)(x)$

$$(4+x)(x)\,0 = \frac{90000\times\cancel{(4+x)}(x)}{\cancel{4+x}} - \frac{18000(4+x)\cancel{(x)}}{\cancel{x}}$$

$$0 = 90000x - 18000(4+x)$$

$$0 = 90000x - 72000 - 18000x$$

$$72000 = 90000x - 18000x$$

$$72000 = 72000x$$

$x = \frac{72000}{72000}$

$x = 1$

$4 + x = 4 + 1 = 5m$

So, the position along the x-axis where $V = 0$ is 5m

4a) What is magnetic flux

The magnetic flux is defined as the strength of magnetic field represented by lines of force. It is usually represented by the symbol Q.

b) An electron with a rest mass of 9.11×10^{-31} kg moves on a circular orbit of radius 1.4×10^{-7} m in a uniform magnetic field of 3.5×10^{-1} weber/meter square perpendicular to speed with which electron moves. find the cyclotron frequency of the moving electron.

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

$$F_B = qVB\sin\theta \quad \text{where } \theta = 90°$$

$$F_B = qVB$$

$$F_B = qvB = \frac{mv^2}{r}$$

$$V = \frac{qBr}{m}$$

$$V = \frac{-1.6 \times 10^{-19} \times 3.5 \times 10^{-1} \times 1.4 \times 10^{-7}}{9.11 \times 10^{-31}}$$

$$V = -8.60593 \text{ m/s}$$

Hence, The angular speed $\omega = \frac{qB}{m_p}$

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

$$= -6.147 \times 10^{10} \text{ rad/s}$$

c) We were told to find the cyclotron frequency in the angular speed The formula was provided above and the values were slotted into the formula.

5) State Bio-Savart Law

1) The vector dB is perpendicular both to $d\hat{l}$ (which points in the direction of the current) and to the unit vector $\hat{r}$ directed from dl toward P

2) The magnitude of $d\vec{B}$ is inversely proportional to r^2, where r is the distance from $d\vec{l}$ to P

3) The magnitude of dB is proportional to the current I and to the magnitude of the length element $d\vec{l}$

4) The magnitude of $d\vec{B}$ is proportional to $\sin\theta$, where θ is the angle between $\hat{r}$ and $d\vec{l}$

Therefore

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

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

Using special integrals.

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

Equation $(***)$ 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 the distance x from point P, we consider it infinitely long. That is, when a is much greater than x,

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

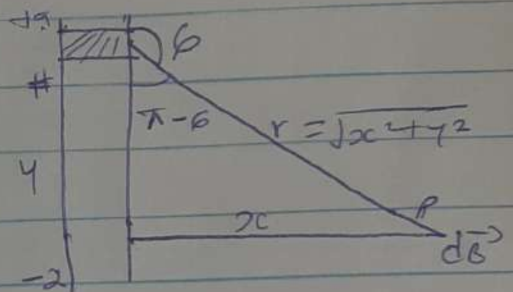
$$\therefore B = \frac{\mu_0 I}{2\pi x}$$

In a physical situation, we have a med symmetry about the y-axis. Thus, at all points in a circle of radius r, around the Conductor, the magnitude of B is

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

b)

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



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

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

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

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

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

Substitution $(**)$ into $(*)$ we have:

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

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

Recall $dl = dy$

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