4c) The cyclotron frequency also known as the angular speed of an electron with mass 9.11×10^{-31} kg and radius 1.4×10^{-1} m with a magnetic field of 3.5×10^{-1} weber/meter square is given as 6.16×10^{10} rad

5a) State the Biot-savart law
Biot-Savart law states that the magnetic flux density near a long straight conductor is directly proportional to the current in the conductor and inversely proportional to the distance from the conductor.

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

5b) Applying the Biot-savart law, we find the magnitude of $\vec{dB}$

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

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

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

$r^2 = x^2 + y^2$ (pythagoras theorem)

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

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

Substituting equation (ii) into (i) we have

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

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

Adeyemi Mayowa Esther PHY102 19/1MHS01/040

COVID-19 Holiday Assignment.

Section A.

2a) Distinguish between the terms: electric field and electric field intensity

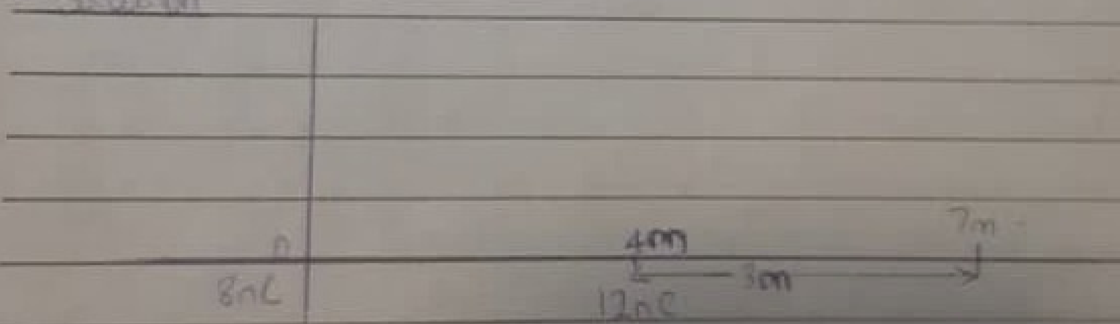
Solution

An electric field is a region of space in which an electric charge will experience an electric force while electric field intensity is the measure of the strength of an electric field at any point

2b) A positive charge $Q_1 = 8nC$ is at the origin, and a second positive charge $Q_2 = 12nC$ is on the x-axis at $x = 4m$. Find,

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

Solution



Electric field $= E = \frac{F}{q} = \frac{kq}{r^2}$

$k = 9\times10^9 Nm^2C^2$, $q_1 = 12\times10^{-9} C$, $r = 3m$, $q_2 = 8\times10^{-9} C$, $r_2 = 7m$

$E_1 = \frac{9\times10^9 \times 12\times10^{-9}}{3^2} = 12 N/C$

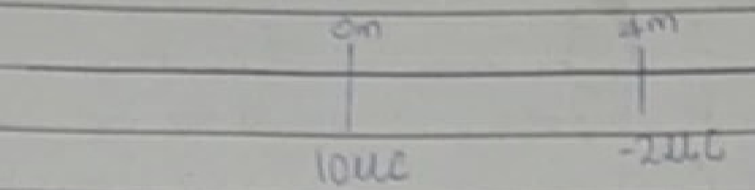
$\therefore E_1 = 12 N/C$.

$E_2 = \frac{9\times10^9 \times 8\times10^{-9}}{7^2} = 1.47$

$E_{net} = 1.47 + 12 = 13.47 N/C$

3) Two point charges $Q_1 = 10\mu C$ and $Q_2 = -2\mu C$ are arranged along the x-axis at $x = 0$ and $x = 4m$ respectively. Find the position along the x-axis where $V = 0$.

Solution.



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

$q_1 = 10 \times 10^{-6} C$, $q_2 = -2 \times 10^{-6} C$, $r = 4m$, $k = 9 \times 10^9$

$F = \frac{9 \times 10^9 \times 10 \times 10^{-6} \times -2 \times 10^{-6}}{4^2}$

$F = -0.0113 N$

$W = F \times d = 0.0113 \times 4 = -0.045 J$

$\therefore$ Work done at the position of 4m = $-0.045 J$

$\therefore V = W/q = -0.045/-2 \times 10^{-6} = 22500$ volts

Work done at the position of 10m = $0.0113 \times 0 = 0 J$

$\therefore V$ at the position of 10m = 0.

= 10m

4) What is Magnetic flux?

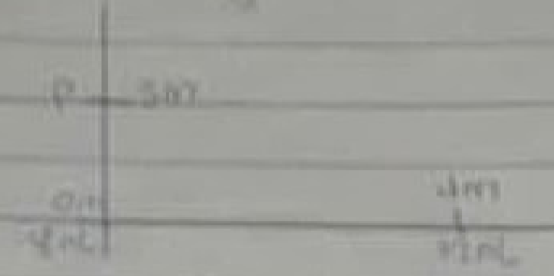
Magnetic flux is defined as the strength of magnetic field represented by lines of force.

5) $m = 9.11 \times 10^{-31} kg$, $q = 1.6 \times 10^{-19} C$, $r = 1.4 \times 10^{-7} m$, $B = 3.5 \times 10^{-1} weber/m^2$

$W = \frac{qB}{m} = \frac{1.60 \times 10^{-19} \times 3.5 \times 10^{-1}}{9.11 \times 10^{-3}}$

$W = 6.147 \times 10^{10}$ rad/s

to the charges



$Q_1 = 8\times10^{-9}C$, $Q_2 = 12\times10^{-9}$, $r_1 = 3m$, $r_2 = 7m$, $k = 9\times10^{9} Nm^2C^{-2}$

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

$E_2 = \frac{9\times10^{9}\times12\times10^{-9}}{7^2} = 2.204 N/C$

$E_{net} = (8 + 2.204) N/C = 10.204 N/C$

5a) State the formulation of the following density of charges

i) Volume charge density, $\rho = dQ/dv \Rightarrow dQ = \rho dv$

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

iii) Linear charge density, $\lambda = dQ/dL \Rightarrow dQ = \lambda dL$

b) Explain with appropriate equations the electric potential difference

An electric field E, exerts a force $F = q_0E$ on a charge. To move the test charge from A to B at constant velocity an external force of $F = -q_0E$ must act on the charge. Then the work done dW is

$$dW = F.dL \quad \text{---(1)}$$

$$F = -q_0E \quad \text{---(2)}$$

Substituting equation (2) in (1) yields

$$dW = -q_0E.dl \quad \text{---(3)}$$

The total work done in moving the charge from point A to B is:

$$W(A\to B)_{ag} = -q_0 \int_A^B E.dL \quad \text{---(4)}$$

From electric potential difference

$$V_B - V_A = \frac{W(A\to B)_{ag}}{q_0} \quad \text{---(5)}$$

From equation 4 and 5, we have: $V_B - V_A = -\int_A^B E.dL$ ---(6)

Equation (iii) becomes

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

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

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

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,

$$(x^2+a^2)^{1/2} \cong a \text{ as } a \to \infty$$

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