PAPER :- 0.1

Q.1. Proved that, $N/C = V/m$

Ans: To prove that

$$\frac{V}{m} = \frac{N}{C}$$

$$\therefore E = \frac{F}{q_0} = \frac{N}{C}$$

$$E = -\frac{dV}{dx} = \frac{V}{m}$$

$$\therefore R.H.S = \frac{V}{m}$$

$$= \frac{J/C}{m} \quad [\because V = J/C]$$

$$= \frac{\frac{N \times m}{C}}{m} \quad [\because J = N \times m]$$

$$= \frac{N \times m}{C \times m}$$

$$= \frac{N}{C} = L.H.S \quad \text{Hence Proved}$$

Q.2. Calculate the work done in moving a test charge $+q_0$ along a semi circular arc, with a source charge $+q$ at the centre of the arc.

Ans: As the displacement and centripetal force (electrostatic attraction force between charges) are perpendicular to each other therefor work done

$$W = Fd \cos 90^\circ = 0$$

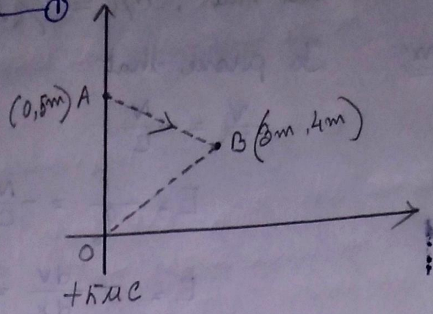
Q.3 A point charge of $+5\ \mu C$ is placed at the origin co-ordinate system. An electron is to be moved from (0, 5m) to (3m, 4m). Find the work done.

Ans: Given, $q = +5\ \mu C$

$$= +5 \times 10^{-6}\ C$$

Charge on electron, $q_0 = 1.6 \times 10^{-19}\ C$

$\therefore W_{A\to B} = q_0 (V_B - V_A)$ —①



$\therefore V_A = 9\times10^9 \frac{q}{r_A}$

$= 9\times10^9 \frac{5\times10^{-6}}{5}$

$= \frac{45\times10^3}{5}$

$= 9\times10^3\ V$

$V_B = 9\times10^9 \frac{q}{r_B}$

$= 9\times10^9 \frac{5\times10^{-6}}{5}$

$= \frac{45\times10^3}{5}$

$= 9\times10^3\ V$

① ⇒ $W_{A\to B} = 1.6\times10^{-19}\left(9\times10^3 - 9\times10^3\right)$

$= 0$

$\therefore$ The work done is 0.

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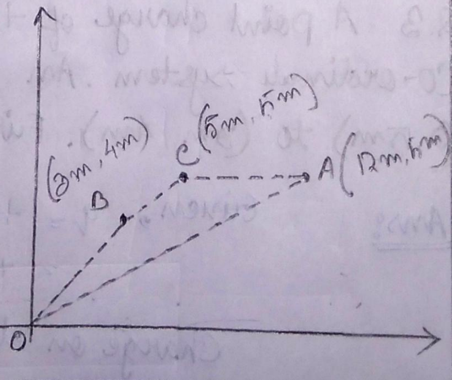
4) A point charge of +8 μC is placed at the origin of co ordinate system. An electron another of −2 nC is to be moved from (12m, 5m) to (3m, 4m) via (5m, 5m). Find the work done.



Ans: Given,

$q = 8\ \mu C$

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

$q_0 = -2\ nC$

$= -2\times10^{-9}\ C$

$A \rightarrow (12m, 5m)$

$B \rightarrow (3m, 4m)$

$C \rightarrow (5m, 5m)$

$$\therefore W_{A \rightarrow C \rightarrow B} = W_{A \rightarrow B} = q_0 [V_B - V_A] \quad \text{—— ①}$$

$$V_A = 9 \times 10^9 \frac{q}{r_A}$$

$$= 9 \times 10^9 \frac{8 \times 10^{-6}}{13}$$

$$= \frac{72 \times 10^3}{13}$$

$$= 5.54 \times 10^3 \ m$$

$$V_B = 9 \times 10^9 \frac{q}{r_B}$$

$$= 9 \times 10^9 \frac{8 \times 10^{-6}}{5}$$

$$= \frac{72 \times 10^3}{5}$$

$$= 14.4 \times 10^3 \ m$$

$$① \Rightarrow W_{A \rightarrow C \rightarrow B} = W_{A \rightarrow B} = -2 \times 10^{-9} [14.4 \times 10^3 - 5.54 \times 10^3]$$

$$= -2 \times 10^{-9} [14.4 - 5.54] \times 10^3$$

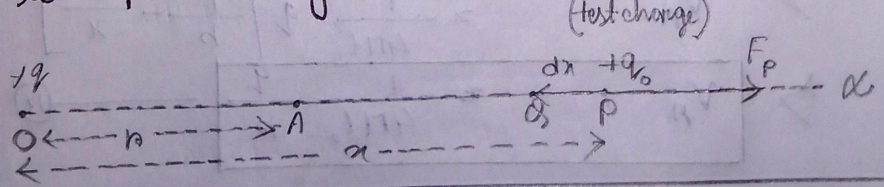
$$= -2 \times 10^{-9} \times 8.86 \times 10^3$$

$$= -17.72 \times 10^{-6}$$

$$= -1.772 \times 10^{-7} \ J.$$

Q. 5. Find an expression for the electric potential due to a point charge.

Ans:



Let the point charge $+q$ be at O, due to which we have to find out electric potential at A, $OA = b$.

By defination of electric potential at A

$$V_A = \frac{W_{\alpha \to A}}{q_0} \quad \text{--- (I)}$$

[Where $W_{\alpha \to A}$ is the amount of work done in moving $+q_0$ from infinity to A]

Let $OP = x$ $(b < x < \alpha)$

Let the test charge $+q_0$ at P

Repulsion force between $+q$ at O & $+q_0$ at P

$$F_P = \frac{1}{4\pi\epsilon_0} \frac{q q_0}{x^2} \text{ (towards right)} \quad \text{--- (II)}$$

Let $\vec{PQ} = \vec{dx}$

The small amount of work done in bringing $+q_0$ from P to Q

$$dW_{P \to Q} = \vec{F_P} \cdot \vec{PQ} = F_P \, dx \cos 180^\circ$$

$[\vec{F_P}$ & $\vec{PQ}$ are in opposite dir$^n]$

$$= -\frac{1}{4\pi\epsilon_0} \frac{q q_0}{x^2} dx \quad \text{--- (III)}$$

$$\therefore W_{\alpha \to A} = \int dW_{P \to Q} = \int_{\alpha}^{b} -\frac{1}{4\pi\epsilon_0} \frac{q q_0}{x^2} dx$$

$$= \int_{\alpha}^{b} -\frac{1}{4\pi\epsilon_0} \frac{q q_0}{x^2} dx$$

$$= -\frac{1}{4\pi\epsilon_0} q q_0 \int_{\alpha}^{b} \frac{dx}{x^2}$$

$$\Rightarrow \frac{W_{\alpha \to A}}{q_0} = -\frac{1}{4\pi\epsilon_0} q \left[-\frac{1}{x}\right]_{\alpha}^{b}$$

$$\Rightarrow V_A = \frac{1}{4\pi\epsilon_0} q \left[\frac{1}{b} - \frac{1}{\alpha}\right]$$

$$\Rightarrow \boxed{V_A = \frac{1}{4\pi\epsilon_0} \frac{q}{b}} \quad \text{--- (IV)}$$