Electric Potential

1. **Solⁿ:-** Proof To prove: $\frac{\text{Newton}}{\text{Coulomb}} = \frac{\text{Volt}}{\text{metre}}$

$$RHS = \frac{\text{Volt}}{\text{metre}}$$

$$= \frac{\text{Joule}}{\text{Coulomb} \times \text{metre}} \quad \left[\text{Volt} = \frac{\text{Newton} \times \text{metre}}{\text{Coulomb}} \right]$$

i.e

$$1V = \frac{1J}{1C}$$

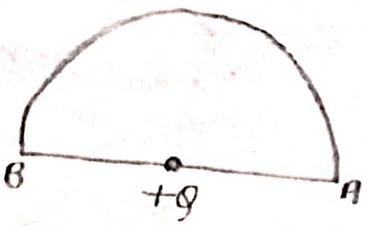
$$= \frac{\text{Newton} \times \text{metre}}{\text{Coulomb} \times \text{metre}}$$

$$= \frac{\text{Newton}}{\text{Coulomb}}$$

$= \cancel{R}$ LHS

$\therefore \quad N/C = V/m$

2. **Solⁿ:-** Since the test charge $+q_0$ is moving along a semi circular arc.



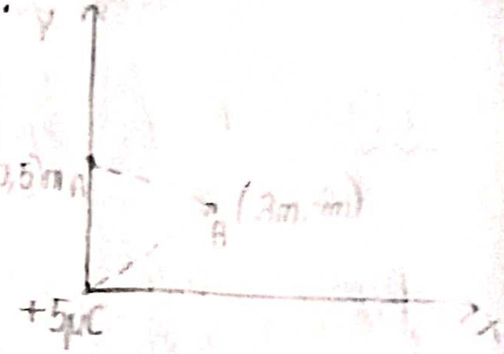
$\therefore \quad \Delta V = V_A - V_B = 0$

$W = q_0 \Delta V$ [$\because$ semi-circular arc is an equipotential surface]

$= q \times 0 \Rightarrow W = 0$

3. **Solⁿ:-**

3. Soln:- Let the pts be A(0,5) & B(3m,4m).



Given,

Potential at A(0,5)

$$V_A = \frac{W}{q}$$

$$\Rightarrow V_A = \frac{kq}{r} = \frac{9\times10^{9}\times5\times10^{-6}}{5}$$

$$\Rightarrow V_A = \frac{45\times10^{+3}}{5} = 9\times10^{+3}\,V$$

Potential at B(3m,4m)

$$V_B = \frac{kq}{r} = \frac{9\times10^{9}\times5\times10^{-6}}{5} = 9\times10^{+3}\,V$$

∴ Work done, $\frac{W_{B\to A}}{q} = V_A - V_B$

$$\cancel{\Rightarrow W_{B\to A} = (9\times10^{+3} - 9\times10^{+3})q}$$

$$\cancel{\Rightarrow W_{B\to A} = 0}$$

∴ $$\Rightarrow W_{A\to B} = (V_B - V_A)q$$

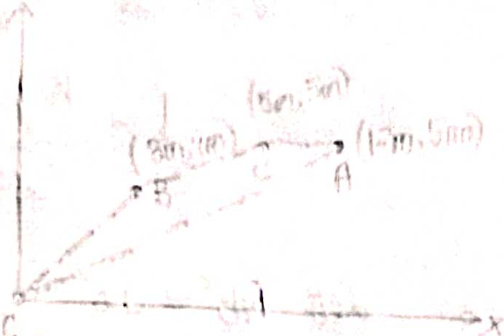
$$\Rightarrow W_{A\to B} = (9\times10^{3} - 9\times10^{3})q$$

$$\Rightarrow W_{A\to B} = 0$$

∴ Work done to move electron from A to B is 0

4. Soln:-

4. Solⁿ:- Let an electron of charge $-2nC$ is moved from $A(12m, 5m)$ to $B(3m, 4m)$ via $C(5m, 5m)$



$$\therefore W_{A\to B} = (V_B - V_A)q_0 \longrightarrow \text{[WD is a conservative force]}$$

$$\therefore V_B = \frac{Kq}{r} = \frac{9\times10^9\times8\times10^{-6}}{5} = \frac{72}{5}\times10^3\,V$$

$$V_A = \frac{Kq}{r} = \frac{9\times10^9\times8\times10^{-6}}{13} = \frac{72}{13}\times10^3\,V$$

$\because$ ~~$-2nC$~~ Let the test charge be q_0

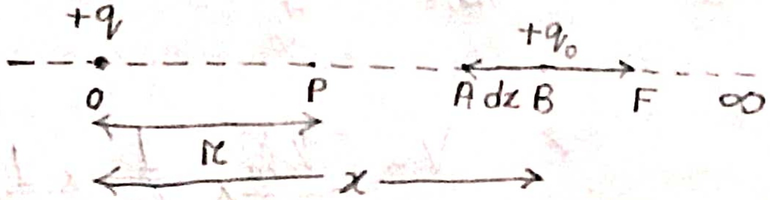
$$\therefore W_{A\to B} = \left(\frac{72\times10^3}{5} - \frac{72\times10^3}{13}\right)(-2\times10^{-9})$$

$$= \frac{(936-360)\times10^3\times(-2)\times10^{-9}}{65}$$

$$= \frac{576\times(-2)\times10^{-6}}{65}$$

$$= -17.72\times10^{-6}\,J$$

5. Solⁿ:-



Let a point charge be $+q$ at O due to which we have to find electric potential at P, i.e

$$V_{AP} = \frac{W_{\infty\to AP}}{q_0} \longrightarrow (1)$$

Let $OB = x$ $(r < x < \infty)$

Let a test charge $+q_0$ be at P.

$\therefore$ Force bet^n $+q$ and $+q_0$ will be

$$F = \frac{Kqq_0}{x^2} \longrightarrow (ii)$$

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

$\therefore$ Work done in moving the test charge from B to A

$$dW_{B\to A} = F.dx\cos 180 \quad \left[\begin{array}{r}\text{Force and } dx \text{ are} \\ \text{in opp. dir}^n\end{array}\right]$$

$$\Rightarrow W = \int dW_{B\to 0} = -\int F dx$$

$$\Rightarrow W_1 = -\int \frac{1}{4\pi\epsilon_0}\frac{q_1 q_0}{r^2}.dx$$

$$= \frac{-1}{4\pi\epsilon_0} qq_0 \int_{\infty}^{r} x^{-2} dx$$

$-\left[\frac{1}{x} - \frac{1}{x}\right]$

$$\therefore W_{\infty\to P} = \frac{-qq_0}{4\pi\epsilon_0 r}$$

$$(i) \Rightarrow V_{\infty} = \frac{W_{\infty\to P}}{q_0}$$

$$\Rightarrow V = \frac{-q\cancel{q_0}}{r} \times \frac{1}{4\pi\epsilon_0} \times \frac{1}{\cancel{q_0}}$$

$$\Rightarrow V = \frac{-q}{4\pi\epsilon_0 r}$$

$$\Rightarrow \boxed{V = -\frac{Kq}{r}} \longrightarrow (iii)$$