Applying the Biot savart law we find the magnitude of the field

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

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

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

From diagram $r^2 = x^2+y^2$

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

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

Substituting equation (2) into (1)

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

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

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

Using special integral

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

Equation (3) therefore becomes

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

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

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

$(x^2+a^2)^{1/2} \cong a$

as $a \rightarrow \infty$

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

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, the magnitude of B is

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

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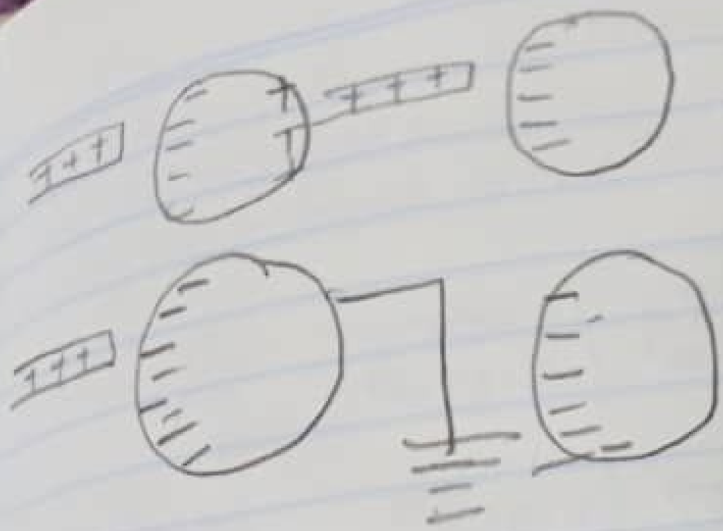
1(a) Charging by Induction.

Consider a negatively charged rubber rod brought near a neutral (uncharged) conducting sphere that is insulated so that there is no conducting path to ground as shown below. The repulsive force between the electrons in the rod and those in the sphere causes a redistribution of charges in the sphere so that some electrons move to the side of the sphere farthest away from the rod. The region of the sphere nearest the negatively charged rod has an excess of positive charge because of the migration of electrons away from this location. If a grounded conducting wire is then connected to the sphere some of the electrons leave the sphere and travel to the earth. If the wire to ground is then removed, the conducting sphere is left with an excess of induced positive charge.

Finally, when the rubber rod is removed from the vicinity of the sphere, the induced positive charge remains on the ungrounded sphere and becomes uniformly distributed over the surface of the sphere.



i.c) ~~k~~ $F = \frac{kq_1q_2}{r^2}$

$q_1 + q_2 = 5\times10^{-5}$ c. F = 1N

d = 2.

$1 = \frac{9\times10^9 \times 5\times10^{-5} \times q_1q_2}{2^2}$.

$4 = 4.5\times10^5 q_1 + 9\times10^9 q_2$.

$4 = 4.5\times10^5 q_1 + 9\times10^9 q_2$.

$9\times10^9 q^2 - 4.5\times10^5 q_1 + 4 = 0$.

$q_1 = 0.0000111$ c

$q_2 = 0.000038$ c

$\approx q_1 = 1.11\times10^{-5}$ c

$\approx q_2 = 3.8\times10^{-5}$ c

1c) $q_1 = q_2 = 8\mu c$.

d = 0.5m.

$E_1 = \frac{kq_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-6}}{1.1^2} = 5.9\times10^4$ c

$f_q = \frac{kq_2}{r^2} = \frac{9\times10^9 \times 8\times10^{-6}}{(1.1)^2} = 5.9\times10^4 c$

$E_q = \frac{kq}{r^2} = \frac{9\times10^9 \times q}{1^2} = 9\times10^9 q$

Vector	Angle	x comp	y comp
$f_1 = 5.9\times10^4$	63.4°	2.6×10^4	5.3×10^4
$f_2 = 5.9\times10^4$	63.4	2.6×10^4	5.3×10^4
$E_q = 9\times10^9 q$	90°	0	$9\times10^9 q$
		$E_x = 0$	$E_y = 1.0\times10^5 + 9\times10^9 q$

