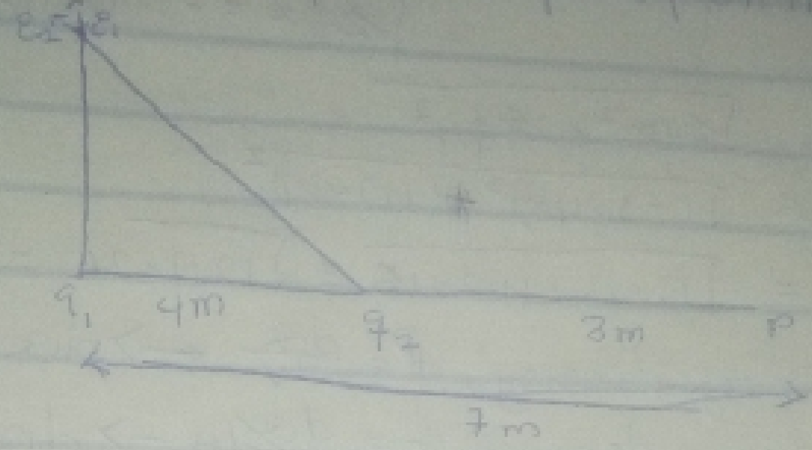
[illegible]

2a Section A

2a Electric field is a region of space in which a charged particle will experience an electric force while Electric field intensity is the force per unit charge

b $q_1 = 8nC$ at origin, $q_2 = 12nC$, x-axis at $x = 4m$

i net electric field at a point p on the x axis at x = 7m



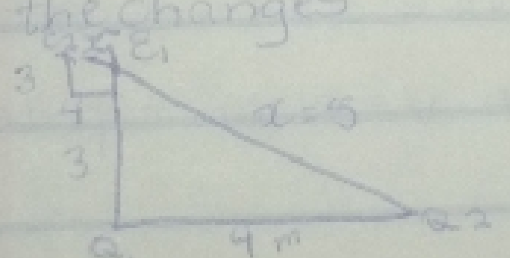
$$E_1 = \frac{kq_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-9}}{7^2} = 1.5 N/C$$

$$E_2 = \frac{kq_2}{r^2} = \frac{9\times10^9\times12\times10^{-9}}{7^2} = 12 N/C$$

$$E_{net} = E_1 + E_2 = (1.5 + 12) N/C = 13.5 N/C$$

ii Electric field at a point Q on the y axis at y = 3m d

the changes



$H^2 = O^2 + A^2$

$H^2 = 3^2 + 4^2$

$H = \sqrt{25} = 5$

$$\mathcal{E}_1 = \frac{kq_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-9}}{3^2} = 8N/C$$

$$\mathcal{E}_2 = \frac{kq_2}{r^2} = \frac{9\times10^9 \times 12\times10^{-9}}{5^2} = 4.32N/C$$

Vector	Angle	x comp	Y comp
$\mathcal{E}_1 = 8N/C$	$90°$	$0N/C$	$8N/C$
$\mathcal{E}_2 = 4.32N/C$	$36.87°$	$-3.48N/C$	$2.59N/C$
Total		$\Sigma f x = -3.48N/C$	$\Sigma f y = 10.59$

$$\mathcal{E}_{net} = \sqrt{\Sigma f x^2 + \Sigma f y^2}$$
$$= \sqrt{(-3.48)^2 + (10.59)^2}$$
$$= \sqrt{12.11 + 112.15} = \sqrt{124.26} = 11.12N/C$$

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

ii Surface charge density, $\sigma = dQ/dA \rightarrow dQ = \sigma dA$

iii Linear charge density, $\lambda = dQ/dl \rightarrow dQ = \lambda dl$

b Electric Potential difference equation. Due to a simple point charge.

