Name:ometie
Eworitsemogha benedict

Department: agric sci

Matricnum: 19/sci07/008

Section A

2). electric field & electric field intensity

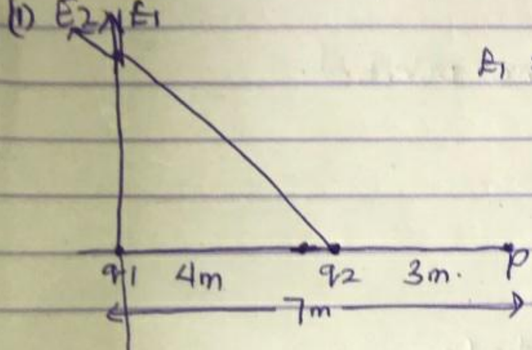
electric field	electric field intensity
• It is a region of space in which an electric charge will experience an electric force.	• It is the force per unit charge.

2b). $q_1 = 8\,nC$ at origin, $q_2 = 12\,nC$ on x-axis at $x = 4m$.

(i) net electric field at point P on the x axis at $x = 7m$.

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

(i)

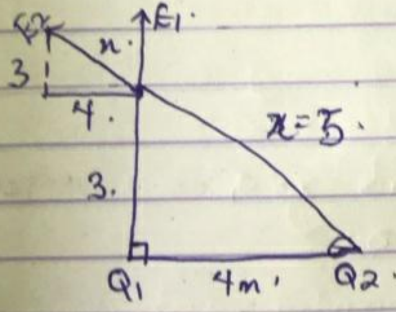


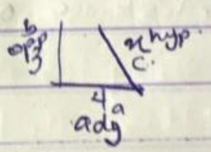
$E_1 = \frac{KQ_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-9}}{7^2} = \underline{1.469\,N/C} \simeq 1.5\,N/C$

$E_2 = \frac{KQ_2}{r^2} = \frac{9\times10^9 \times 12\times10^{-9}}{7^2} = \underline{12\,N/C}$

(i) $E_{net} = \vec{E_1} + \vec{E_2} = (1.5 + 12)\,N/C = \underline{\underline{13.5\,N/C}}$

(ii). $\vec{E}$ at Point Q on the y axis at $y = 3m$ due to charge.





$c^2 = a^2 + b^2$

$c^2 = 4^2 + 3^2$

$c = 5$

$E_1 = \frac{KQ_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-9}}{3^2}$ $\vec{E_1} = 8\,N/C$.

$E_2 = \frac{KQ_2}{r^2} = \frac{9\times10^9 \times 12\times10^{-9}}{5^2} = 4.32\,N/C$.

vector	angle	x-comp	y-comp.
$E_1 = 8\,N/C$.	$90°$	$0\,N/C$.	$8\,N/C$.
$E_2 = 4.32$.	$36.87°$	$-3.45\,N/C$.	$2.59\,N/C$.
		$E_{fx} = -3.45\,N/C$	$E_{fy} = 10.59\,N/C$

$E_{net} = \sqrt{E_{fx}^2 + E_{fy}^2}$

$E_{net} = 11.12\,N/C$

where Q = charge.
V = volume.
L = length.
A = area.

13. formulation of identities of charge.

a) volume charge density $\rho = \frac{dQ}{dv} = dQ = \rho dV$.

(ii) surface charge density $\sigma = dQ/dA = dQ = \sigma dA$.

(iii) linear charge density $\lambda = dQ/dL = dQ = \lambda dL$.

sow

b) electric potential difference equation:

• due to a single point charge:

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

where Q = point charge. V = electric potential.
r_B = distance of Q to point B.
r_A = distance of Q to point A.

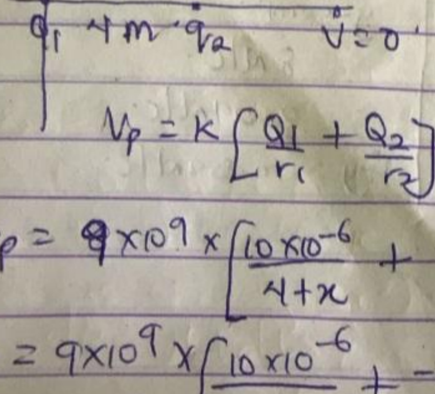
• due to several point charges

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

where V = electric potential.
Q = point charge.
r = distance of Q.

3c). Solution

Point charge $Q_1 = 10\mu C$ $Q_2 = -2\mu C$ along x-axis $x=0, x=4m$ respe
find the position along the x-axis where $V=0$.



$$V_p = \frac{1}{4\pi\varepsilon_0}\left(\frac{Q_1}{r_1} + \frac{Q_2}{r_2}\right) \quad \text{recall } \frac{1}{4\pi\varepsilon_0} = 9\times10^9 = K.$$

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

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

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

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

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

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

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

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

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

$x = 1$

$\therefore$ position along the x-axis is 1m.

where $V=0$

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

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

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

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

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

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

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

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

$x = 0.67m$

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

Section B.

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

$\phi = B \cdot dA$

4b) $m_e = 9.11 \times 10^{-31} kg$, $r = 1.4 \times 10^{-7} m$; $B = 3.5 \times 10^{-4} w/m^2$

cyclotron frequency = angular speed. $q = 1.6 \times 10^{-19}$

$$F_B = qvB = \frac{m_e v^2}{r}$$

$$m_e v = qBr$$

$$v = \frac{qBr}{m_e} = \frac{1.6 \times 10^{-19} \times 3.5 \times 10^{-4} \times 1.4 \times 10^{-7}}{9.11 \times 10^{-31}}$$

$$v = 8.61 \times 10^{-3} m/s$$

$$\omega = \frac{v}{r} = \frac{qB}{m_e} = \frac{1.6 \times 10^{-19} \times 3.6 \times 10^{-4}}{9.11 \times 10^{-31}}.$$

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

4c) in 4b we were given parameters; Mass of electron = $9.11 \times 10^{-31} kg$, radius = $1.4 \times 10^{-7} m$ $B = 3.5 \times 10^{-4} w/m^2$.

And we were asked to find the cyclotron frequency which is the same thing as angular speed. It is called cyclotron frequency because it is a frequency of an accelator called cyclotron.

Recall ω = angular speed.

$\omega = \frac{qB}{m_e}$ since cyclotron frequency = angular speed.

∴ The cyclotron frequency = $6.14 \times 10^{-10} s^{-1}$ having a unit of $\frac{1}{T}$ which is the unit of frequency dimensionally.

5a

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

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

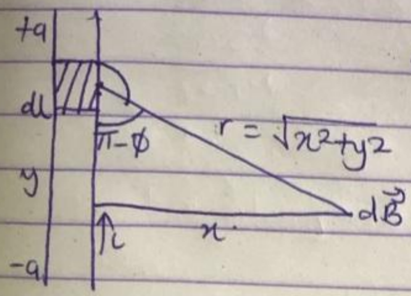
where μ_0 (permeability of free space) = $4\pi \times 10^{-7} T \cdot m/A$; r = radius

$d\vec{B}$ = 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 Bio-savart law, we find the magnitude of the field $(d\vec{B})$ from the diagram,

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

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

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

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

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

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

substitute (ii) into (i)

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

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

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

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

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

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