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MATRIC NO: 19/MHS11/050

PHY 102 ASSIGNMENT

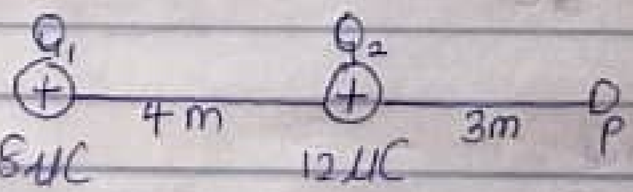
SECTION A

QUESTION 2

a) An Electric field is a region of space in which an electric charge will experience an electric force. While, the Electric field strength or Electric field intensity, E can be defined as the force per unit charge. Mathematically, it is given as $E = \frac{F(N)}{q_0(C)}$ which is measured in Newton per Coulomb (N/C)

b) $Q_1 = 8\mu C$, $Q_2 = 12\mu C$, $x = 4m$, $k = 9\times10^9$

i at $x = 7m$

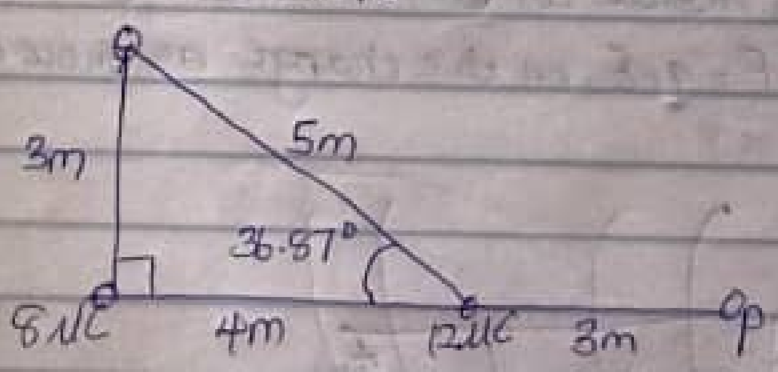


$$E_{1p} = \frac{kq_1p}{r^2} = \frac{9\times10^9 \times (8\times10^{-9})}{7^2} = 1.469 N/C$$

$$E_{2p} = \frac{kq_2p}{r^2} = \frac{9\times10^9\times(12\times10^{-9})}{3^2} = 12 N/C$$

$$E_{net} = 12 + 1.469$$
$$= 13.469 N/C$$
$$= 13.5 N/C$$

ii



By pythagoras
hyp = 5m
$\cos\theta = \frac{4}{5}$

$\theta = 36.87°$

$$E_{1q} = \frac{kq}{r^2} = \frac{9\times10^9 \times 8\times10^{-9}}{3^2} = 8 N/C$$

$$E_{2q} = \frac{kq}{r^2} = \frac{9\times10^9 \times 12\times10^{-9}}{5^2} = 4.32 N/C$$

Vector	Angle	x-Component	y-Component
$E_{1q} = 8N/C$	90°	$8\cos 90 = 0$	$8\sin 90 = 8$
$E_{2q} = 4.32N/C$	36.87°	$4.32\cos 36.87^\circ = 3.46$	$4.32 \sin 36.87^\circ = 2.59$
		$\Sigma = 3.46N/C$	$\Sigma = 10.59N/C$

$$E_{net} = \sqrt{(3.46)^2 + (10.59)^2}$$
$$E_{net} = 11.14N/C$$

QUESTION 3

a)

i Volume change density, $\rho = \frac{dQ}{dV} \rightarrow dQ = \rho dV$

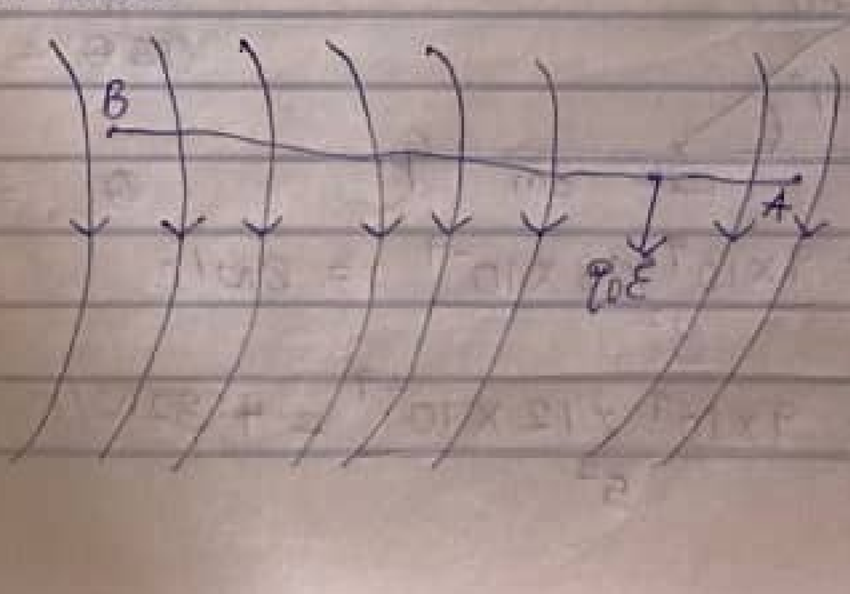
ii Surface charge density, $\sigma = \frac{dQ}{dA} \rightarrow dQ = \sigma dA$

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.

Suppose a test charge, q_0 is moved from point A to point B along an arbitrary path inside an electric field, E. The electric field exerts a force, $F = q_0E$ on the charge as shown in the diagram below.



