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(1a) **Charging by induction:-**

Electric charges can be obtained on an object without touching it, by a process called electrostatic induction. Consider a positively charged rubber rod brought near a neutral conducting sphere that is insulated so that there is no conducting path to ground as shown below. The repulsive force between the protons in the rod and those in the sphere causes a redistribution of charges on the sphere so that some protons move to the side of the sphere farthest away from the rod. The region of the sphere nearest the positively charged rod has an excess of negative charge because of the migration of protons away from this location. If a grounded conducting wire is then connected to the sphere, some of the protons 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 negative charge.

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

(1b) $K = 10^9$

$Ov_1 + Ov_2 = 5 \times 10^{-5} C$

$F = 1N$

$d = 2m$

Calculate the charge on each sphere.

Recall that,

$K = 9 \times 10^9$

$F = \frac{KOv_1v_2}{r^2}$

$1 = \frac{9 \times 10^9 \times (Ov_1v_2 \; 5 \times 10^{-5})}{2^2}$

$4 = 9 \times 10^9 \times 5 \times 10^{-5} Ov_1 + 9 \times 10^9 Ov_2$

$9 \times 10^9 Ov_2 - 45 \times 10^5 Ov_1 + 4 = 0$

$Ov_1 = 0.0000111C$

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$DV_2 = 0.0000038C$

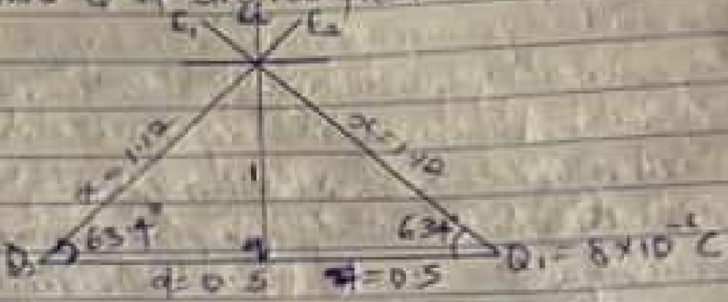
$\therefore DV_1 = 1.11 \times 10^{-5} C$

$DV_2 = 3.8 \times 10^{-6} C$

(c) $Q_1 = Q_2 = 8\mu C$

$d = 0.5m$

determine Q if electric field at a point P is Zero



$$E_1 = \frac{KQV_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-6}}{(1.12)^2} = 5739.795918$$

$$E_2 = \frac{KQV_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-6}}{(1.12)^2} = 5739.795918$$

$$E_Q = \frac{KQV}{r^2} = \frac{9\times10^9 \times QV}{1} = 9\times10^9 Q$$

	Vector	Angle	x-comp	y-comp
E_1	5739.795918	63.4	$E_1 \times \cos\theta$	$E \times \sin\theta$
			-2570.045785	5132.262839
E_2	5739.795918	63.4°	2570.045785	5132.262839
E_Q	$9\times10^9 Q$	90°	$E_Q\cos 90 = 0$, $E_x = 0$	$9\times10^9 Q$, $E_y = 10264.52$

(1)

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

$E_q = \sqrt{(0)^2 + (10264.52568)^2}$

since $E = 0$

$0 = 9\times10^9 Q + 10264.52568$

making Q subject of formula

$$Q = \frac{-10264.52568}{9\times10^9}$$

(2) $Q = 1.140502853 \times 10^{-6}$

$\therefore Q = 11.4\mu C$

(37) i) Surface charge density

ii) Linear charge density

iii) Volume charge density.

(36) 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 the other. It is measured in volt or Joules per

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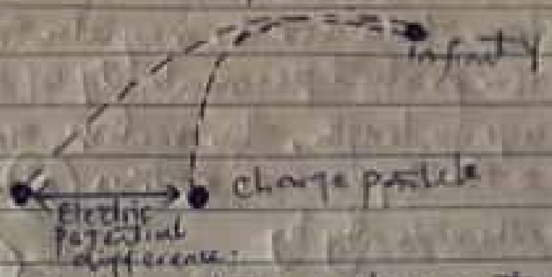
Coulomb Electric potential difference is a scalar quantity.
The Capacity of the charged body to do work determines the electrical potential on it. The measure of the electrical potential is the work done to charge a body to one Coulomb, i.e.,

$$\text{electrical potential} = \frac{\text{Workdone}}{\text{Charge}}$$

$$V = W/Q.$$



When a body is charged to a different electric potential as compared to the other charged body, the two bodies are said to a potential difference. Both the bodies are under stress and strain and try to attain maximum potential.

