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MATRIC NUMBER:- 19/MHS02/014.

DEPARTMENT :- NURSING

COURSE CODE :- PHY 102

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

b) 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 $x = 7m$

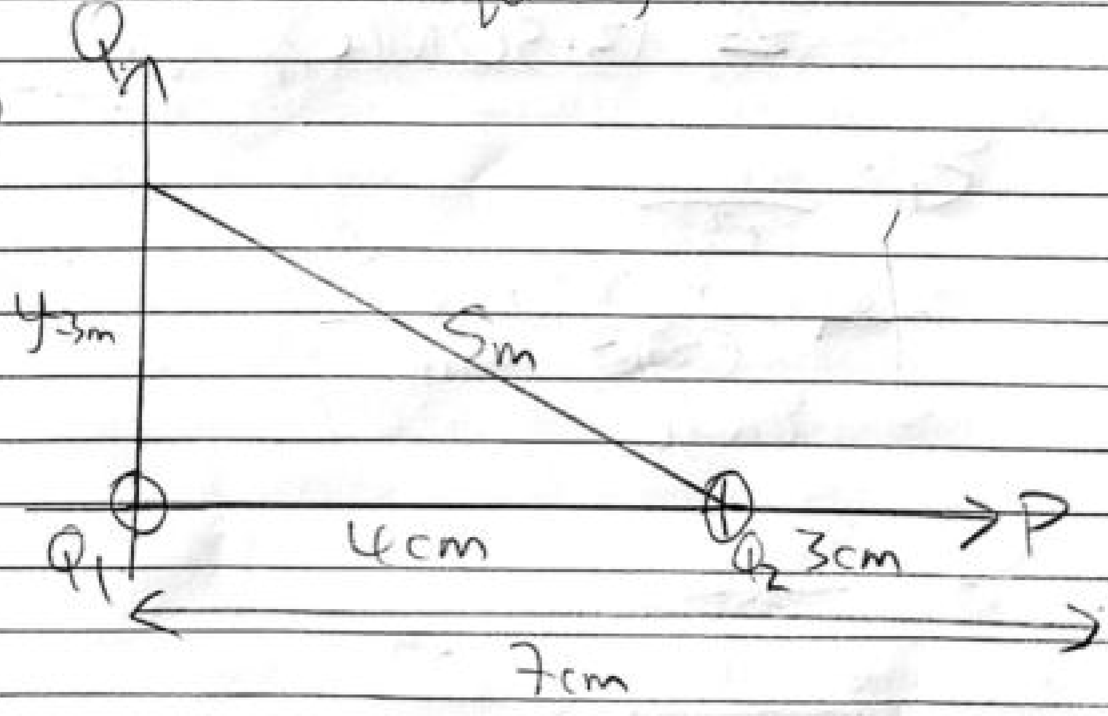
ii) The electric field at a point Q on the y axis at $y = 3m$ due to the charges.

Answers

a) Electric field is a region of space in which an electric charge will experience an electric force while electric field intensity is the force per unit charge.

$$E = \frac{F(N)}{q_0(C)}$$

b)



$$E_1 = \frac{kQ_1}{r^2}$$

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

$$= 1.47 N/C$$

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$$E_2 = \frac{Kq_2}{r_2^2}$$

$$= \frac{9\times10^9 \times 12\times10^{-9}}{(3)^2}$$

$$= 12\,N/C$$

Vector	angle	x component	y component
$F_1 = 1.47 N/C$	0°	$E_{1x} = 1.47\cos 0^\circ = 1.47$	$E_{2y} = 1.47 \sin 0^\circ = 0$
$E_2 = 12 N/C$	0°	$E_{2x} = 12\cos 0^\circ = 12$	$E_{2y} = 12 \sin 0^\circ = 0$
		$\Sigma E_x = 13.47 N/C$	$\Sigma E_y = 0$

