Relation b/w W_{ext}, W_{con}, ΔU & U.

$$W_{ext} = -W_c$$

$$W_{ext} = \Delta U$$

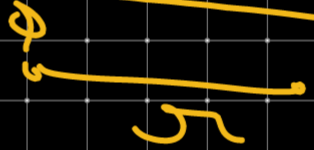
$$W_{ext} = U_f - U_i$$

$$\Delta U = -W_c$$

$$U_f - U_i = -W_c$$

$$U_f - U_i = -W_{elec}$$

$$U_i - U_f = W_{ele}$$



Imp

$$V_r - V_\infty^{\,0} = \frac{W_{\infty \to r}}{q}$$

$$V_r = \frac{Kq}{r}$$

Relation b/w ΔU & ΔV (OR) U & V.

q @ ∞

$$V_r = \frac{W_{\infty-r}}{q}$$

$$W_{ext} = \Delta U$$

$$W_{\infty-r} = U_r - U_\infty \quad (U_\infty = 0)$$

$$V_r - V_\infty = \frac{W_{\infty-r}}{q} \quad (V_\infty = 0)$$

$$\boxed{\Delta U = W_{\infty-r}}$$

$$V_r = \frac{U_r}{q}$$

$$\boxed{U_r = qV_r}$$

Electric Potential

#

$$U = \frac{K q_1 q_2}{r}$$

$$V = \frac{K q_1}{r}$$

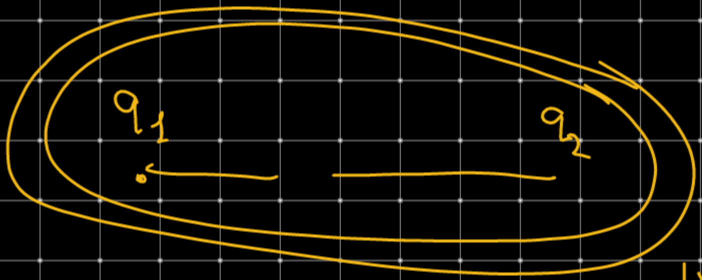
$$U = q_2 [V]$$

$$U = q_2 \left[\frac{K q_1}{r}\right] = \frac{K q_1 q_2}{r}$$

Electric potential Energy of System of charge.

① q_1 ——— r ——— q_2

$$U = \frac{K q_1 q_2}{r}$$



∞

q_2

$$\boxed{W_{ext}(\infty - r) = \Delta U}$$

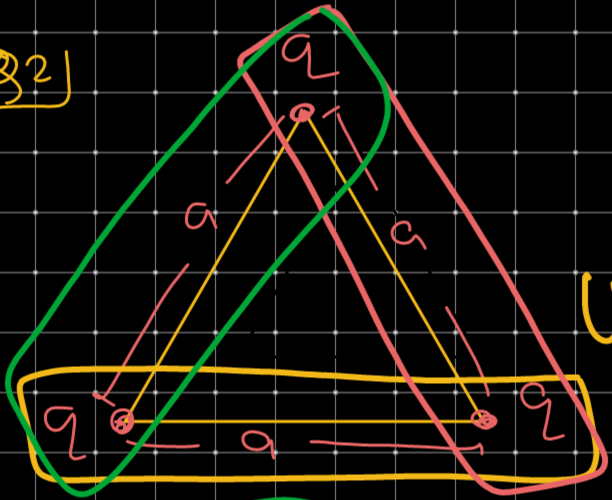
$$W_{ext(\infty - r)} = U_f - U_i$$

$U_i = 0$

$$= U_f$$

$$U = \frac{K q_1 q_2}{r}$$

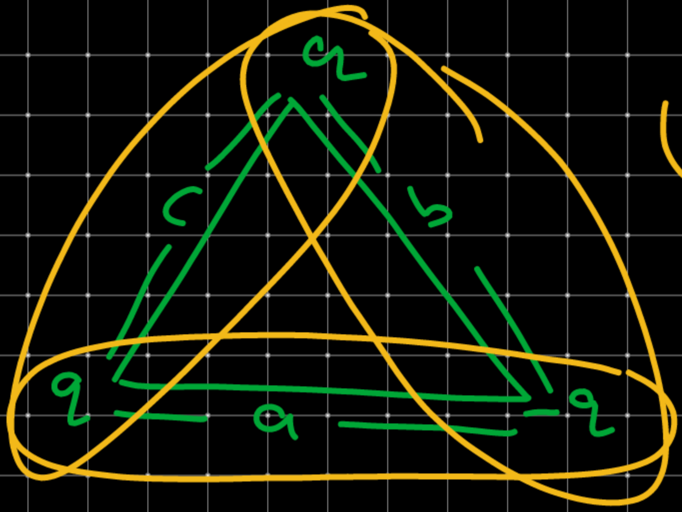
Q2)



