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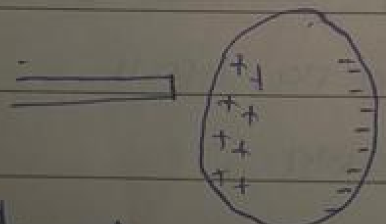
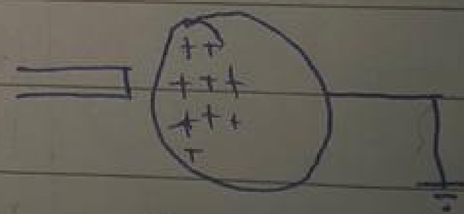
1a 19/MHS01/135

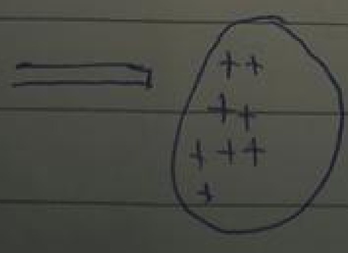
Elastic Charges can be obtained without touching by electrostatic induction consider a negative charged rubber brought near a neutral (uncharged) conducting sphere that is Insulated so that there is no conducting path to the gro the repulsive Force between the electrons in the rod and tho in the sphere will cause a redistribution of charges so th negative electron move to the side of the sphere Farthest aw from the rod and the region of the sphere nearest to the negat Charged rod has an excess of positive charges. A ground wir is then connected to the sphere and the negative electr in the sphere leave the sphere and travel to the earth. The wire to the ground in, the removed and the sphere is left with excess positive charge. And when the rubber rod is finally removed the induced positive charge remains on the sphere and becomes evenly distributed



Phase A



Phase B



Phase C

Phase D

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$F = 1N$

$d = 2m$

$q_1 + q_2 = 5\times10^{-5}C$

$q = 5\times10^{-5} - q_2$

$k = 9\times10^{9}$

$$F = \frac{k q_1 q_2}{d^2}$$

$$1 = \frac{9\times10^{9}\times(5\times10^{-5} - q_2)\times q_2}{(2)^2}$$

$4 = (9\times10^{9}\times5\times10^{-5}\times q_2) - (9\times10^{9}\times q_2\times q_2)$

$4 = 4.5\times10^{5}q_2 - 9\times10^{9}q_2^{2}$

Solving using the quadratic formula

$q_1 = 3.8\times10^{-15}C.$

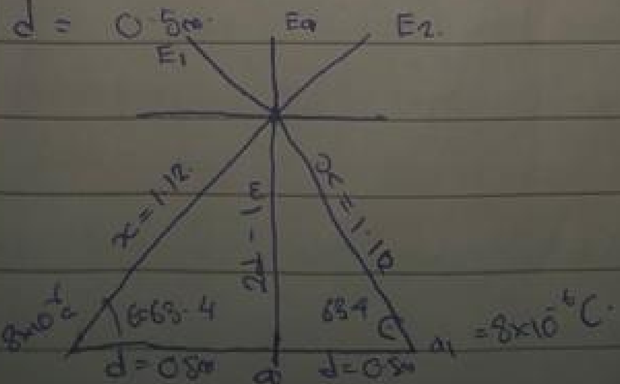
$q_2 = 1.2\times10^{-5}C.$

Hence a charge on each spher is

$3.8\times10^{-15}C$ and $1.2\times10^{-5}C$ respectively

C $Q_1 = Q_2 = 8uC$,

$d = 0.5m$




$\tan\theta = 1/0.5$

$\theta = \tan^{-1}(2)$

$\theta = 63.4$

$x^2 = 1^2 + 0.5^2$

$x = \sqrt{1.25}$

$x = 1.12$

$$E_1 = \frac{kq_1}{r^2} = \frac{9\times10^{9}\times8\times10^{-6}}{(1.12)^2} = 5.7\times10^{4}$$

$$E_2 = \frac{kq}{r^2} = \frac{9\times10^{9}\times8\times10^{-6}}{(1.12)^2} = 5.7\times10^{4}$$

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

| Vector | Angle | x-component | Y component |
|---|---|---|---|
| $E_1 = 5.7\times10^{4}$ | $63.4^\circ$ | $-5.7\times10^{4}\cos 63.4 = -2.6\times10^{4}$ | $5.7\times10^{4}\sin 63.4 = 5.1\times10^{4}$ |
| $E_2 = 5.7\times10^{4}$ | $63.4^\circ$ | $2.6\times10^{4}$ | $5.1\times10^{4}$ |
| $E_q = 9\times10^{9}q$ | $90^\circ$ | 0 | $9\times10^{9}q$ |

