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19/MHS01/187
PHY 102

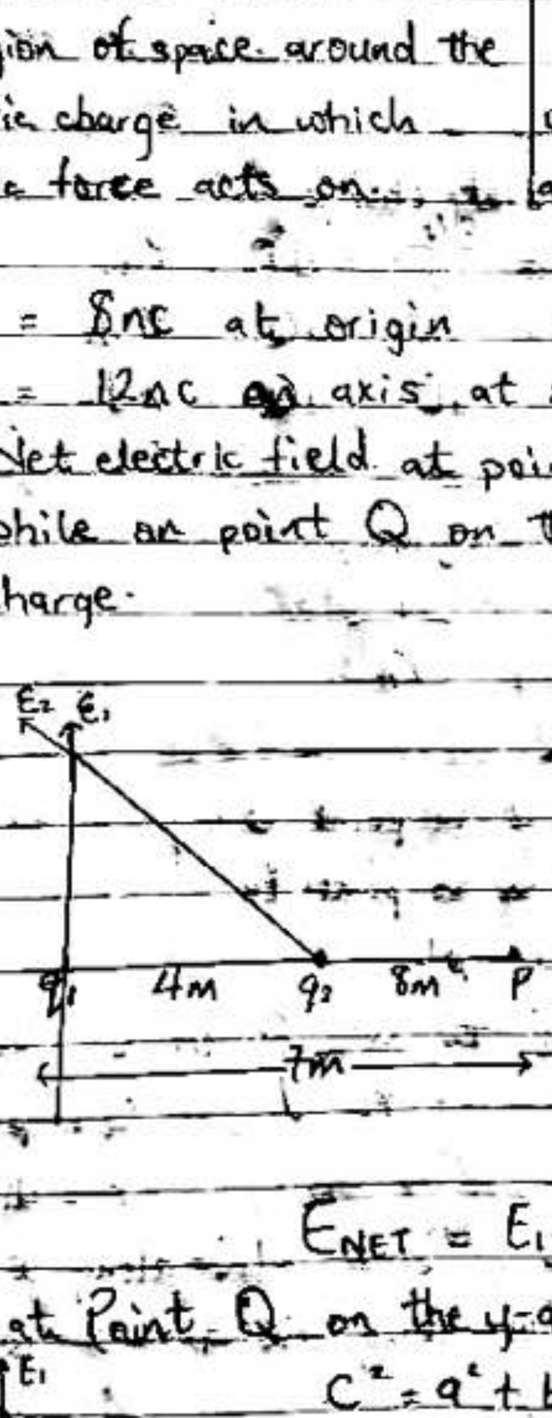
2) a) Electric field and Electric field intensity

Electric Field	Electric Field Intensity
A region of space around the electric charge in which electric force acts on.	The measure of the strength of an electric field at any point also force per unit charge.

b) $q_1 = 8nC$ at origin
$q_2 = 12nC$ on axis at $x = 4m$

i) Net electric field at point P on the axis at $x = 7m$ while on point Q on the y-axis at $y = 3m$ due to the charge.

i)



$E_1 = \frac{KQ_1}{r^2} = \frac{9 \times 10^9 \times 8 \times 10^{-9}}{7^2}$

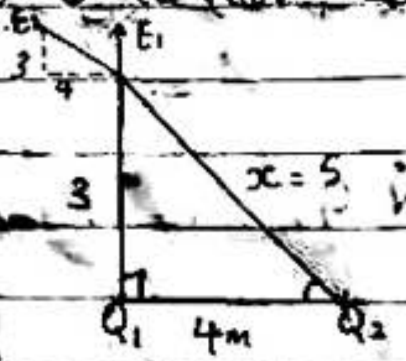
$= 1.469 N/C \approx 1.5 N/C$

$E_2 = \frac{KQ_2}{r^2} = \frac{9 \times 10^9 \times 12 \times 10^{-9}}{7^2}$

$= 12 N/C$

$E_{NET} = E_1 + E_2 = 1.5 + 12 N/C = 13.5 N/C$

ii) E at Point Q on the y-axis at $y = 3m$ due to charge



$C^2 = a^2 + b^2$, $c^2 = 4^2 + 3^2$, $c = \sqrt{25} = 5$

$E_1 = \frac{KQ_1}{r^2} = \frac{9 \times 10^9 \times 8 \times 10^{-9}}{5^2}$, $E_1 = 8N/C$

$E_2 = \frac{KQ_2}{r^2} = \frac{9 \times 10^9 \times 12 \times 10^{-9}}{5^2} = 4.32 N/C$

Vector	Angle	x-comp	y-comp
$E_1 = 8N/C$	90°	$0N/C$	$8N/C$
$E_2 = 4.32$	36.87°	$-3.45N/C$	$2.59N/C$
		$E_x = -3.45N/C$	$E_{fy} = 10.59N/C$