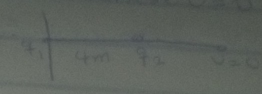
$$V_B - V_A = \frac{Q}{4\pi\varepsilon_0}\left[\frac{1}{r_B} - \frac{1}{r_A}\right]$$

where Q = Point charge, r_B = distance Q to B

r_A = distance Q to A V = electric potential

3c $Q_1 = 10\mu C$, $Q_2 = -2\mu C$, $x = 0$, $x = 4m$
find position along x-axis where $v = 0$

$$V_p = k\left[\frac{Q_1}{r_1} + \frac{Q_2}{r_2}\right]$$



$$= 9\times10^9\left[\frac{10\times10^{-6}}{4+x} + \frac{-2\times10^{-6}}{x}\right]$$

$$0 = 9\times10^9 \times \left[\frac{10\times10^{-6}}{4+x} + \frac{-2\times10^{-6}}{x}\right]$$

$$0 = \frac{10\times10^{-6}}{4+x} + \frac{-2\times10^{-6}}{x} = \frac{10\times10^{-6}}{4+x} = \frac{2\times10^{-6}}{x}$$

$$10\times10^{-6}x = (4+x)(2\times10^{-6})$$

$$10\times10^{-6}x = 8\times10^{-6} + 2\times10^{-6}x$$

$$10\times10^{-6}x - 2\times10^{-6}x = 8\times10^{-6}$$

$$8\times10^{-6}x = 8\times10^{-6}$$

$$x = \frac{8\times10^{-6}}{8\times10^{-6}} = 1$$ position along the x-axis

Section B

4a) Magnetic flux is defined as the strength of the m
field which can be represented by linear of force
denoted as Φ

b $M_e = 9.11\times10^{-31}$ kg, $r = 1.4\times10^{-7}$ m, B=
$q = 1.6\times10^{-19}$, cyclotron frequency = x

$F_B = qvB = \frac{m_e v^2}{r}$

$m_e v = qBr \therefore v = \frac{qBr}{m_e} = \frac{1.6\times10^{-19} \times 3.5\times10^{-1} \times \ldots}{9.11\times10^{-31}}$

$\omega = 6.14\times10^{10}\,C^{-1} \rightarrow$ Cyclotron frequency

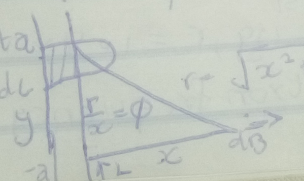
c. In 4b we were given $M_e = 9.11 \times 10^{-31}$ kg, $r = \ldots$, $B = 3.5\times10^{-1}\,w/m^2$ And asked to find the cyclotron frequency also known as angular speed. It is called cyclotron frequency because it is a frequency of an accelerator called cyclotron

Recall ω = angular speed = cycloton frequency $= \frac{qvB}{m_e}$

It has a unit of $\frac{1}{T}$ which is the unit of frequency dimensionally

5a Biot Savart law states that the magnetic field is directly proportional to the product permeability of free space (μ), the current (I), the change in length, the radius and inversely proportional to square of radius (r^2)

b) Magnetic field of a straight current carrying conductor



A section of a straight current carrying conductor

Applying Biot-Savart law we find the magnitude of the field (dB^y) by

$$B = \frac{N_0 I}{4\pi} \int_{-a}^{a} \frac{dL \sin\theta}{r^2}$$

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

$$B = \frac{N_0 I}{4\pi} \int_{-a}^{a} \frac{dL \sin(x - \theta)}{r^2}$$

from the diagram $r^2 = x^2 + y^2$

$$B = \frac{N_0 I}{4\pi} \int_{-a}^{a} \frac{dL \sin(x - \theta)}{x^2 + y^2} \quad \text{--- (i)}$$

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

substitute (ii) into (i)

$$B = \frac{N_0 I}{4\pi} \int_{-a}^{a} dL \frac{x}{(x^2 + y^2)(x^2 + y^2)^{1/2}}$$

$$= \frac{N_0 I}{4\pi} \int_{-a}^{a} dL \frac{x}{(x^2 + y^2)^{1/2}}$$

$dL = dy$ ∴ $B = \frac{N_0 I x}{4\pi} \int_{-a}^{a} \frac{1}{(x^2 + y^2)^{1/2}} dy$

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

$$B = \frac{N_0 I}{4\pi x} \left(\frac{2a}{(x^2 + a^2)^{2}}\right) \therefore (x^2 + a^2)^{1/2}$$

$$B = \frac{N_0 I}{2\pi x} = \frac{N_0 I}{2\pi r}$$