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MATRIC NUMBER: 19/MHS02/021

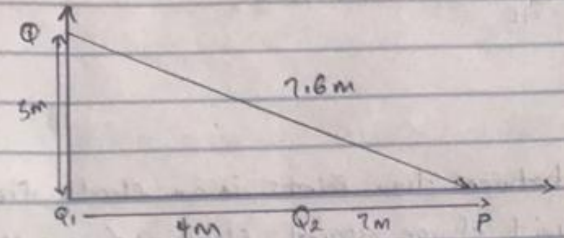
COURSE: PHYSICS 102

DEPARTMENT: NURSING

ASSIGNMENT

Questions answered; 2,3,4 and 5

2a) An electric field is a region of space in which an electric charge will expe-rience an electric force while electric field intensity can be defined as the strength of electric field at any point in space.

b) 

where $Q_1 = 8nC$

$Q_2 = 12nC$

Recall, $E = kq_1/r^2$

$\therefore E_1 = \frac{[9\times10^9 Nm^2/C] \times [8\times10^{-9}C]}{[7.0m]^2}$

$E_1 = 1.47N/C$

$E_2 = \frac{[9\times10^9 Nm^2/C]\times[12\times10^{-19}C]}{[3.0m]^2}$

$E_2 = 12N/C$

Vector	Angle	x component	y component
$E_1 = 1.47N/C$	0°	$E_1 = 1.47\cos 0^\circ$ $E_1 = 1.47N/C$	$E_1 = 1.47\sin 0^\circ$ $E_1 = 0^\circ$
$E_2 = 12N/C$	0°	$E_2 = 12\cos 0^\circ$ $E_2 = 12N/C$	$E_2 = 12\sin 0^\circ$ $E_2 = 0^\circ$
		$\Sigma E_x = 13.47N/C$	$\Sigma E_y = 0^\circ$

