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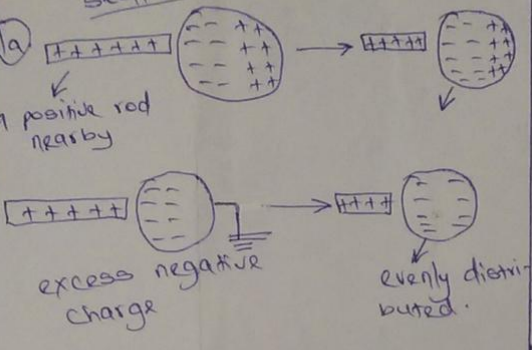
Course Code: Phy 102
Matric No. 19/MHS11/075

Assignment

SECTION A

(1a)



(1b) $F = 1.0N \quad k = 9 \times 10^9 \quad r = 2.0m$

$q_1 + q_2 = 5.0 \times 10^{-5}C$ ...... ①

$F = \frac{kq_1q_2}{r^2}$ ...... ②

$q_1 = 5.0 \times 10^{-5} + q_2$ ...... ③

from eqn ②

$F = \frac{kq_1q_2}{r^2}$

$1 = \frac{9\times10^9(5.0\times10^{-5} - q_2)q_2}{2^2}$

$1 = \frac{9\times10^9\times(5.0\times10^{-5} - q_2)q_2}{4}$

$4 = 4.5\times10^5 q - 9\times10^9 q^2$

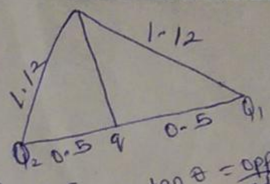
collect like terms

$= 9\times10^9 q^2 - 4.5\times10^5 q + 4$

using quadratic equation

$q_1 = 3.84\times10^{-5}C$ or $1.15\times10^{-5}C$

1c.



$x^2 = 1^2 + 0.5 \qquad \tan\theta = \frac{opp}{adj}$

$x = \sqrt{1.25} \qquad \tan\theta = \frac{1}{0.5}$

$x = 1.12 \qquad \theta = 63.4^\circ$

$Q_1 = Q_2 = 8\times10^{6}C$

$E_p = E_1 + E_2 + E_q$

$E_1 = \frac{kq_1}{r_1^2} \quad E_2 = \frac{kq_2}{r_2^2} \quad E_q = \frac{kq}{r_q^3}$

$E_1 = \frac{9\times10^9\times8\times10^{-6}}{1^2} = 7.2\times10^4$

$E_2 = \frac{9\times10^9\times8\times10^{-6}}{1^2} = 7.2\times10^4$

$E_q = \frac{9\times10^9\times q}{1^2} = 9\times10^9 q$

vector	angle	x com	y com
$E_1 = 7.2\times10^4$	63.4°	$7.2\times10^4\cos 63.4$ -32,238.5	64379.10
$E_2 = 7.2\times10^4$	63.4°	32238.55	64379.10
$E_q = 9\times10^9 q$	90°	0°	$9.2\times10^{9}q$
		$Efx = 0$	$Ey = 128758.2$

magnitude $= \sqrt{(Ex^2) + (Ey)^2} = |q| = 1.4uC$

(2a) Electric field & Electric field intensity

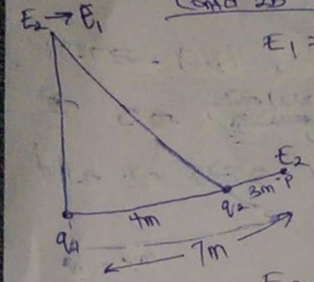
Electric field	Electric field intensity
It is a region of space in which an electric charge will experience an electric force.	It is the force per unit charge.

2b. $q_1 = 8nC$ 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.

Contd 2b



$E_1 = \frac{kQ_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-9}}{7^2}$

$= 1.469\ N/C \approx 1.5$

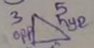
$E_2 = \frac{kQ_2}{r^2} = \frac{9\times10^9\times12\times10^{-9}}{7^2}$

$= 12\ N/C$

$E_{net} = 1.5 + 12\ N/C$

$= 13.5\ N/C$

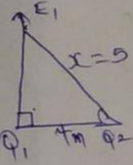
ii) $\vec{E}$ at point Q on the y axis at y=3m due to charge.



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

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

$c = 5$



$E_1 = \frac{kQ_1}{r^2} = \frac{9\times10^9\times8\times10^9}{3^2}$

$E_1 = 8\ N/C$

$E_2 = \frac{kQ_2}{r^2} = \frac{9\times10^9\times12\times10^{-9}}{5^2}$

$= 4.32\ N/C$

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
		$Efx = -3.45\ N/C$	$Efy = 10.59\ N/C$

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

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

SECTION B

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

$\phi = B \cdot dA$

4b) $m_e = 9.11\times10^{-31}\ kg$, $r = 1.4\times10^{-7}\ m$

$B = 3.5\times10^{-1}\ w/m^2$

cyclotron frequency = angular speed

$q = 1.6\times10^{-19}$

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

$m_e v^2 = qBr$

$v = \frac{qBr}{m_e} = \frac{1.6\times10^{-19}\times3.5\times10^{-1}\times1.4\times10^{-7}}{9.11\times10^{-31}}$

$v = 8.61\times10^{-3}\ m/s$

$w = \frac{v}{r} = \frac{qB}{m_e} = \frac{1.6\times10^{-19}\times3.5\times10^{-1}}{9.11\times10^{-31}}$

$w = 6.14\times10^{10}\ s^{-1}$

4c) In 4b above, we were given parameters; mass of electron $= 9.11\times10^{-31}\ kg$ radius $= 1.4\times10^{-7}\ m$ $B = 3.5\times10^{-1}\ w/m^2$ And asked to find the cyclotron frequency which is the same as angular speed. So recall,

w = angular speed

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

since cyclotron frequency = angular speed

The cyclotron frequency $= 6.14\times10^{-10}\ s^{-1}$

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(5a) Biot - 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,

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

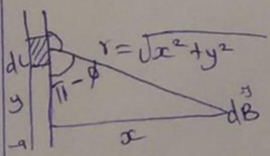
where μ_0 = permeability of free space

r = radius, $d\hat{B}$ = magnetic field

I = steady current; dL = length of wire. Unit is w/m^2.

(5b)

(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.

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

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

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

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

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

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

substitute eqn (2) into (1)

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

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

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

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

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

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

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