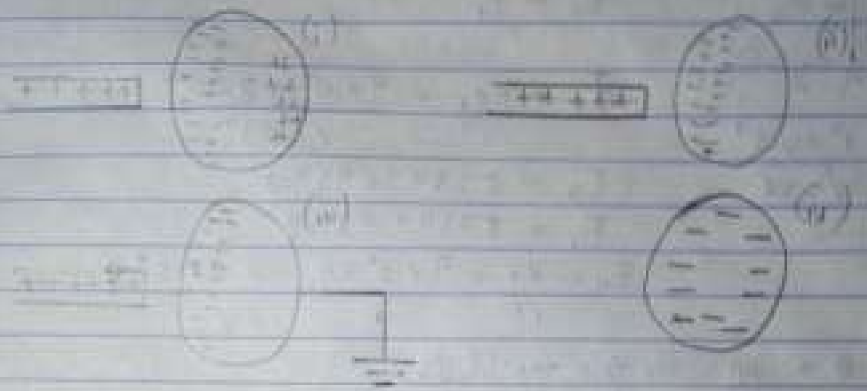
Name: Onwere Joanna Kamsi
Department: MBBS
Matric No : 19/MHC01/352

a.



b. Given: $F = 1N$, $r = 2m$, $k = 9 \times 10^{9}$

Recall: $q_1 + q_2 = 5.0 \times 10^{-5} C$

$$F = \frac{k q_1 q_2}{r^2} \Rightarrow \frac{F r^2}{k} = q_1 q_2$$

$$q_1 q_2 = \frac{1 \times 2^2}{9 \times 10^9} = 4.444 \times 10^{-10}$$

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

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

$$q_2 = q_1$$

$$q_1 (5.0 \times 10^{-5} - q_1) = 4.444 \times 10^{-10}$$

$$\underset{A}{q_1^2} - \underset{B}{5.0 \times 10^{-5} q_1} - \underset{C}{4.444 \times 10^{-10}} = 0$$

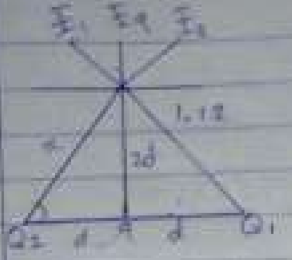
$$\frac{5.0 \times 10^{-5} + \sqrt{(5.0 \times 10^{-5})^2 - 4(4.444 \times 10^{-10})}}{2}$$

$$q_1 = 3.84 \times 10^{-5} C$$

$$q_2 = 5.0 \times 10^{-5} - 3.84 \times 10^{-5}$$

$$q_2 = 1.16 \times 10^{-5} C$$

c.



$d = 0.5$

$Q_2 = Q_1 = 3 \times 10^{-6}$

$E_2 = E_1$

$E_2 = \frac{kq_2}{r^2} = \frac{9 \times 10^9 \times 3 \times 10^{-6}}{(1.12)^2}$

$x^2 = 1^2 + 0.5^2$

$\sqrt{x^2} = \sqrt{1.25}$

$x = 1.12$

$E_2 = 57397.95912$

$E_1 = 57397.95912$

$E_q = \frac{kq}{r^2} = \frac{9 \times 10^9 \times q}{1} = 9 \times 10^9 \cdot q$

$\tan\theta = \frac{opp}{adj} \Rightarrow \theta = \tan^{-1}\left(\frac{1}{0.5}\right)$

$\theta = 63.43°$

Vector	Angle	X-Component	Y-Component
$E_1 = 57397.95912$	$63.4°$	25700.45785	51322.62839
$E_2 = 57397.95912$	$63.4°$	-25700.45785	51322.62839

