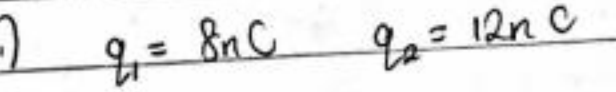
(2.) (a.) Electric field is the region of space in which an electric charge will experience an electric ~~for~~ force while electric~~f~~ field intensity also known as electric field strength is defined as the force per unit charge, it is the magnitude of electric field.

(b.) (i.) $q_1 = 8nC \quad q_2 = 12nC$

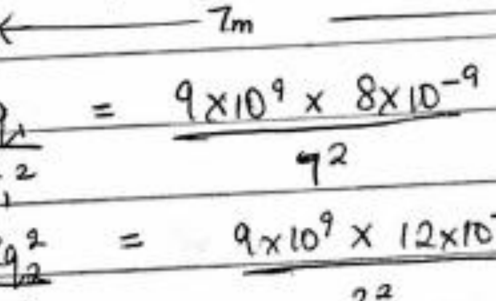


$$E_1 = \frac{Kq_1}{r_1^2} = \frac{9\times10^9 \times 8\times10^{-9}}{7^2} = 1.469N/C$$

$$E_2 = \frac{Kq_2^2}{r_2^2} = \frac{9\times10^9 \times 12\times10^{-9}}{3^2} = 12N/C$$

$$E_{net} = E_1 + E_2 = [1.469N/C + 12N/C] = 13.469N/C \simeq \underline{13.5N/C}$$

(ii.)



$$|Pq_2| = \sqrt{3^2+4^2} = \sqrt{25} = 5m$$

$$\sin\theta = 3/5$$

$$\theta = \sin^{-1}(3/5) = 36.9°$$

$$E_1 = \frac{Kq_1}{r_1^2} = \frac{9\times10^9 \times 8\times10^{-9}}{3^2} = 8N/C$$

$$E_2 = \frac{Kq_2}{r_2^2} = \frac{9\times10^9 \times 12\times10^{-9}}{5^2} = 4.32N/C$$

vector	Angle	x-component	y-component
$E_1 = 8N/C$	90°c	$E_1x = 8\cos 90° = 0\ N/C$	$E_1y = 8\sin 90° = 8\ N/C$
$E_2 = 4.32N/C$	36.9°	$E_2x = 4.32\cos 36.9 = 3.45N/C$	$E_2y = 4.32\sin 36.9° = 2.60N/C$
		$\Sigma E_x = 3.45N/C$	$\Sigma E_y = 10.60N/C$

$$E_{net} = \sqrt{\Sigma E_x^2 + \Sigma E_y^2} = \sqrt{3.45^2 + 10.6^2}$$

$$= \sqrt{124.2625}$$

$$= 11.147 \simeq \underline{11.15N/C}$$

(4.) (a) magnetic flux ~~is~~ refers to the number of magnetic lines of force passing through a given closed surface which is the magnetic field. It is what generates the field around a magnetic material. The SI unit of magnetic flux is Weber (Wb).

(b) $m = 9.11 \times 10^{-31}kg$, $r = 1.4 \times 10^{-7}m$, $\theta = 90°$; $B = 3.5 \times 10^{-1}T$, $v = 3 \times 10^{8}ms^{-1}$

$$F = qVB\sin\theta = \frac{mv^2}{r}$$

$$q \times 3 \times 10^{8} \times 3.5 \times 10^{-1} \times \sin 90° = \frac{9.11 \times 10^{-31} \times (3 \times 10^{8})^2}{1.4 \times 10^{-7}}$$

$$q = \frac{9.11 \times 10^{-31} \times \cancel{3 \times 10^{8}} \times 3 \times 10^{8}}{\cancel{3 \times 10^{8}} \times 3.5 \times 10^{-1} \times \sin 90 \times 1.4 \times 10^{-7}} = \frac{2.733 \times 10^{-22}}{4.9 \times 10^{-8}} = 5.578 \times 10^{-15}C$$

$$\omega = \frac{qB}{m_e} = \frac{5.578 \times 10^{-15} \times 3.5 \times 10^{-1}}{9.11 \times 10^{-31}} = \frac{1.952 \times 10^{-15}}{9.11 \times 10^{-31}} = 2.14 \times 10^{15}$$