$E_{net} = \sqrt{Efx^2 + Efy^2}$

$E_{net} = 11.12 N/C$

5) Formulation of Indentres of charge

a i) Volume charge density $\rho = \frac{dQ}{dv} = dQ = \rho dv$

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

iii) Linear charge density $\lambda = \frac{dQ}{dL} = dQ = \lambda dL$

b Electric potential difference equation

$$V_B - V_A = \frac{Q}{4\pi\varepsilon_0}\left(\frac{1}{r_B} - \frac{1}{r_A}\right)$$

where Q = point charge

r_B = distance of Q to point B

r_A = distance of Q to point A

Due to several point charges

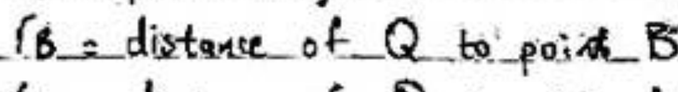
$$V_P = \frac{1}{4\pi\varepsilon_0}\left[\frac{Q_1}{r_1} + \frac{Q_2}{r_2}\right]$$ where V = Electric potential

Q = point charge

r = distance of Q

c) Point Charge $Q_1 = 10\mu C$, $Q_2 = -2\mu C$ along x-axis x = 0

x = 4m find the position along the x-axis where V = 0.



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

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

$$0 = 9\times10^{9}\times\left[\frac{10\times10^{-6}}{4+x} + \frac{-2\times10^{-6}}{x}\right]$$

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

$$10\times10^{-6}x = (4+x)(2\times10^{-6})$$

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

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

$$8\times10^{-6} = 8\times10^{-6}x$$

$$x = \frac{8\times10^{-6}}{8\times10^{-6}} = 1$$

position along the x-axis is 1m

where $V = 0$

$$V = K\left[\frac{Q_1}{r_1} + \frac{Q_2}{r_2}\right]$$

$$0 = \left[\frac{10\times10^{-6}}{4-x} + \frac{-2\times10^{-6}}{x}\right]$$

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

$$[4-x][2\times10^{-6}] = 10\times10^{-6}x$$

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

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

$$8\times10^{-6} = 12\times10^{-6}x$$

$$x = \frac{8\times10^{-6}}{12\times10^{-6}} \qquad x = 0.67m$$

position of $V = 0$ is $0.67m$

4a) Magnetic flux is defined as the strength of the magnetic field which can be represented by line of forces. It is denoted as ϕ

$$\phi = B\cdot dA$$

b) $Me = 9.11\times10^{-31}kg$, $r = 1.4\times10^{-7}m$, $B = 3.5\times10^{-1}\,wb/m^2$

Cyclotron frequency = angular speed $q = 1.6\times10^{-19}$

$$F_B = qVB = \frac{MeV^2}{r}$$

$MeV = qBr$

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

$V = 8.61 \times 10\ m/s$

$\omega = \frac{V}{r} = \frac{qB}{Me} = \frac{1.6 \times 10^{-19} \times 3.5 \times 10^{-1}}{9.11 \times 10^{-31}}$

$\omega = 6.14 \times 10^{10}\ s^{-1}$

e) Mass of electron = 9.11×10^{-31} Kg

radius = 1.4×10^{-7} m

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

and we were asked to find the Cycloton frequency which is the same thing as angular speed. It is called cycloton frequency because it is the frequency of an accelerator called cyclotron.

Recall ω = angular speed

$\omega = \frac{qB}{Me}$ Since cyclotron frequency is angular speed The Cycloton frequency $= 6.14 \times 10^{10}\ s^{-1}$ having a unit of $\frac{1}{T}$ which is the unit of frequency dimensionally.

5a) Biot - Savart law states that the magnetic field is directly proportional to the product permeability of free space (μ) the current (I), the charge in length, the radius and inversely proportional to square of radius (r^2). Mathematically

$$dB = \frac{\mu_o I\, dl^{y} \times \hat{r}}{4\pi r^2}$$

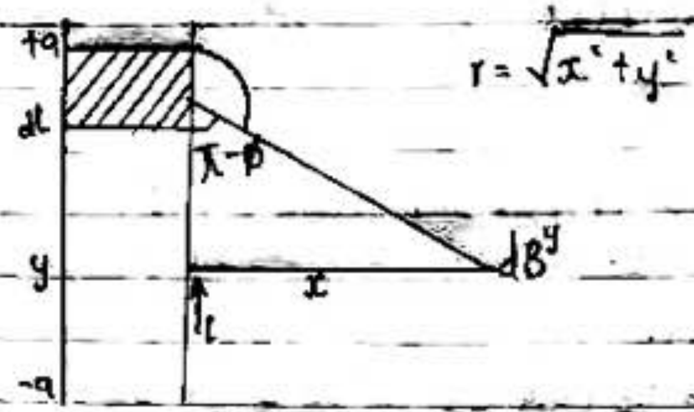
where μ_o [permeability of free space] $= 4\pi \times 10^{-7}\ T \cdot m/A$,

r = radius

dB = magnetic field, I = steady current

dL = Length of wire unit is w/m^2.

5b) Magnetic field of a straight current carrying conductor.



A section of a straight current carrying conductor

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

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

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

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

from the diagram $r^2 = x^2+y^2$

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

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

Substitute (ii) into (i)

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

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

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

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

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

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