$\Sigma_x = 0$ $\Sigma_y = 102645.2568$

$E_q = \sqrt{(0)^2 + (102645.2568)^2}$

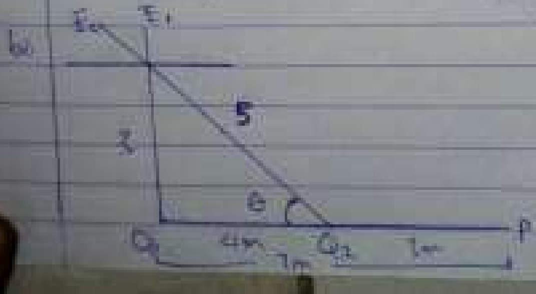
$E_q = 0 + 102645.2568 = 102645.2568$

$\therefore q = \frac{E_q}{9 \times 10^9} = \frac{102645.2568}{9 \times 10^9}$

$q = 1.14 \times 10^{-5} C$

20. An electric field is a region of space in which an electric charge will experience an electric force and can be represented by lines of force while the electric field intensity at a point is the force per unit charge acting on a positive charge placed at that point and it is a vector quantity.

(b)



$\tan\theta = \frac{opp}{adj} = \frac{3}{4}$

$\theta = \tan^{-1}(3/4)$

$\theta = 36.9°$

$E_{net} = E_1 + E_2$

$E_1 = \frac{kq_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-9}}{7^2} = 1.47 N/C$

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

$E_{net} = (1.47 + 12) N/C$

$E_{net} = 13.5 N/C$

ii. $E_1 = \frac{kQ_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-9}}{3^2} = 8 N/C$

$E_2 = \frac{kQ_2}{r^2} = \frac{9\times10^9 \times 12\times10^{-9}}{5^2} = 4.32 N/C$

Vector	Angle	x-component	y-component
$E_1 = 8 N/C$	$90°$	0	8
$E_2 = 4.32 N/C$	$36.9°$	-3.45	2.59

$\Sigma x = -3.45 \quad \Sigma y = 10.59$

$E_{net} = \sqrt{(-3.45)^2 + (10.59)^2}$

$E_{net} = 11.14 N/C$

To get the direction of E:

$\tan\theta = \frac{E_y}{E_x} = \frac{10.59}{3.45} = 3.07$

$\theta = \tan^{-1}(3.07) = 72.0$

4a. Magnetic flux is defined as the strength of magnetic field represented by lines of force. It is usually represented by the symbol Φ. It is a vector quantity and measured in Weber (Wb).

b. Given: $m_e = 9.11\times10^{-31} kg$, $r = 1.4\times10^{-7} m$, $B = 3.5\times10^{-1} W/m^2$, $q = -1.6\times10^{-19}$

Recall:

Since the electron moves in a circular orbit,

$m_e v = qBr$

$$v = \frac{qBr}{m_e}$$

$$v = \frac{-1.6 \times 10^{-19} \times 3.5 \times 10^{-1} \times 5.4 \times 10^{-7}}{9.11 \times 10^{-31}} = -3605.93 \, m/s$$

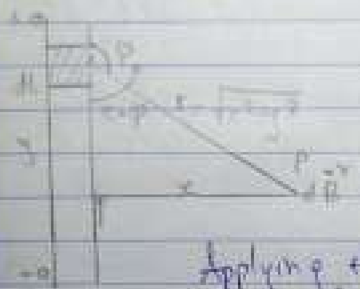
Hence, the cyclotron frequency is

$$\omega = \frac{qB}{m_e} = \frac{-1.6 \times 10^{-19} \times 3.5 \times 10^{-1}}{9.11 \times 10^{-31}} = -6.15 \times 10^{10} \text{ rad/s}$$

c. The answer is negative because we are using an electron thus, the rotation will be clockwise. The electron is moving at a cyclotron frequency of 6.15×10^{10} rad/s.

5a. The Biot - Savart law is an equation used to find the total magnetic field created at some point on a current carrying wire or current consisting of charges flowing through space

b.



Applying the Biot- Savart law, we find the magnitude of the field $d\vec{B}$

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

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

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

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

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

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

Substituting (**) into (*), we have

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

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

Recall $dl = dy$

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

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

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

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

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 larger than x, $\Rightarrow (x^2+a^2)^{1/2} \cong a$, as $a \to \infty$.

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

In a physical situation, 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 $B = \dfrac{\mu_0 I}{2\pi r}$ ---- (#)

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