$E_x = 0$  $E_y = 102000$

$$\text{Magnitude} = \sqrt{(E_x)^2 + (E_y)^2}$$

$$E_q = \sqrt{(0)^2 + (102000)^2}$$

Since $E = 0$

$0 = 9\times10^{9}q + 102000$

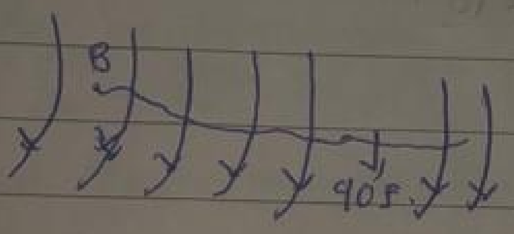
$9\times10^{9}q = -102000$

$$q = \frac{-102000}{9\times10^{9}}$$

$q = \simeq 11.4uC$

3a) Volume charge density $\rho = \frac{dQ}{dV} \rightarrow dQ = \rho dV$
Surface Charge density $\sigma = \frac{dQ}{dA} \rightarrow dQ = \sigma dA$
linear Charge density $\lambda = \frac{dQ}{dl} \rightarrow dQ = \lambda dl$

b) Electrical Potential difference-
the electric potential difference between two points in a electric field. can be defined as the work done per unit charge. against electrical force, when a charge is transported. from one point to the other. It is measured in Volt (V) or Joules per colomb.




In the diagram from above to move the test charge from A to B at constant velocity an external force of $F = -q_0 E$ must act on the charge therefore the elemental work done $dw$ is given as $dw = F dl$ —①
$F = -q_0 E$ —②
substituting eqn (2) into (1) yields
$dw = -q_0 E dl$ —③
then the total work done in moving the charge from A to B is
$W(A \rightarrow B)_{Ag} = -q_0 \int_A^B E dl$ —(4)

3) 4b Magnetic flux: this is defined as the strength of magnetic field which can be represented by line of force
It is represented by the symbol $\phi$ mathematically given
$\phi = B \cdot dA$.

3) b $M = 9 \times 10^{-31} kg$.
$r = 1.4 \times 10^{-9} m$
$B = 3.5 \times 10^{-1}$ weber/meter$^2$
cyclotron frequency = angular speed
$w = v/r = qb/m$.
$w = qB/m = \frac{1.6 \times 10^{-19} \times 3.5 \times 10^{-1}}{9 \times 10^{-31}}$
$W = 62222222222.22222 T^{-1}$.

c. The parmeters stated were
i Radius = $1.4 \times 10^{-2}$ m.
ii mass of electron = $9.11 \times 10^{-31} kg$
iii Magnetic field of $3.5 \times 10^{-1}$ weber/meter$^2$.
iv And the questioned being asked was to find the cyclotron frequency which is equal to angular speed.
Recall that angular speed is given as $w = v/r$.

So therefore sustituting values gives the final answer to be $62222222222.22222 T^{-1}$ since cyclotro frequency

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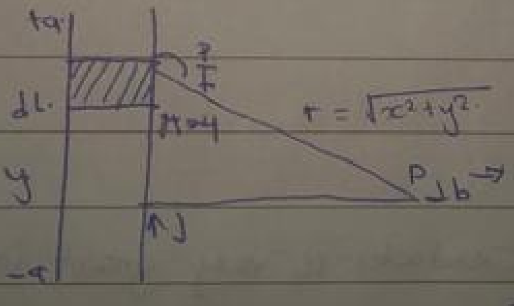
5a. Bio - Savart law states that the magnetic field is directly proportional that product permeability of free space ($\mu$) the current ($I$) the change in length, the radius and inversely proportional to the square of radius ($r^2$)

It can be represented mathematically as

$$\vec{db} = \frac{\mu_0}{4\pi} \frac{I\vec{dl} \times \vec{r}}{r^2}$$

Where $\mu_0$ is a constant called permeability of free space

5b Magnetic field of a straight current carrying conductor




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

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

From diagram $r^2 = x^2 + y^2$ (pythagoras theorem) - - - (1)

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

But $\sin(\pi - \alpha) = \frac{x}{\sqrt{x^2+y^2}} = \frac{x}{(x^2+y^2)^{2}}$ ——— ②

Substituting 2 into ① we have:

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

Recall $dl = dy$

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

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

using special integrals

Equation (3) therefore becomes:

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

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

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

When the length 2a of the conductor is very great in comparison to its distance x from point P, we consider it infinitely long. that is when a is much larger than x

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

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

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 $B = \mu_0 I / 2\pi r$ — (4)

Equation 4 defines the magnitude field of flux density B near a long straight carrying conductor.