$|E| = \sqrt{(E_x)^2 + (E_y)^2}$

$\sqrt{(0)^2 + (1.0\times10^5)^2 (9\times10^9 q)^2}$

$\vec{E}$

$|E| = \sqrt{(1.0\times10^5)^2} + \sqrt{(9\times10^9 q)^2}$

$|E| = 1.0\times10^5 + 9\times10^9 q$

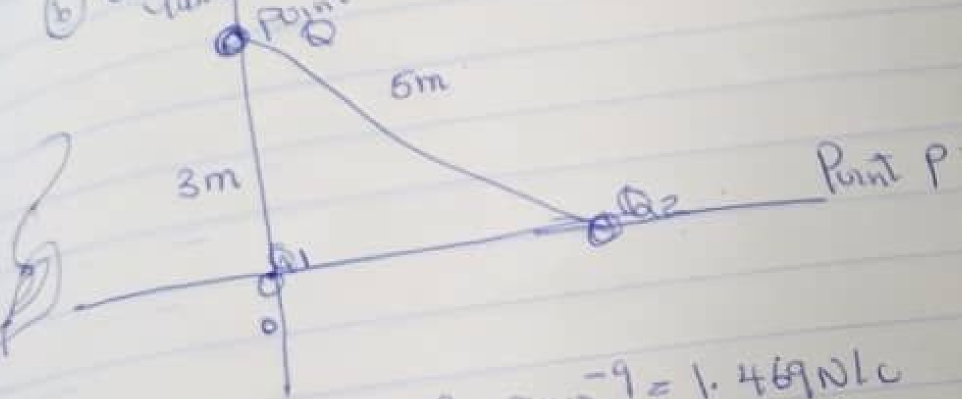
$0 = 1.0\times10^5 + 9\times10^9 q$

$q = \frac{-1.0\times10^5}{9\times10^9} = 1.1\times10^{-5} c$

(c) An electric field is a region in space in which an electric charge will experience an electric force. Hill an electric field intensity can be defined as the force per unit charge.

(b) $Q_1 = 8nC$ $Q_2 = 12nC$ $x = 4\,m$ $K = 9\times10^9\,Nm^2/C^2$

(axis)



$$E_1 = \frac{kq_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-9}}{7^2} = 1.469\,N/C$$

$$E_2 = \frac{kq_2}{r^2} = \frac{9\times10^9 \times 12\times10^{-9}}{3^2} = 12\,N/C$$

Vector	Angle	x component	y component
1.469	0°	$x\cos\theta$ $1.469\cos\theta$ 1.469	$y\sin\theta = 1.469 \times \sin\theta$ $= 0$
12	0°	$x\cos\theta = 12\cos 0$ $= 12$	$y\sin\theta = 12 \times \sin\theta$ 0
		13.469	0

Section B

4a) Magnetic flux is defined as the strength of the magnetic field represented by lines of forces. It is represented by the symbol ϕ

(b) $m = 9.11 \times 10^{-31}$ kg $\quad r = 1.4 \times 10^{-7}$

$B = 3.5 \times 10^{-1} \quad q = 1.6 \times 10^{-19}$ C

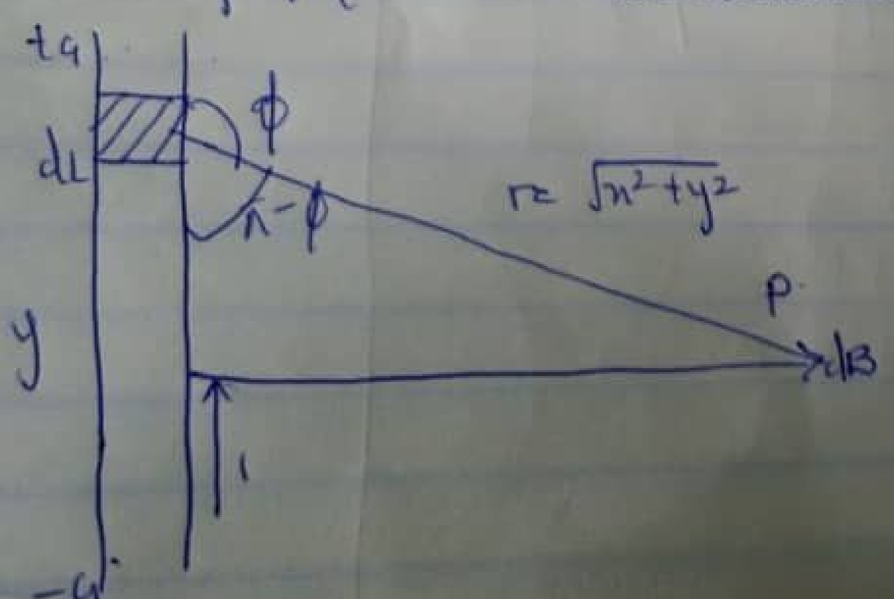
$$f = \frac{qB}{2\pi m}$$

$$f = \frac{1.6 \times 10^{-19} \times 3.5 \times 10^{-1}}{2 \times 3.142 \times 9.11 \times 10^{-31}}$$

$$\frac{5.6 \times 10^{-20}}{5.724 \times 10^{-30}}$$

$$f = 9.8 \times 10^{9} \text{ rad/s}$$

5a) Bio 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 current and inversely proportional to the distance from point to wire.



$E = \sqrt{(\Sigma x)^2 + (\Sigma y)^2}$

$E = \sqrt{(13.469)^2 + (0)^2}$

$E = \sqrt{181.41 + 0}$

$= 13.469$

(ii) $q_1 = 8nC$ $q_2 = 12nC$ $r = 3m$

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

$= 8N/C$

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

$= 4.32N/C$

Vector	Angle	x	y
8	90	0	8
4.32	53.33	2.59	3.66
		Σx 2.59	$\Sigma y = 11.66$

$E = \sqrt{(\Sigma x)^2 + (\Sigma y)^2}$

$E = \sqrt{(2.59)^2 + (11.66)^2}$

$E = 11.75N/C$