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Assignment Solutions

Section A

~~Electric field~~

Electric field & electric field intensity.

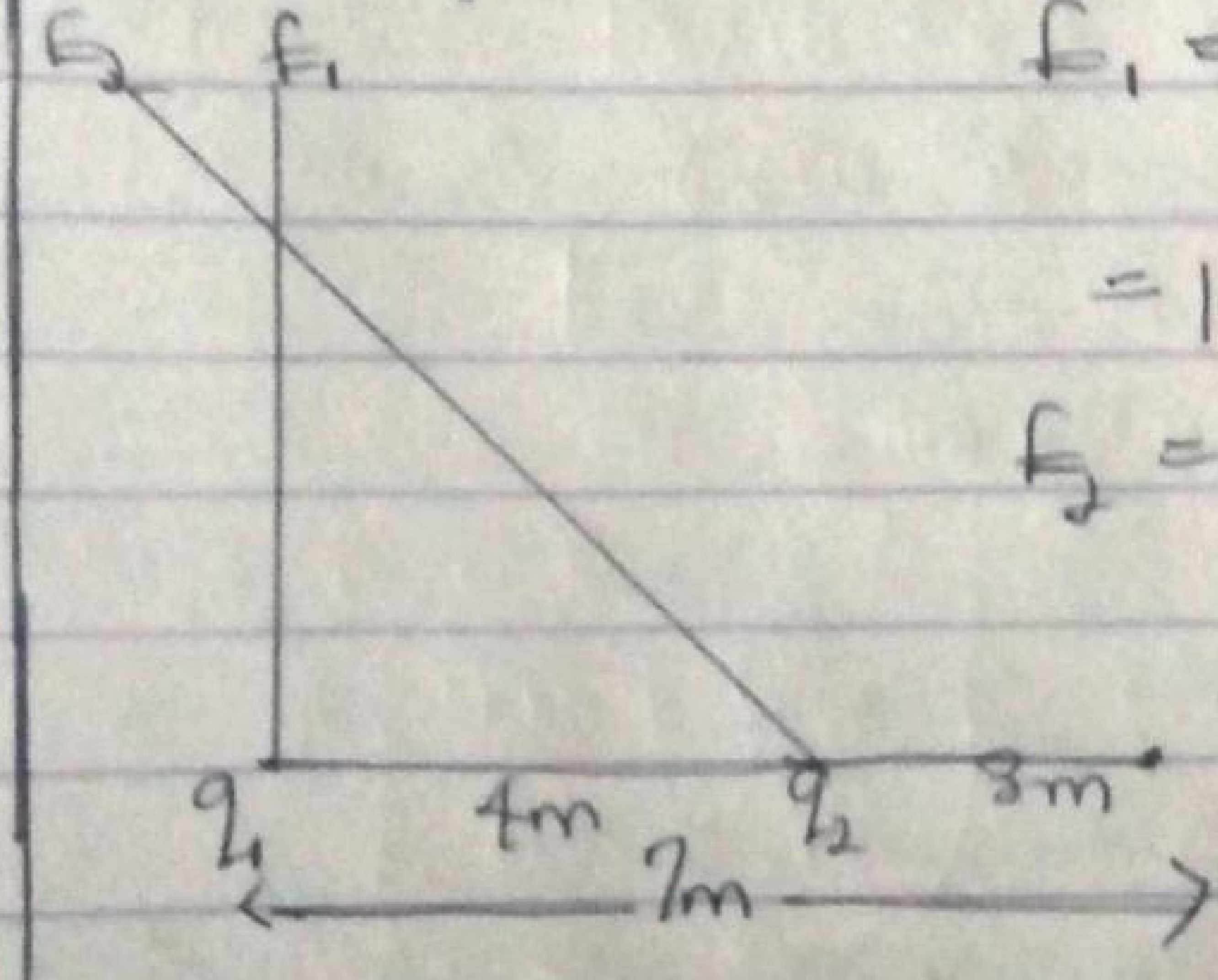
Electric field	Electric field intensity
It is a region of space in which an electric charge will experience and electric force	It is a force per unit charge.