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

$\sqrt{[13.47]^2 + [0]^2}$

$\sqrt{181.4409}$

$E_{net} = 13.47N/C$

11

$Hyp^2 = 3^2 + 4^2$

$Hyp^2 = 9 + 16$

$Hyp^2 = 25$

$Hyp = \sqrt{25}$

$Hyp = 5\ m$

Electric field relative to Point Q

$$E_1 = \frac{KQ_1}{r_1^2}$$

where $r_1 = 3\ m$

$$E_1 = \frac{9\times10^{9} \times 8\times10^{-9}}{3^2}$$

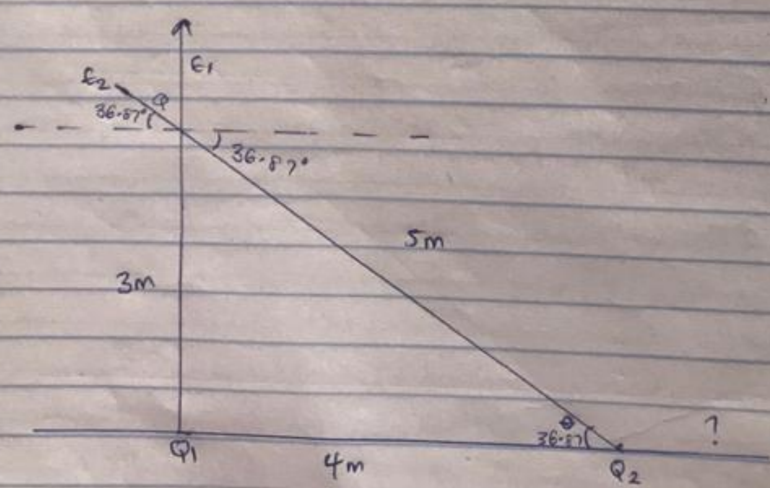
$$E_1 = \frac{72}{9} = 8\ N/C$$

$$E_2 = \frac{KQ_2}{r_2^2}$$

where $r_2 = 5\ m$

$$E_2 = \frac{9\times10^{9} \times 12\times10^{-9}}{5^2}$$

$$E_2 = \frac{108}{25} = 4.32\ N/C$$



$\sin\theta = \frac{Opp}{Hyp}$; $\sin\theta = 3/5$ $\sin\theta = 0.6$

$\theta = \sin^{-1} 0.6$

$\theta = 36.87°$

Vector	Angle	X component	Y component
$E_1 = 8 N/c$	$90°$	$8 \cos 90° = 0°$	$8 \sin 90° = 8$
$E_2 = 4.32 N/c$	$36.87°$	$4.32 \cos 36.87° = 3.46°$	$4.32 \sin 36.87° = 2.59°$
		$\Sigma_{fx} = 3.46 N/c$	$\Sigma_{fy} = 10.59 N/c$

$E = \sqrt{[\Sigma_{fx}]^2 + (\Sigma f_y)^2}$

$E = \sqrt{(3.46)^2 + (10.59)^2}$

$E = \sqrt{124.1197}$

$E = 11.14 N/c$

$\tan\theta = \frac{|\Sigma f_y|}{|\Sigma f_x|} = \frac{|10.59|}{|3.46|}$

$\tan\theta = 3.0607$

$\theta = \tan^{-1}(3.0607)$

$\theta = 71.91°$ //

a) 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) Electric potential Difference

The electric potential difference between two Points in an electric field can be defined as the work done per unit charge against electrical forces when a charge is transported from one Point to the other. It is measured in volt (V) or Joules per Coulomb (J/C). Electric Potential difference is a scalar quantity.

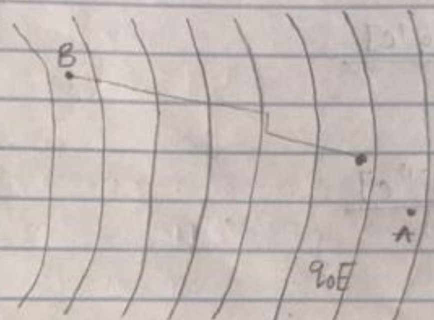


fig 4.1

Consider the diagram above, suppose a test charge q_0 is moved from point A Point B along an arbitrary Path inside an electric field E. The electric field E exerts a force $F = q_0E$ on the charge as shown in fig 3.1. To move the test charge from A to B at constant velocity, an external force of $F = -q_0E$ must act on the charge. Therefore, the elemental work done dW is given as:

$$dW = F.dL \quad --- (1)$$

But

$$F = -q_0E \quad --- (2)$$

substituting equation (2) in (1) yields

$$dW = -q_0EdL \quad --- (3)$$

Then total work done in moving the test charge from A to B is:

$$W(A \to B)_{ag} = -q_0 \int_A^B E\,dL \quad --- (4)$$

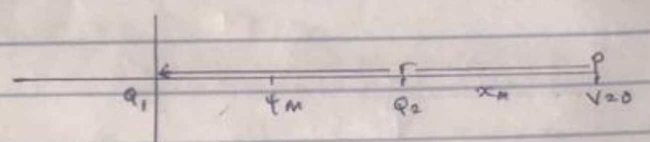
From the definition of electric potential difference, it follows that:

$$V_B - V_A = \frac{W(A \to B)_{ag}}{q_0}$$

Putting equation (4) in (5) yields

$$V_B - V_A = -\int_A^B E\,dL \quad --- (6)$$

(c)



$Q_1 = 10 \times 10^{-6}\,C$

$Q_2 = -2 \times 10^{-6}\,C$

$r_1 = 4 + x$

$r_2 = x$

$$V_p = k\left[\frac{Q_1}{r_1} + \frac{Q_2}{r_2}\right]$$

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

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

$$\frac{10 \times 10^{-6}}{4+x} - \frac{(2 \times 10^{-6})}{x} = 0$$

$$\frac{10 \times 10^{-6}x - 4+x(2 \times 10^{-6})}{4+x^2} = 0$$

$$\frac{10 \times 10^{-6}x - 4 \times 2 \times 10^{-6} + 2 \times 10^{-6}x}{4+x^2} = 0$$

