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SECTION A

QUESTION 2a

Electric field	Electric field intensity
An electric field is a region of space in which an electric charge will experience an electric force.	This can be defined as the force per unit charge.

2b

i) $\vec{E} = \frac{kq_1}{r_1^2} + \frac{kq_2}{r_2^2}$

$= \frac{kq_1}{x^2} + \frac{kq_2}{(x-a)^2}$

$= \frac{(8.99 \times 10^9)(8 \times 10^{-9})}{(7)^2} + \frac{(8.99 \times 10^9)(12 \times 10^{-9})}{(3)^2}$

$= \frac{71.92}{49} + \frac{107.88}{9}$

$= 13.45$

$\simeq 13.5\ N/C$

ii) $\vec{E} = \frac{kq_1}{r_1^2} + \frac{kq_2}{r_2^2}$

$= \frac{kq_1}{x^2} + \frac{kq_2}{(a-x)^2}$

$= \frac{(8.99 \times 10^9)(8 \times 10^{-9})}{(3)^2} + \frac{(8.99 \times 10^9)(12 \times 10^{-9})}{(1)^2}$

$= \frac{71.92}{9} + \frac{107.88}{49}$

$= 11.2N/C.$

QUESTION 3a

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, $\lambda = \frac{dQ}{dL} \rightarrow dQ = \lambda dL$

3b

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 on point to the other. It is measured in volt (v) or Joules per Coulomb (J/C). Electric potential difference is a scalar quantity. Mathematically,

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

3C

i to the left $(x<0)$

$$V = \frac{kQ}{r}$$

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

$$0 = \frac{9 \times 10^{9} \times 10 \times 10^{-6}}{x} - \frac{9 \times 10^{9} \times 2 \times 10^{-6}}{4+x}$$

$$\frac{\cancel{9 \times 10^{9}} \times 2 \times \cancel{10^{-6}}}{4+x} = \frac{\cancel{9 \times 10^{9}} \times 10 \times \cancel{10^{-6}}}{x}$$

$$\frac{2}{4+x} \times \frac{10}{x}$$

$2x = 40 + 10x$

Collect like terms

$10x - 2x = -40$

$8x = -40$

Divide both sides by 8

$x = -5m$

ii to the right

$D = \frac{10\times10^{-6}\times9\times10^{9}}{x} = \frac{2\times10^{-6}\times9\times10^{9}}{x-4}$

$\frac{2\times\cancel{10^{-6}}\times\cancel{9\times10^{9}}}{x-4} = \frac{10\times\cancel{10^{-6}}\times9\times10^{9}}{x}$

$\frac{2}{x-4} \times \frac{10}{x}$

$2x = 10x - 40$

$10x - 2x = 40$

$8x = 40$

$\therefore x = 5m$

$\therefore$ the points are 5m and -5 m

SECTION B

QUESTION 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.

4b

$m = ~~9\times10~~\ 9.11\times10^{-31}kg$

$r = 1.4\times10^{-7}m$

$B = 3.5\times10^{-1}T$

$q = 1.6\times10^{-19}$

$\omega = ?$

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

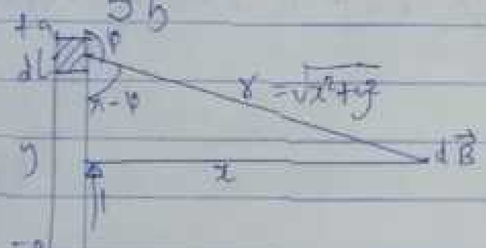
$\omega = \frac{1.6\times10^{-19}\times3.5\times10^{-1}}{9.11\times10^{-31}}$

$= 6.147\times10^{10}$ rad/s

QUESTION 5a

Biot-Savart law states that it is a mathematical expession which illustrates the magnetic field produced by a stable electric current in a particular electromagnetism of physics

5b



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)

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

But $\sin(\pi-\varphi) = \dfrac{x}{\sqrt{x^2+y^2}}$

$$= \frac{x}{(x^2+y^2)^{1/2}} \quad \cdots (b)$$

substituting (b) into (a), 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 $dl = dy$

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

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

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 (c) 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. That is when a is much larger than x

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

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

$\therefore$ The magnitude of B is

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