$q_1 = 8nC$ at origin, $q_2 = 12nC$ 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



$$E_1 = \frac{KQ_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-9}}{7^2}$$

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

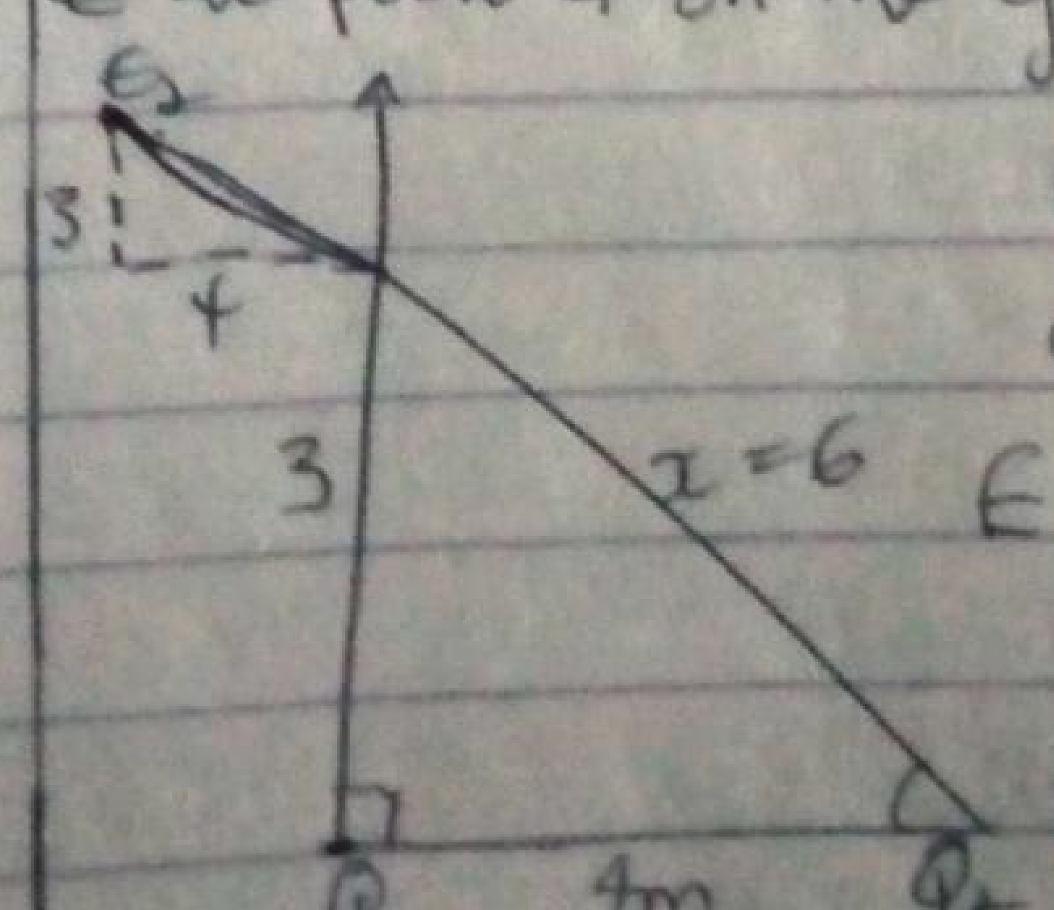
$$E_2 = \frac{KQ_2}{r^2} = \frac{9\times10^9 \times 12\times10^{-9}}{7^2}$$

$$= 12 N/C$$

$$E_{net} = \vec{E_1} + \vec{E_2} = 1.5 + 12 = 13.5 N/C$$

E at point Q on the y-axis at $y = 3m$ due to charge.

ii



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

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

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

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

Vector	Angle	x-comp	y-comp
$f_1 = 8N/c$	90	$0 N/c$	$8 N/c$
$f_2 = 4.30$	36.87	$-3.45 N/c$	$2.59 N/c$
		$\Sigma f_x = -3.45 N/c$	$\Sigma f_y = 10.59 N/c$

$$f_{net} = \sqrt{\Sigma f_x^2 + \Sigma f_y^2}$$

$$f_{net} = 11.12 N/c$$

3a Formulation of Identities of charges.