Q) Find Potential Energy of the System.

$$U = \frac{Kqq}{r} + \frac{Kqq}{r} + \frac{Kqq}{r}$$

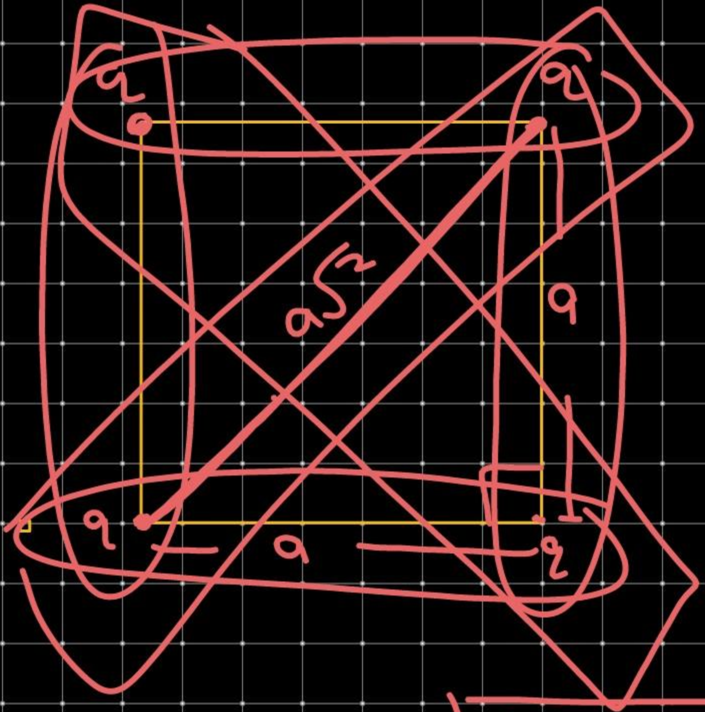
$$U = \frac{3Kq^2}{r}$$



$$U = \frac{kq(-q)}{a} + \frac{kq(-q)}{b} + \frac{kqq}{c}$$

$$U = -\frac{kq^2}{a} - \frac{kq^2}{b} + \frac{kq^2}{c}$$

Q3)



$$U = \frac{Kqq}{a} + \frac{Kqq}{a} + \frac{Kqq}{a} + \frac{Kqq}{a} + \frac{Kqq}{a\sqrt{2}} + \frac{Kqq}{a\sqrt{2}}$$

$$U_T = \frac{4Kq^2}{a} + \frac{2Kq^2}{a\sqrt{2}}$$

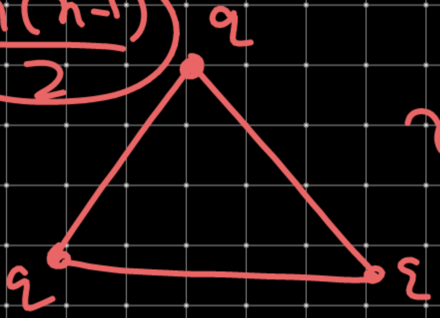
$$= \frac{4Kq^2}{a} + \frac{Kq^2\sqrt{2}}{a}$$

$$U_T = \frac{Kq^2}{a}\left[4+\sqrt{2}\right]$$

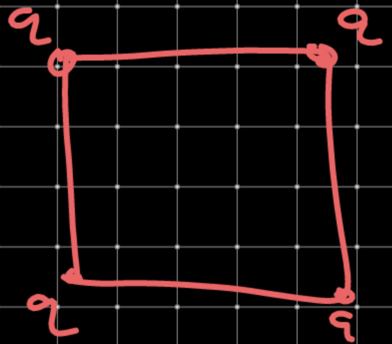
$$\frac{n(n-1)(n-2)!}{2!\,(n-2)!} \qquad {}^{n}C_2 = \frac{n!}{2!\,(n-2)!}$$

