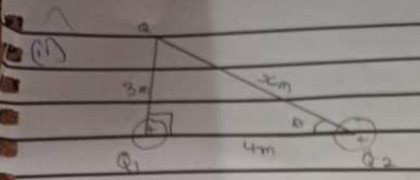
(ii)



$x = \sqrt{3^2 + 4^2} = 5m$

$\theta = \tan^{-1}(3/4) = 36.87°$

$E_1 = \frac{9\times10^9 \times 8\times10^{-9}}{3^2} = 8N/C$ $\qquad E_2 = \frac{9\times10^9 \times 12\times10^{-9}}{5^2} = 4.32N/C$

Vector	x com.	y com.
E_1	$8\cos 90$	$8\sin 90$
E_2	$-4.32\cos 36.87$	$4.32\sin 36.87$
$\Sigma =$	-3.456	10.592

$E_N = \sqrt{(-3.456)^2 + (10.592)^2} = \sqrt{124.1344} = 11.14 N/C$

3(a)(i) Volume charge density $\rho = dQ/dV$

(ii) Surface charge density $\sigma = dQ/dA$

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

(b) Electric potential difference between two points in an electric is the work done per unit charge when moving a charge from one point to another. It's measured in volt (V) or Joules per Coulomb (J/C).

$dW = F \cdot dL$

$F = -q_o E$

$dW = -q_o E\,dL$

$W(A \to B)_{ng} = -q_o \int_A^B E\,dL$

from the definition;

$V_B - V_A = W(A \to B)_{ng}/q_o$

$\therefore V_B - V_A = -\int_A^B E\,dL$

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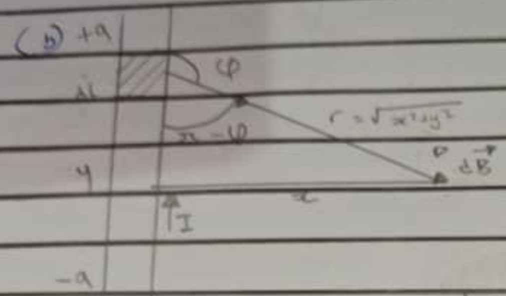
5(a) The Biot Savart Law states that the magnetic intensity at any point due to a steady current in an infinitely long straight wire is directly proportional to the distance from point to wire.

(b)



* A section of a straight current carrying conductor

applying 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, $r^2 = x^2 + y^2$

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

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

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

recall $dl = dy$

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

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

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

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

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

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

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

$$B = \frac{\mu_0 I}{2\pi r_{\parallel}}$$

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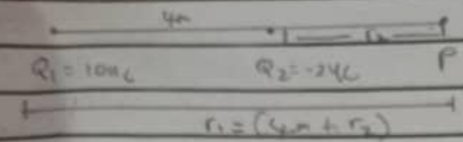
(c)



$V_P = 0$

$V_P = K\left[\frac{Q_1}{r_1} + \frac{Q_2}{r_2}\right]$

$0 = (9\times10^9)\left[\frac{(10\times10^{-9})}{(4+r_2)} + \frac{(-2\times10^{-9})}{r_2}\right]$

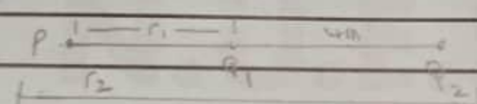
$0 = \frac{90}{4+r_2} - \frac{18}{r_2}$

$\frac{18}{r_2} = \frac{90}{4+r_2} \Rightarrow 72 + 18r_2 = 90r_2$

$r_2 = 72/72 = 1m$

$\therefore r_1 = 1+4 = 5m$

or if



$r_2 = 4 + r_1$

$0 = (9\times10^9)\left[\frac{(10\times10^{-9})}{r_1} + \frac{(-2\times10^{-9})}{(4+r_1)}\right] \Rightarrow 0 = \frac{90}{r_1} - \frac{18}{4+r_1}$

$\frac{18}{4+r_1} = \frac{90}{r_1} \Rightarrow 18r_1 = 360 + 90r_1$

~~$17r_1 = 360 \Rightarrow r_1 = 360/17 = r_1 = 360/17 =$~~

$-72r_1 = 360 \Rightarrow r_1 = -5m$

$\therefore r_2 = 4 + (-5) = -1m$

$\boxed{r_1 = 5m \text{ and } r_2 = 1m \quad \text{or} \quad r_1 = -5m \text{ and } r_2 = -1m}$

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SECTION B

4a) Magnetic flux is the number of field lines passing through the plane or area 'A' perpendicular to the magnetic field.

b) Cyclotron frequency $(f) = \frac{qB}{2\pi m}$

$= \frac{1.6 \times 10^{-19} C \times 0.35 T}{2 \times \pi \times 9.11 \times 10^{-31} kg} = 9.78 \times 10^{9}$ rad/s

c) The electron is travelling in a uniform circular ~~math~~ path and the force experienced by it is: $F_B = ma$.

Because it is in circular motion, we use centripetal acceleration v^2/r

$F_B = qVB = \frac{mv^2}{r}$

$r = mv/qB$

$\omega = v/r = qB/m$

The period T of motion is $\frac{2\pi r}{v} = \frac{2\pi}{\omega} = \frac{2\pi m}{qB}$

$F = 1/T$

$\therefore$ $F = qB/2\pi m$

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