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

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

iii Inner charge density $\lambda = dQ/d_L = dQ = \lambda\, dL$

b Electric Potential difference equation

=> due to a single point charge

$$V_B - V_A = \frac{Q}{4\pi\epsilon_0}\left[\frac{1}{r_B} - \frac{1}{r_A}\right]$$

where Q = point charge

r_B = distance of Q to point B

r_A = distance of Q to point A

V = electric potential.

=> due to several point charges.

$$V_r = \frac{1}{4\pi\epsilon_0}\left[\frac{Q_1}{r_1} + \frac{Q_2}{r_2}\right] \text{ where}$$

V = Electric potential

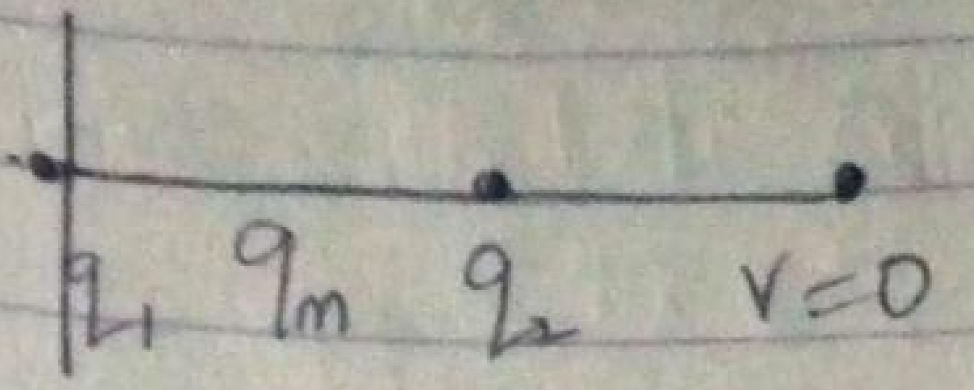
Q = Point charge

r = distance of Q

c Point charge $Q_1 = 10\mu c$, $Q_2 = -2\mu c$ along x-axis $x =$
$x = 4m$ respectively

find the position along x-axis where $V=0$

$$V_P = \frac{1}{4\pi\epsilon_0}\left[\frac{Q_1}{r_1} + \frac{Q_2}{r_2}\right] \text{ recall } \frac{1}{4\pi\epsilon_0} = 9\times10^9$$



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

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

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

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

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

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

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

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

$$x = 1$$

$\therefore$ Position along the x-axis is 1m

where $v = 0$

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

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

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

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

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

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

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

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

$$x = 0.67\text{m}$$

$\therefore$ Position of $V=0$ is $\underline{0.67\text{m}}$

SECTION B

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. $M_e = 9.11 \times 10^{-31} kg$, $r = 1.4 \times 10^{-7} m$; $B = 3.5 \times 10^{-1} wb/m^2$

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

$F_B = qV_B = \frac{M_e v^2}{r}$

$M_e v = qBr$

$V = \frac{qBr}{m_e} = \frac{1.6 \times 10^{-19} \times 3.5 \times 10^{-1} \times 1.4 \times 10^{-7}}{9 \times 11 \times 10^{-31}}$

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

$W = \frac{v}{r} = \frac{qB}{m_e} = \frac{1.6 \times 10^{-19} \times 3.5 \times 10^{4}}{9.11 \times 10^{-31}}$

$W = 6.14 \times 10^{18} e^{-1}$

c Mass of electron $= 9.11 \times 10^{-11} kg$

radius $= 1.4 \times 10^{-} m$ $B = 3.5 \times 10^{-1} wb/m^2$

Cyclotron frequency = angular speed. It is referred to as cyclotron frequency because it is a frequency of an accelerator called cyclotron.

