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2) Distinguish between the electric field and electric field Intensity.

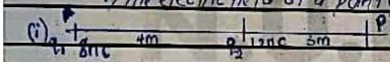
Electric field is a region of space in which an electric charge will experience an electric force WHILE Electric field Intensity is said to be the force per unit charge.

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 ~~force~~ 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.

(i)

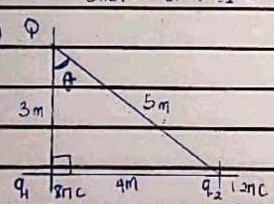


$$E_1 = \frac{kq_1}{r_1^2} = \frac{9\times10^9\times8\times10^{-9}}{7^2} = 1.5N/C$$

$$E_2 = \frac{kq_2}{r_2^2} = \frac{9\times10^9\times12\times10^{-9}}{3^2} = 12N/C$$

$$E_{net} = E_1 + E_2 = (1.5 + 12)N/C = 13.5N/C$$

(ii)



$Hyp^2 = Opp^2 + Adj^2$

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

$Hyp^2 = 16 + 9$

$Hyp = \sqrt{25} = 5$

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$$E_1 = \frac{kq_1}{r_1^2} = \frac{9\times10^9 \times 8\times10^{-9}}{3^2} = 8N/C$$

$$E_2 = \frac{kq_2}{r_2^2} = \frac{9\times10^9\times 12\times10^{-9}}{5^2} = 4.32N/C$$

	(N/C)	Angle	x component	y component.
$E_1 =$	8	90°	$8\cos 90 = 0$	$8\sin 90 = 8$
$E_2 =$	4.32	53.1	$4.32\cos 53.1 = 2.59$	$4.32\sin 53.1 = 3.455$
Σ			2.59	11.455

$$E_{net} = \sqrt{(2.59)^2 + (11.455)}$$
$$= \sqrt{6.71 + 131.22}$$
$$= \sqrt{137.93}$$
$$= 11.74 N/C$$

3) a) *State the formulation of the following identities of charges.*
(i) volume charge density (ii) surface charge density (iii) Linear Charge density

(i) volume Charge density, $\rho = dQ/dv \rightarrow dQ = \rho dv$
(ii) Surface Charge density, $\sigma = dQ/dA \rightarrow dQ = \sigma dA$
(iii) Linear Charge density, $\lambda = dQ/dA \rightarrow dQ = \lambda dl$

b) *Explain with appropriate equations, the electric potential difference.*

The electric potential difference between two points in an electronic 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 a scalar quantity and measured in volts(v) or Joules per coulomb (J/C). In an electric field, Suppose a test charge q is moved from point A to a point B along an obituary path. The electric field exists a force, $F = q_0 E$ on the charge. For the test charge to move from point A to point B, an external force,

$f = -q_0 E$ acts on the charge.

The work done in moving this charge is given as

$$dW = f \cdot dl \quad ---(1) \qquad \text{But } f = -q_0 E \quad ---(2)$$

Substituting equation (2) in (1) yields

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

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

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

from the definition of electrical potential difference, it follows that

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

Putting equation (4) in (5) yields

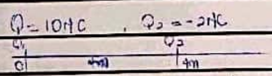
$$V_B - V_A = -\int_A^B E\, dl \quad ---(6)$$

$$\Delta U = \frac{-W(A \to B)_E}{q_0} = \frac{W(A \to B)_{tq}}{C}$$

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

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

$Q_1 = 10\mu C$, $Q_2 = -2\mu C$; $V = 0$



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

$$0 = 9 \times 10^9 \times \left[\frac{10 \times 10^{-6}}{r_1} - \frac{2 \times 10^{-6}}{r_2}\right]$$

$$\frac{0}{9 \times 10^9} = \frac{10 \times 10^{-6}}{r_1} - \frac{2 \times 10^{-6}}{r_2}$$

$$2r_1 = 10r_2 \;;\; r_1 = 5r_2$$

When $V = 0$, the position along the x-axis from Q_1 is 5m and from Q_2 is 1 m.

4a) *What is magnetic flux?*

Magnetic flux is defined as the strength of magnetic field represented by lines of force.

4b) *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/m² perpendicular to the speed of light with which electron moves. find the cycloton frequency of the moving electron.*

Using or taking speed of light as 3×10^8 m/s

$$W = \frac{V}{r} \quad \text{where } V = 3\times10^8 \text{ m/s},\ r = 1.4\times10^{-7} \text{ m}$$

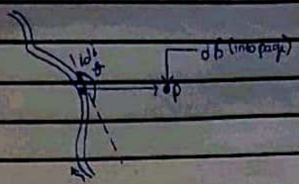
$$= \frac{3\times10^8}{1.4\times10^{-7}} = 2.14\times10^{14} \text{ rad/s}$$

4c) Discuss your answer in 4b above.

I was to find the cycloton frequency, and I was given mass, radius, magnetic field and these was perpendicular to the speed of light with which electron moves. Knowing fully well that the speed of light is constant which 3×10^8 m/s, I used Angular speed = speed of light ÷ the radius of the electron.

) State the Biot-Savart law.

Biot-Savart law is based on the following observations for the magnetic field $d\vec{B}$ at a point P associated with a length element dl of a wire carrying a steady current I. See the figure below

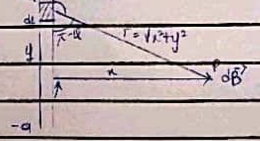


Observations

1) The vector $d\vec{B}$ is perpendicular both to $d\hat{l}$ and to the unit vector $\hat{r}$ directed from $d\vec{l}$ 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 $d\vec{B}$ 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 dl.

Therefore Biot-Savart law states that the magnetic intensity at any point due to a steady current in an infinitely long straight wire is directly proportional to the current and inversely proportional to the distance from point to wire.

5b) Using the Biot-Savart law, show that the magnitude of the magnetic field of a straight current-carrying conductor is given as $B = \frac{\mu_0 I}{2\pi r}$



Applying the Biot - Savart Law, we find the magnitude of the field dB'

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

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

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

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

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

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

Substituting $(**)$ into $(*)$ we have

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

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

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

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

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

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

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

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

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 longer than x,

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

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

In a physical solution, we have axial symmetry about the y-axis. Thus, at all points in a circle of radius r, around the conductor, the magnitude of B is $B = \frac{\mu_0 I}{2\pi r}$ ---- (#)

Equation (#) defines the magnitude of the magnetic field of flux density B near a long, straight current carrying conductor.