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

$$= \sqrt{(13.47)^2 + (0)^2}$$

$$= 13.47\,N/C$$

$$\simeq 13.50\,N/C$$

$$E_1 = \frac{Kq_1}{r_1^2}$$

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

$$= 8\,N/C$$

$$E_2 = \frac{Kq_2}{r_2^2}$$

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

$$= 4.32\,N/C$$

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Vector	angle	x component	y component
$\mathcal{E}_1 = 8N/C$	$90°C$	$\mathcal{E}_{1x} = 8 \cos 90° = 0$	$\mathcal{E}_{1y} = 8 \sin 90° = 8$
$\mathcal{E}_2 = 4.32N/C$	$36.87°$	$\mathcal{E}_{2x} = 4.32 \cos 36.87° = 3.46$	$\mathcal{E}_{2y} = 4.32 \sin 36.87° = 2.59$
		$\mathcal{E}_{\mathcal{E}x} = 3.46N/C$	$\mathcal{E}_{\mathcal{E}y} = 10.59$

$$\mathcal{E} = \sqrt{\mathcal{E}_{\mathcal{E}x}^2 + \mathcal{E}_{\mathcal{E}y}^2}$$
$$= \sqrt{(3.46)^2 + (10.59)^2}$$
$$= 11.14\ N/C$$

$$\text{Angle} = \tan^{-1}\left(\frac{\mathcal{E}_{\mathcal{E}y}}{\mathcal{E}_{\mathcal{E}x}}\right)$$
$$= \tan^{-1}\left(\frac{10.59}{3.46}\right)$$
$$= 71.91°$$

3' a) State the formulation of the following identities of charges

i) Volume charge intensity

ii) Surface Charge density

iii) Linear Charge density.

b) Explain with appropriate equations; the electric potential difference

c) 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 $V = 0$.

Answers

a) i) Volume charge density

Volume charge density is given as;-

$$P = \frac{q}{V}$$

where q is the charge and V is the volume of distribution. The S.I unit is cm^{-3},

ii) Surface change density

This is given as $\sigma = \frac{q}{A}$, where

q is the charge and A is the area of the surface the S.I unit is cm^{-2},

iii) Linear charge density

This is is given as $\lambda = \frac{q}{l}$

where q is the charge and l is the length over which it is distributed. The S.I unit is cm^{-1},

b) The electric potential difference is defined as the amount of work done in carrying a unit charge from one point to another in an electric field. In other words, the potential difference is defined as the difference in the electric potential of the ~~two~~ two charged bodies.

In equation form, the electric potential difference between points A and B is;

$$\Delta V = V_B - V_A = \frac{\text{work}}{\text{charge}}$$

$$= \frac{\Delta P.E}{\text{charge}}$$

$$\Delta V = \frac{\Delta P.E}{q}$$

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and $q\Delta U = \Delta p.E$

The unit of electric potential difference is the volt, abbreviate V.

Since ~~J/C~~ V is equivalent to JC^{-1}

This implies that the unit of E.p.D can also be given as $\frac{J}{C}$ or JC^{-1},

c) Given

$Q_1 = 10\,\mu C$

$Q_2 = -2\,\mu C$

$x_1 = 0$

$x_2 = 4m$

Potential is $\frac{kQ}{V}$

Testing three cases: to the left of Q_1, to the right of Q_2, and in between

To the left $(x<0)$.

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

$\Rightarrow \frac{10k}{x} = \frac{2k}{4+x}$

cross multiplying

$2k\lambda = 10k(4+\lambda)$

$2\lambda = 10(4+\lambda)$

$2\lambda = 40 + 10\lambda$

$-40 = 10\lambda - 2\lambda$

$\Rightarrow -40 = 8\lambda$

$\lambda = \frac{-40}{8}$

$= -5m$

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In between

$V = \frac{10k}{\lambda} - \frac{2k}{4-\lambda}$

$\Rightarrow \frac{10k}{\lambda} = \frac{2k}{4-\lambda}$

$10k(4-\lambda) = 2k\lambda$

$40 - 10\lambda = 2\lambda$

$40 = 2\lambda + 10\lambda$

$40 = 12\lambda$

$\lambda = \frac{40}{12}$

$= \frac{10}{3}$

which is not in between the points.