$$\text{No of pair} = \frac{n(n-1)}{2}$$

$$= \frac{n(n-1)}{2}$$



$$\text{No of pair} = \frac{3(3-1)}{2} = 3$$

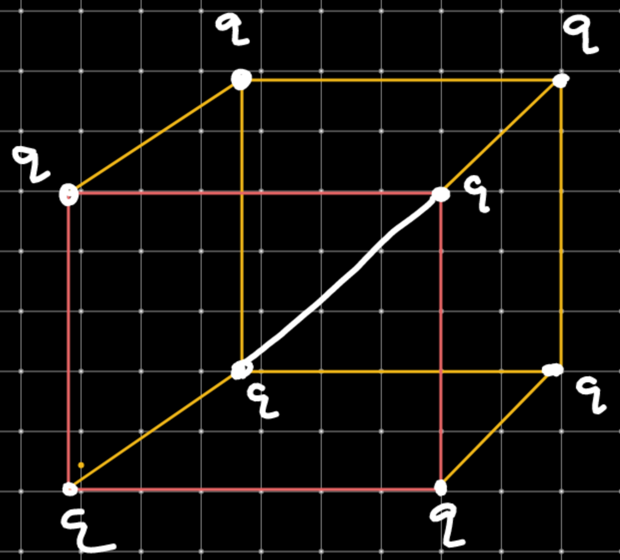


$$\text{no} = \frac{4(4-1)}{2}$$

$$= 2 \times 3$$

$$= 6$$

Side = a



$$\text{no of pair} = \frac{\overset{4}{\cancel{8}}(8-1)}{\cancel{2}}$$

$a\sqrt{3} \to (4)$

$$4 \times \frac{Kq^2}{a\sqrt{3}}$$

$= 4 \times 7 = 28$

$\hookrightarrow (a) \longrightarrow 12 \Rightarrow 12 \times \frac{Kqq}{a}$

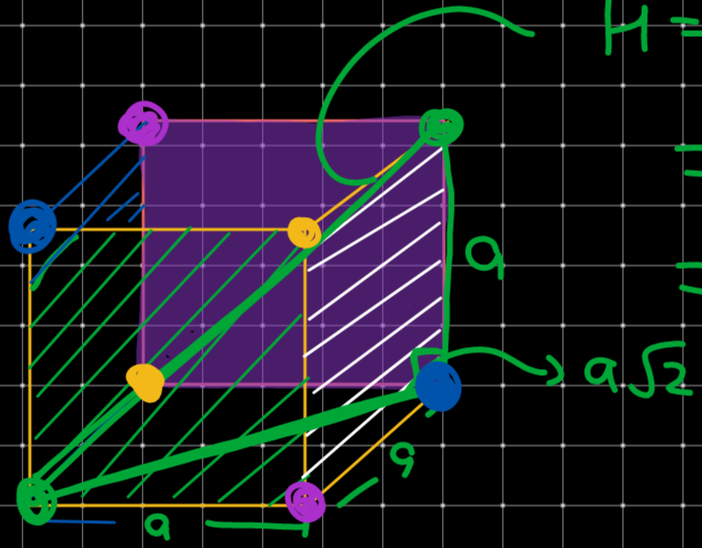
$= \frac{12Kq^2}{a}$

→ 6 Plane

$1 \to \underline{2}$

$a\sqrt{2} \Rightarrow \text{Pair} = 12 \text{ Pair}$

$$V_{a\sqrt{2}} = 12\left[\frac{Kq^2}{a\sqrt{2}}\right]$$



$$H = \sqrt{(a\sqrt{2})^2 + a^2}$$

$$= \sqrt{2a^2 + a^2}$$

$$= a\sqrt{3}$$

Q4)

⇒ Work Energy theorem

$$W_T = K_f - K_i$$

$$W_{nc} + W_c = K_f - K_i$$

If $W_{nc} = 0$

$$W_c = K_f - K_i$$

$$U_i - U_f = K_f - K_i$$

$$K_i + U_i = K_f + U_f$$

Mechanical Energy Conservation.