$$= 2.14 \times 10^{15} rad/s$$

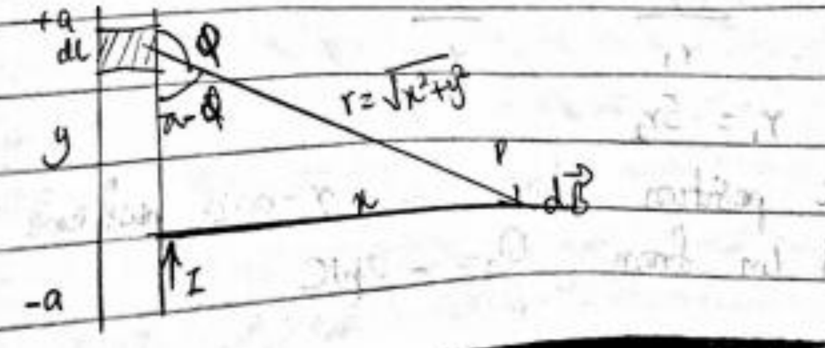
(c) The motion of the electron is in a uniform circular motion so the acceleration will be the centripetal acceleration, v^2/r $[F_B = qVB = \frac{mv^2}{r}]$. The angular speed of the electron will be $\omega = V/r$ so if you carry out the necessary substitutions, 2.14×10^{15} rad/s will be the angular speed also known as cyclotron frequency of the electron because the ~~charged par~~ electron circulates at this angular speed in the type of accelerator called cyclotron.

(5.) (a) Biot-Savart law is an equation that describes the magnetic field created by a current-carrying wire, and allows you to calculate its strength at various points.

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

where μ_0 is permeability of free space $[\mu_0 = 4\pi \times 10^{-7} T.m/A]$

(b)



(3.)(a)(i.) Volume charge density, $\rho = \frac{dQ}{dV} \rightarrow dQ = \rho dV$

(ii.) Surface charge density, $\sigma = \frac{dQ}{dA} \longrightarrow dQ = \sigma dA$

(iii.) Linear charge density, $\lambda = \frac{dQ}{dL} \rightarrow dQ = \lambda dL$

(b) The electric potential difference between two points in an electric ~~f~~ field can be defined as the work done per unit charge against electrical forces when a charge is transported from one point to ~~the~~ the other. It is a scalar quantity and measured in Volts (V) or Joules per Coulomb (J/C). In an electric field, suppose a test charge q_0 is moved ~~from~~ from a point A to a ~~poo~~ point B along an arbitrary path. The electric ~~fie~~ field exerts a force, $F = q_0 E$ on the charge. For the test charge to move from point A to point B, ~~let~~ an external force, $f = -q_0 E$ acts on the charge. The work done in moving this charge is given as; $dW = F.dL \rightarrow ①$

Recall; $F = -q_0 E \longrightarrow ②$ Substituting $F = -q_0 E$ in eqn ①; $dW = -q_0 E dL \longrightarrow ③$

∴ The total work done in moving test charge ~~for~~ from A to B is:

$$W(A \rightarrow B)_{Ag} = -q_0 \int_A^B E dL \longrightarrow ④$$

From the definition of electric potential difference; $\boxed{V_B - V_A = \frac{W(A\rightarrow B)_{Ag}}{q_0}} \rightarrow ⑤$

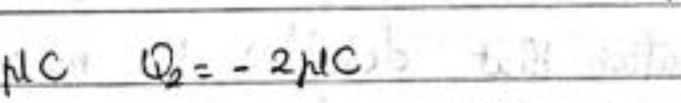
Substituting eqn ④ in ⑤ ; $V_B - V_A = -\int_A^B E dL \longrightarrow ⑥$

$$\Delta U = \frac{-W(A\rightarrow B)_{E}}{q_0} = \frac{W(A\rightarrow B)_{Ag}}{E}$$

$$\therefore V_B - V_A = \frac{\Delta U}{q_0} = \frac{U_B - U_A}{q_0}$$

[Potential difference can also be the potential energy per unit charge.]

(c) $Q_1 = 10\mu C \quad Q_2 = -2\mu C$



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

when $V=0$; $0 = 9\times10^9 \left[\frac{10\times10^{-6}}{r_1} - \frac{2\times10^{-6}}{r_2}\right]$

$$\frac{0}{9\times10^9} = \frac{10\times10^{-6}}{r_1} - \frac{2\times10^{-6}}{r_2} ; \quad \frac{10\times10^{-6}}{r_1} = \frac{2\times10^{-6}}{r_2}$$

$$2r_1 = 10r_2 ; \quad r_1 = 5r_2$$

Referring to the diagram above, the position along the x-axis where $V = 0$ is 5m from $Q_1 = 10\mu C$ and 1m from $Q_2 = -2\mu C$

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

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

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

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

From the diagram, $r^2 = x^2 + y^2$ (pythagoras theorem).

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

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

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

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

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

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

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

Using eqn (3); $B = \frac{\mu_0 I x}{4\pi}\left[\frac{y}{x^2(x^2+y^2)^{1/2}}\right]_{-a}^{a}$

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

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

when the length $2a$ of the conductor is very great in comparison to its distance ~~x~~ from point P, it is said to be infinitely long.

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

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