Isha Mahanta
Electric potential
Paper 01

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① Prove that, $N/C = V/m$

Solⁿ:- Taking RHS, V/m

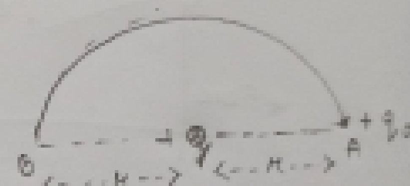
$$= \frac{J}{Cm} \quad (\because 1V = 1J/1C)$$

$$= \frac{Nm}{Cm} \quad (\because J = N \times m)$$

$$= N/C = LHS$$

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

② Calculate the workdone in moving a test charge $+q_0$ along a semi circular arc, with a source charge $+q$ at the centre of the arc (1)



We know

$$W_{A\to B} = q_0[V_B - V_A]$$

$$V_A = \frac{1}{4\pi\epsilon_0}\frac{q}{r}$$

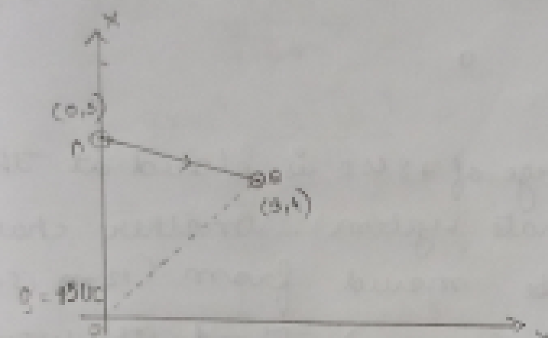
$$V_B = \frac{1}{4\pi\epsilon_0}\frac{q}{r}$$

$$\therefore W_{A\to B} = q_0\left[\frac{1}{4\pi\epsilon_0}\frac{q}{r} - \frac{1}{4\pi\epsilon_0}\frac{q}{r}\right]$$

$$= q_0 K \times 0$$

$$= 0$$

3) A point charge of +5 μC is placed at the origin of coordinate system. An electron is ~~as~~ to be moved from (0,5m) to (3m,4m). Find the work done. (3)



A → (0,5), B → (3,4)

$q_0 = -1.6 \times 10^{-19} C$

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

We know, $W_{A \to B} = q_0 [V_B - V_A]$

Now

$V_A = 9 \times 10^9 \cdot \frac{5 \times 10^{-6}}{OA}$

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

$= 9 \times 10^{+9-6}$

$= 9 \times 10^3 V$

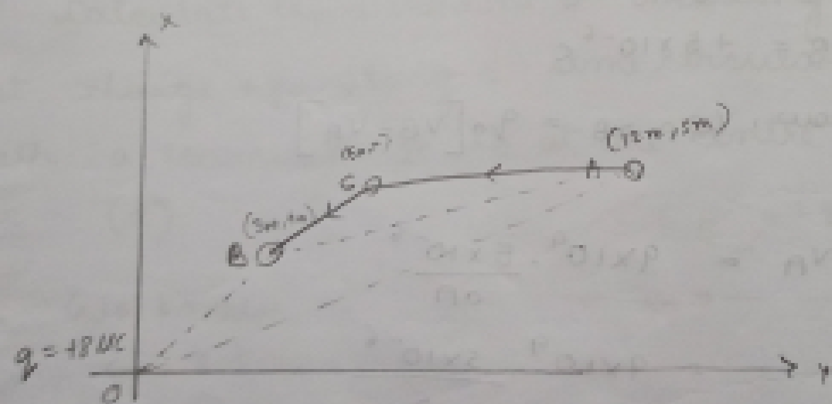
$V_B = 9 \times 10^9 \cdot \frac{5 \times 10^{-6}}{\sqrt{25}}$

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

$= 9 \times 10^3 V$

$$W_{A \to B} = q_0 [V_B - V_A]$$
$$= -1.6 \times 10^{-19} [9 - 9] 10^3$$
$$= \cancel{-16} - 1.6 \times 10^{-19} \times 0$$
$$= 0$$

Q4. A point charge of +8 μc is placed at the origin of coordinate system. Another charge of -2nC is to be moved from (12m, 5m) to (8m, 4m) via (5m, 5m). Find the work done (3)



A → (12m, 5m)

B → (8m, 4m)

C → (5m, 5m)

$q_0 = \cancel{+8 \times 10^{-16}} +8 \times 10^{-6}$

$q = -2 \times 10^{-9}$

$W_{A \to C \to B} = W_{A \to B}$ ($\because$ Workdone by conservative force depends only on final & initial position)

$= q_0 [V_B - V_A]$

$V_A = 9 \times 10^9 \cdot \frac{-2 \times 10^{-9}}{\sqrt{169}}$

$= 9 \times 10^9 \cdot \frac{-2 \times 10^{-9}}{13}$

$= \frac{-18 \times 1}{13} = -\frac{18}{13} \text{ V}$

$V_B = 9 \times 10^9 \cdot \frac{-2 \times 10^{-9}}{\sqrt{25}}$

$= \frac{-18 \times 10^0}{5}$

$= -\frac{18}{5} \text{ V}$

$W_{A \to B} = 8 \times 10^{-6} \left[-\frac{18}{5} + \frac{18}{13} \right]$

$= 8 \times 10^{-6} \left(\frac{-18 \times 13 + 18 \times 5}{65} \right)$

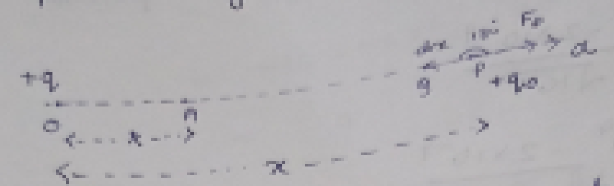
$= 8 \times 10^{-6} \left(\frac{-234 + 90}{65} \right)$

$= 8 \times 10^{-6} \left(\frac{-144}{65} \right)$

$= 8 \times 10^{-6} \times (-2.22)$

$= -17.7 \times 10^{-6} \text{ J}$

Q5. Find the expⁿ for electric potential due to a point charge



Let a point charge '+q' be at O due to which potential at A (OA = x) is

$V_A = \frac{W_{\infty \to A}}{+q_0}$ (workdone in bringing '+q₀' from ∞ to A) ---- (i)

Let

$OP = x \; (x < x < \infty)$

Let '+q₀' be moved from ∞ to A

When '+q₀' is at P, the repulsive force acting on '+q₀' due to +q is

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

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

W.D in moving '+q₀' from P to Q is

$dW_{P \to Q} = F_P \cdot dPQ \cos 180^\circ$

$= F_P \, dx \cos 180^\circ$ ($\because \vec{F_P}$ & $\vec{dx}$ are in opp dirⁿ)

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

$$\therefore W_{\infty \to A} = \int dW_{p \to q}$$

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

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

$$= -\frac{1}{4\pi\epsilon_0} q_0 q \left[-\frac{1}{x}\right]_{\infty}^{x}$$

$$\frac{W_{\infty \to A}}{q_0} = \frac{q}{4\pi\epsilon_0}\left[\frac{1}{x} - \frac{1}{\infty}\right]$$

$$V_A = \frac{q}{4\pi\epsilon_0}\left[\frac{1}{x} - 0\right]$$

$$\boxed{V_A = \frac{1}{4\pi\epsilon_0}\frac{q}{x}} \quad \text{- - - - (iv)}$$