W = angular speed

$W = \frac{qB}{m_e}$.

Cyclotron frequency $= 6.14 \times 10^{-19} e^{-1}$

having a unit of $1/r$ 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 (e+)

current (I), the change in length, the radius and universely proportional to the square of radius (r^2) mathematically.

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

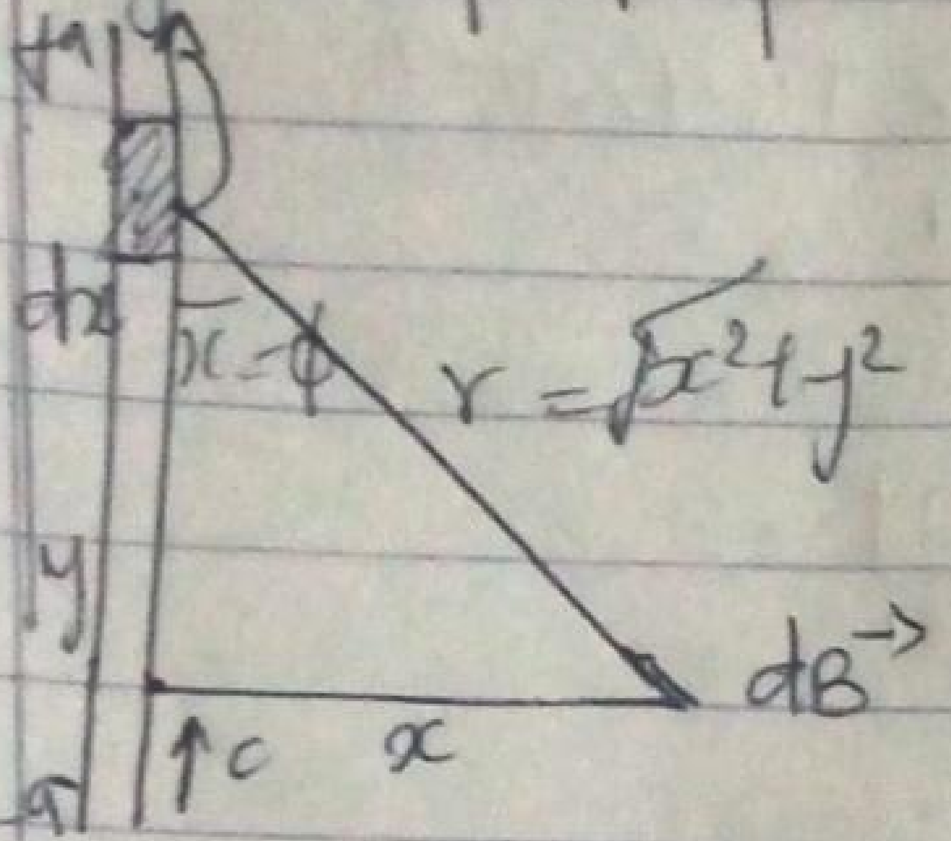
where μ_0 = Permeability of free space $= 4\pi \times 10^{-7}$ T. m/A

r = radius

$d\vec{B}$ = magnetic field, I = steady current, dl = length of wire

unit is wb/m²

b Magnetic field of a straight current carrying conductor



A section of a straight current carrying conductor.

Applying Biot-savart law, we find the magnitude of the field (dB) 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 $r^2 = x^2 + y^2$

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

$$\text{But } \sin(\pi - \phi) = \frac{x}{\sqrt{x^2+y^2}} = \frac{x}{(x^2+y^2)^{1/2}} \quad \text{- - - - - (11)}$$

Substitute the value of equ (11) into (1)

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

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

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

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

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