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19/ENG04/004
Elect/Elect Engineering

PHY 102 Assignment

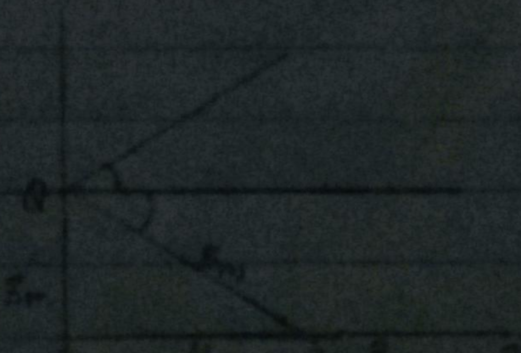
Questions 2, 3, 4, 5.

Section A

2a Electric field: this is a region of space in which an electric charge will experience an electric force.
Electric field intensity: Unlike electric field, this is defined as the force per unit charge.

2b $Q_1 = 8nC$; $Q_2 = 12nC$; $x = 4m$

i $r = 7m$



$E_1 = \frac{kq_1}{r_1^2} = \frac{9 \times 10^9 \times 8 \times 10^{-9}}{7^2} = 1.5 NC^{-1}$

$E_2 = \frac{kq_2}{r_2^2} = \frac{(9 \times 10^9) \times (12 \times 10^{-9})}{3^2} = 12 NC^{-1}$

$E_{net} = 12 + 1.5 = 13.5 \ NC^{-1}$

2b (a) $QE_1 = \frac{9 \times 10^9 \times 8 \times 10^{-9}}{3^2} = 8 \ NC^{-1}$

$\cancel{\theta}$	$\cancel{x \cos\theta}$	$\cancel{\sin\theta}$
$\cancel{90}$	$\cancel{0}$	$\cancel{+8}$

$\frac{9 \times 10^9 \times 12 \times 10^{-7}}{25} = 4.32 \ NC^{-1}$

	θ	x	y
8	90	$8\cos(90) = 0$	$8\sin(90) = 8$
4.32	36.87	$4.32\cos(36.87) = 3.46$	$4.32\sin(36.87) = 2.60$

$\Sigma F_x = 3.46 \quad \Sigma F_y = 10.60$

Using Pythagoras Theorem

$x = \sqrt{(10.60^2) + (3.46^2)}$

$= 11.15 \ NC^{-1}$

Electric field at point Q $= 11.15 \ NC^{-1}$

(3a)(i) Volume Charge Density: $\rho = dQ/dV \rightarrow dQ = \rho dV$

(ii) Surface Charge Density: $\sigma = dQ/dA \rightarrow dQ = \sigma dA$

(iii) Linear Charge Density: $\lambda = dQ/dL \rightarrow dQ = \lambda dL$

~~3(a)(i) Volume Charge Density : $\rho = dQ/dV \rightarrow dQ = \rho dV$~~

~~(ii) Surface Charge Density : $\sigma = dQ/dA \rightarrow dQ = \sigma dA$~~

~~(iii) Linear Charge Density : $\lambda = dQ/dL \rightarrow dQ = \lambda dL$~~

3(b) Electric Potential Difference : The electric potential difference between two points in an electric field can be defined as the workdone per unit charge against electrical forces when a charge is transported from one point to another.

$$dW = F \cdot dl$$

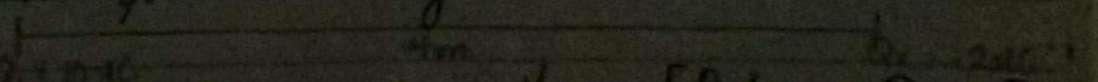
$$\text{But} \quad F = -q_0 E$$

$$\therefore \quad dW = -q_0 E \, dl$$

$$W(A \rightarrow B)_{Ag} = -q_0 \int_A^B E \, dl$$

$$V_B - V_A = \frac{W(A \rightarrow B)_{Ag}}{q_0} = \int_A^B E \, dl \,//$$

3(c) ~~Electric field intensity~~ $= \cancel{q/4\pi\varepsilon_0 r^2}$



$Q_1 = 10\mu C$; $Q_2 = -2\mu C$. $\quad V = 1/4\pi\varepsilon_0 \left[Q_1/r_1 \times Q_2/r_2 \right]$

$$\frac{0}{4 \times 10^{4}} = \frac{10 \times 10^{-6}}{r_1} \quad \frac{-2 \times 10^{-6}}{r_2}$$

$$2r = 10r^2 \,; \quad r_1 = 5r_2 \,//$$

Section B

4a Magnetic Flux: This is defined as the number of magnetic field lines passing through a given closed surface. It is also known as the strength of a magnetic field represented by lines of force.

4b $B = 3.5 \times 10^{-1}$ Weber/meter square

$m = 9.11 \times 10^{-31}$ kg

$r = 1.4 \times 10^{-7}$ m

$q = 1.6 \times 10^{-19}$

$\omega = ?$

$$\omega = \frac{qB}{m}$$

50

$$\omega = \frac{1.6 \times 10^{-19} \times 3.5 \times 10^{-1}}{9.11 \times 10^{-31}}$$

$= 6.15 \times 10^{10}$ rad/s

4c We were asked to find the cyclotron frequency of a moving electrons.

First, a cyclotron frequency is also known as angular velocity (ω) because the charge particle circulates at this angular speed in the type of accelerator called "cyclotron". Second, we were given mass of electron. Also, magnetic field which are all we need for this formula of obtaining the angular velocity

" $\omega = qB/m$ "

In which m is mass

B is magnetic field and

(charge on electron) q which is a constant $1 \cdot 6 \times 10^{-19}$

Biot-Savart law

5(a) this is an equation that describes the magnetic field created by a current wire and allows you to calculate its strength at various points.

~~$d\vec{B}$ ... $\frac{\mu_0}{4\pi}$ $I d\vec{l} \times \hat{r}$~~

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

(5) ~~Biot - Savart law : dis~~

Using ~~Bio~~ Biot - Savart Law find the magnitude of $d\vec{B}$

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

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

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

Substitute (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 $dl = dy$ (3)

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 (3) 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 great in comparison to its distance 'x' from point, P, we consider it infinitely long that is, when 'a' is no longer than x, $(x^2+a^2)^{1/2} \doteq a$, as $a \to \infty$ (tends to infinity). $\therefore$ $B = \dfrac{\mu_0 I}{2\pi x}$.

In a physical situation, we have axis symmetry about the y-axis. thus at all points in the circle of radius, r, around the conductor, the magnitude of the magnetic field of a straight current carrying conductor is :-

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