Section B.

(4a) Magnetic flux is defined as the strength of the magnetic field which can be represented by line of force. It is represented by the symbol ϕ. Mathematically given as $\phi = B \cdot dA$.

(4b) $m = 9 \times 10^{-31}$ Kg
$r = 1.4 \times 10^{-7}$ m
$B = 3.5 \times 10^{-1}$ weber/meter^2
Cyclotron frequency = angular speed

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

$$w = \frac{qB}{m} = \frac{1.6 \times 10^{-19} \times 3.5 \times 10^{-1}}{9 \times 10^{-31}}$$

$$w = 62222222.2222 \, T^{-1}$$

(4c) parameters
(i) Mass of electron = 9.11×10^{-31} Kg
(ii) Radius = 1.4×10^{-7} m
(iii) Magnetic field = 3.5×10^{-1} Weber/meter^2
∴ Cyclotron frequency = Angular speed. It is called cyclotron frequency because it is a frequency of an accelerator called cyclotron.
Recall the Angular speed is given as ω

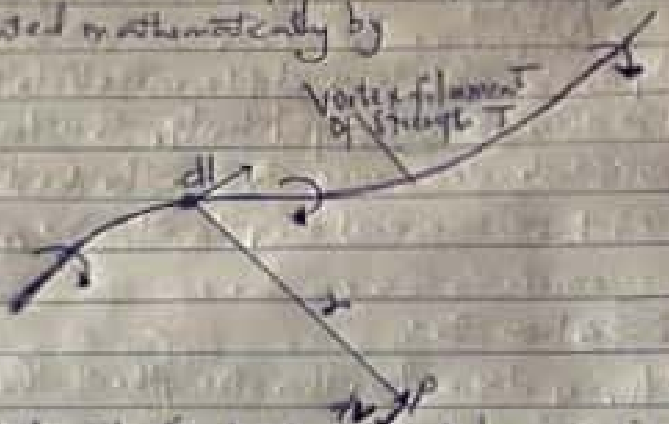
Substituting angular speed, we have

$1.6 \times 10^{-10} \times 3.5 \times 10^{-15}$ / $1.6 \times 10^{-10} \times 3 - 8 \times 10^{?}$

$= 62222222222.222 \times 10^{?}$

So since cyclotron frequency is equal to angular speed, the cyclotron frequency is equal to $= 612222.22222\,T^{-1}$, having a unit as $1/T$ which is equal to the unit of frequency, dimensionally.

(5a) Biot - Savart law states that the magnetic field is directly proportional to the product permeability of free space, the current, the change in length, the radius and inversely proportional to the square of radius (r^2). It can be represented mathematically by



Mathematically, Biot Savart law is given as

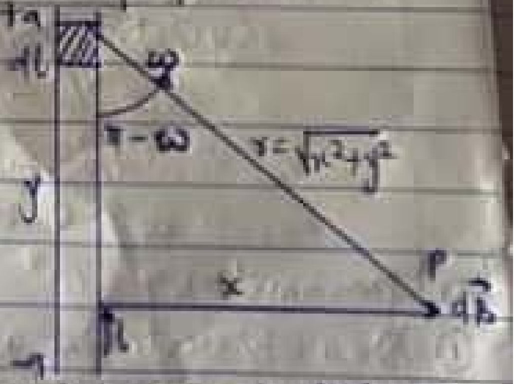
$$dB = KIdl\sin\theta/r^2$$

$$dB = \mu_0/4\pi \times Idl\sin\theta/r^2$$

Where K is the product permeability of free space.

(5b) Magnetic field of a straight current carrying conductor.

Fig 1: A section of a straight current carrying conductor



Applying the Biot-Savart law, we find the magnitude of the field.

~~[illegible]~~ Recall; when the length of ~~[illegible]~~ the conductor is very great in comparison to its distance from point P, we consider it infinitely long. That is, when a is much larger than, in a physical situation, we have axial symmetry about the y-axis. Thus, at all points in a circle of radius around the conductor, the magnitude of B is always (as shown above). Equation defines the magnitude of the magnetic field of flux density B near a long, straight current carrying conductor.