$$\frac{10 \times 10^{-6}x - 4 \times 2 \times 10^{-6} + 2 \times 10^{-6}x}{4+x^2} = 0$$

$$\frac{10 \times 10^{-6}x - 8 \times 10^{-6} + 2 \times 10^{-6}x}{4+x^2} = 0$$

$$10\times10^{-6}x - 8\times10^{-6} + 2\times10^{-6}x = 0 + 4 + x^2$$

$$10\times10^{-6}x - 8\times10^{-6} + 2\times10^{-6}x = 0$$

$$1.2\times10^{-5}x - 8\times10^{-6} = 0$$

$$\frac{1.2\cancel{\times10^{-5}}x}{1.2\cancel{\times10^{-5}}} = \frac{8\times10^{-6}}{1.2\times10^{-5}}$$

$$x = 0.666$$

$$\simeq 1m$$

since $r_1 = 4 + x$

$r_1 = 4 + 1$

$r_1 = 5m$

$\therefore r_1 = 5m \quad r_2 = 1m$ //

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

b, $m = 9.11 \times 10^{-31}$ kg $\quad q = 1.602 \times 10^{-19}$

$r = 1.4 \times 10^{-7}$ m

$B = 3.5 \times 10^{-1}$ weber/meter square

$F =$

$$\omega = V/r = qB/m$$

$\omega = qB/m$

$$\omega = \frac{1.602 \times 10^{-19} \times 3.5 \times 10^{-1}}{9.11 \times 10^{-31}}$$

$$\omega = 6.15 \times 10^{10}$$

$$\simeq 6.2 \times 10^{10}\ T^{-1}$$

c, In the question we were given parameters such as

i, mass of the electron $= 9.11 \times 10^{-31}$ kg

ii A radius of 1.4×10^{-7} m

iii magnetic field of 3.5×10^{-1} weber/meter square;

- And we were asked to find the cyclotron frequency which is equal or the same thing as angular speed, It is called cyclotron frequency because it is a frequency of an accelerator called cyclotron.

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

substituting, we have $\omega = \frac{qB}{m} = \frac{1.602 \times 10^{-19} \times 3.5 \times 10^{-1}}{9.11 \times 10^{-31}}$

$$\omega = 6.15 \times 10^{10} \simeq 6.2 \times 10^{10}\ T^{-1}$$

So since cyclotron frequency is equal to angular speed the cyclotron frequency is equal to $6.2 \times 10^{10}\ T^{-1}$, having a unit of $\frac{1}{T}$ which is equal to the unit of frequency dimensionally.

5 c. 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, the radius and inversely proportional to square of radius (r^2). It can be represented mathematically by;

1 $$d\vec{B} = \frac{\mu_0 I \, d\vec{l} \times \hat{r}}{4\pi r^2}$$

where μ_0 is a constant called premeability of free space.

$$\mu_0 = 4\pi \times 10^{-7} \ Tm/A$$

The unit of $\vec{B}$ is weber/metre square.

5b,

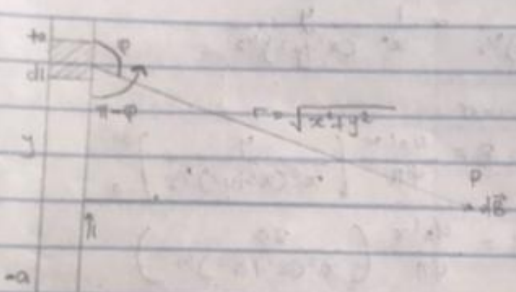


Fig 1: A section of a straight current carrying conductor

Applying the Biot - Savart law, we find the magnitude of the field $d\vec{B}$

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

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

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

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

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

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

substituting (**) into (*), we have

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

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

Recall, $dl = dy$

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

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

Using special integrals:

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

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 its distance x from Point P, ~~we consider it infinitely long~~ we consider it infinitely long. That is, when a is much larger than x,

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

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

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

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

Equation (4) defines the magnitude field of flux density B near a long straight current carrying conductor