— To the right

$V = \frac{10k}{\lambda} = \frac{2k}{\lambda-4}$

$\Rightarrow \frac{10k}{\lambda} = \frac{2k}{\lambda-4}$

$10k(\lambda-4) = 2k\lambda$

$10(\lambda-4) = 2\lambda$

$10\lambda - 40 = 2\lambda$

$-40 = 2\lambda - 10\lambda$

$\cancel{-}40 = \cancel{-}8\lambda$

$\lambda = \frac{40}{8}$

$= 5m$

4. a) What is Magnetic flux?

b) An electron with a rest mass of 9.11×10^{-31} kg moves in 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 the speed with ~~wh~~ which electron moves.
Find the cyclotron frequency of the moving eletron.

c) Discuss your answer in 4b above.

Answers

4 a) Magnetic flux (often denoted as ϕ or ϕ_B) through a surface can be described as the component of the magnetic field passing through that surface.
The S.I unit of magnetic flux is Weber.

b) Given,

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

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

$q = 1.602 \times 10^{-19} C$

Cyclotron frequency, $f = \frac{qB}{2\pi m}$

$= \frac{1.602 \times 10^{-19} \times 3.5 \times 10^{-1}}{2 \times 3.14 \times 9.11 \times 10^{-31}}$

$= \frac{5.607 \times 10^{-20}}{5.724 \times 10^{-30}}$

$\therefore f = 9.8 GH_z$ or $9.8 \times 10^{9} H_z$

c) Since the cyclotron frequency (or equivalently, gyrofrequency) is the number of cycles a particle completes around its circular orbit every second, the solution above thus shows that the particle completes 9.8×10^{5} cycle per second.

5. a) State the Biot - Savart Law.

b) Using the Biot - Savart Law, show that the magnitude of the magnetic field of a straight current-carrying conductor is given as.

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

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Answers

a) Biot - Savart's law states that the magnitute of the magnetic flux density or magnetic induction, dB near a long, straight conductor is directly proportional to the current I, the length dl, and inversely proportional to the square of the distance r and its direction is perpendicular to the plane containing dl and r.

Mathematically, it can be expressed as

$$dB \propto \frac{I\, dl \sin\theta}{r^2}$$

$$\Rightarrow dB = \frac{k I\, dl \sin\theta}{r^2}$$

where, k is a constant given as

$$\frac{\mu_0}{4\pi}$$

Thus, $dB = \frac{\mu_0}{4\pi} \cdot \frac{I \cdot dl \sin\theta}{r^2}$

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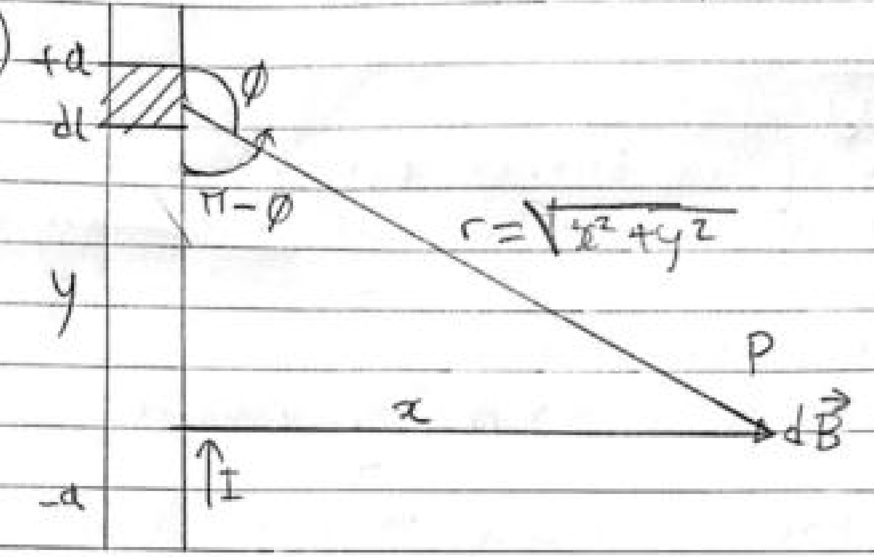
b)



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

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

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

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

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

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

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

Substituting equ (1) into equ (2), we have

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

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

Recall $dl = dy$

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

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

Using special integrals;

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

Equation (3) therefore becomes

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

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

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

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,

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

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