To move the ...
an external ...
Then, the e...
dl ...

But
$F = -$ ...
Substituting ...
$dW =$ ...
Therefore, t...
A to B is:
$W(A$ ...

from the ...
V_B ...

Putting ...
$V_B - V$ ...

c)

$Q_1 = 10\mu$ ...
$Q_2 = -2$ ...

The point ...
Elect...

Equating ...
2×10^{-9} ...
$4\pi\varepsilon_0($ ...

y-component

$8 \sin 90 = 8$

$32 \sin 36.87° = 2.59$

$E = 10.59 N/C$

dV

$J dA$

λdL

two points in
done per unit
is transported
n volt (V) or
difference is a

oint A to point B
ld, E. The electric
as shown in the

To move the test charge from A to B at constant velocity, an external force of $F = -q_0 E$ must act on the charge. Then, the elemental workdone dW is given as:

$$dW = F \cdot dL \quad \ldots (1)$$

But

$$F = -q_0 E \quad \ldots (2)$$

Substituting (2) in (1) gives

$$dW = -q_0 E \, dL \quad \ldots (3)$$

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

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

from the definition of potential difference, we can say that

$$V_B - V_A = \frac{W(A \to B)_{ag}}{q_0} \quad \ldots (5)$$

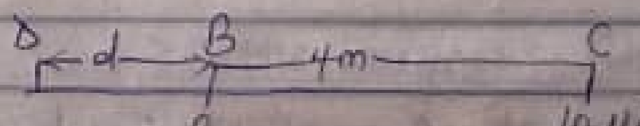
Putting (4) in (5):

$$V_B - V_A = -\int_A^B E \, dL$$

c)

$Q_1 = 10 \mu C$

$Q_2 = -2 \mu C$



The point is at δ because the net force, $B = 0$

$$\text{Electric Field intensity} = \frac{q}{4\pi \varepsilon_0 r^2}$$

$$= \frac{-2 \times 10^{-9}}{4\pi \varepsilon_0 (d)^2} = 0$$

and also

$$\frac{10 \times 10^{-9} C}{4\pi \varepsilon_0 (4+d)^2} = 0$$

Equating both sides

$$\frac{2 \times 10^{-9} C}{4\pi \varepsilon_0 (d)^2} = \frac{10 \times 10^{-9} C}{4\pi \varepsilon_0 (4+d)^2}$$

$$\frac{2}{d^2} = \frac{10}{(4+d)^2}$$

$$2(4+d)^2 = 10d^2$$

$$2(4+d)(4+d) = 10d^2$$

$$2(16+4d+4d+d^2) = 10d^2$$

$$32+8d+8d+2d^2 = 10d^2$$

$$32+16d+2d^2 = 10d^2$$

$$32+16d+2d^2-10d^2 = 0$$

$$32+16d-8d^2 = 0$$

$$8d^2-16d-32 = 0$$

$$d^2-2d-4 = 0$$

Using Almighty formula

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

$$d = \frac{-(-2) \pm \sqrt{(-2)^2-4(1)(-4)}}{2(1)}$$

$$d = 1 \pm 4.4721$$

$$d = 5.5 \text{ or } -3.5m$$

The point on x-axis is 5.5m or -3.5m

SECTION B

QUESTION 4

a) Magnetic flux is the strength of magnetic field represented by lines of force. it is usually represented by the symbol ϕ.

b) $m = 9.11 \times 10^{-31} kg$

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

$B = 3.5 \times 10^{-1} W/m^2$

$q = 1.6 \times 10^{-19} C$

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

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

$V = 8.61 \times 10$

∴ Angular S

c) The charg
or angular
accelerato
can also be

QUESTION

a) The Biot
magnetic f
It is given

where

b) Magnitud
carrying

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the fiele

$V = 8.61 \times 10^3\, m/s$

$\therefore$ Angular Speed / Cyclotron frequency $= \omega = \frac{qB}{m} = \frac{V}{r}$

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

$$= 6.15 \times 10^{10}\, rad/s$$

c) The charge particle circulates at the angular frequency or angular speed of $6.15 \times 10^{10}\, rad/s$ in the type of accelerator called cyclotron. Therefore, angular speed can also be seen as the cyclotron frequency.

QUESTION 5

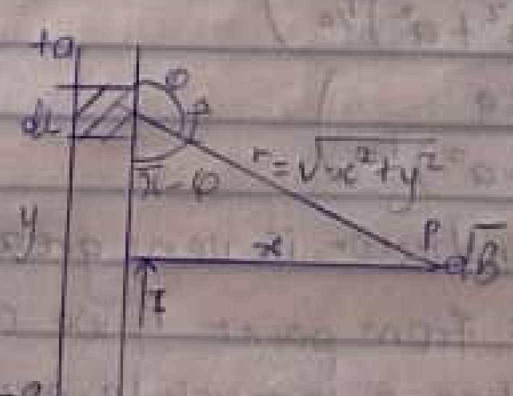
a) The Biot-Savart law is an equation describing the magnetic field generated by a constant electric current. It is given as,

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

where μ_0 is a constant called permeability of free space

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

b) Magnitude of the magnetic field of a straight current carrying conductor



A section of a straight carrying conductor.

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

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

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

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

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

Substituting $(**)$ into $(*)$

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

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

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 $(***)$ 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. That is, when a is much larger than x

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

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

At all points in a circle of radius r, around the conductor;

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