$$[W_c = U_i - U_f]$$

$$W_{ext} = -W_c$$

⇓

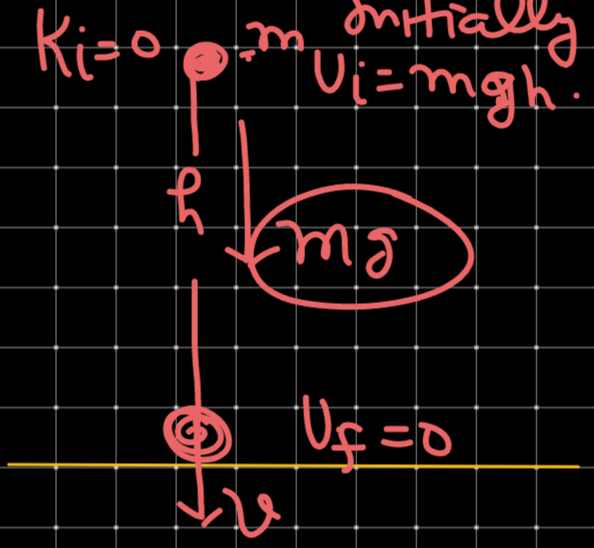
$$\Delta U = -W_c$$

$$W_c = -\Delta U$$

$$= -[U_f - U_i]$$

$$W_c = U_i - U_f$$

Initially rest



$$U_i + K_i = U_f + K_f$$

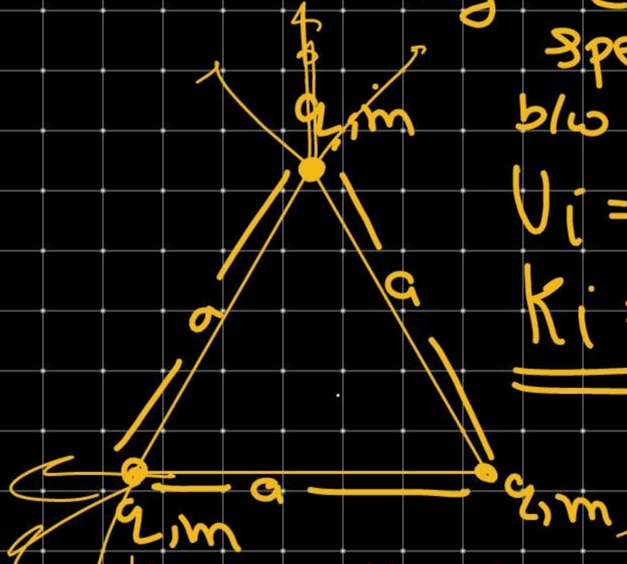
$$mgh + 0 = 0 + \frac{1}{2} m v^2$$

$$2gh = v^2$$

$U = 0$

$$v = \sqrt{2gh}$$

If charges are free to move, then find speed of each particle when distance b/w charges are 2a.



$U_i = \frac{3Kq^2}{a}$

$K_i = 0$

$U_i + K_i = U_f + K_f$

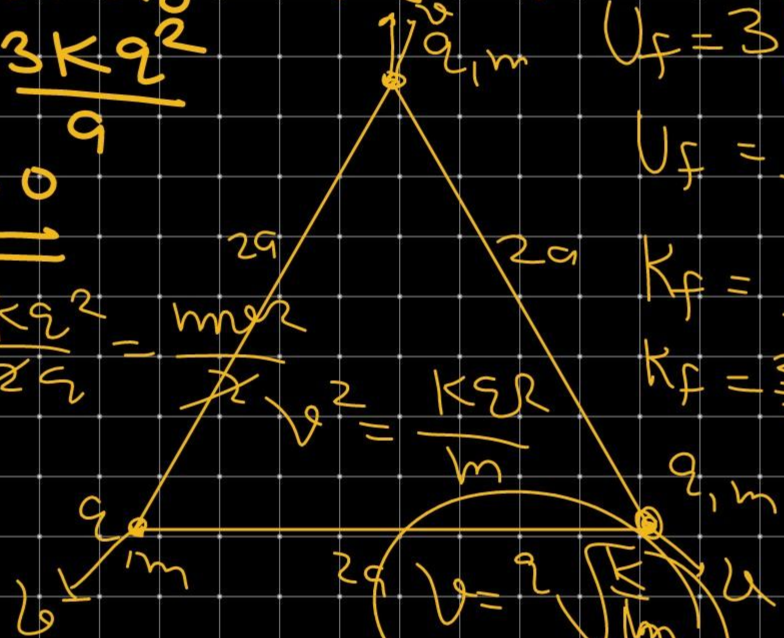
$\frac{3Kq^2}{a} + 0 = \frac{3Kq^2}{2a} + \frac{3mv^2}{2}$

$\frac{Kq^2}{a} - \frac{Kq^2}{2a} = \frac{mv^2}{2}$

$\frac{Kq^2}{2a} = \frac{mv^2}{2}$

$v^2 = \frac{Kq^2}{m}$

$v = q\sqrt{\frac{K}{m}}$



$U_f = 3\left[\frac{Kq^2}{2a}\right]$

$U_f = \frac{3Kq^2}{2a}$

$K_f = 3\left[\frac{1}{2}mv^2\right]$

$K_f = \frac{3}{2}mv^2$

Q5)

2C (fixed) — 4C, mass 1kg (rest, free to move)

Find speed of 4C charge when distance b/w charges becomes 9m.

Sol) Electrostatics, Conservative Nature.

$U_i + K_i = U_f + K_f$

$\frac{K(2)(4)}{3} + 0 = \frac{K(2\times4)}{9} + \frac{1}{2}\times1\times v^2$

$\frac{8K}{3} - \frac{8K}{9} = \frac{1}{2}v^2$

$\frac{16K}{9} = \frac{1}{2}v^2$

$\frac{1}{2}v^2 = \frac{16}{9}\times 9\times10^9$

$v^2 = 16\times2\times10^9$

$v = 4\sqrt{2}\times10^4\times\sqrt{10}$

$= 4\sqrt{20}\times10^4$

$= 4\times2\sqrt{5}\times10^4$

$v = 8\sqrt{5}\times10^4\ m/s$

Q7)

$2\mu C$ (fixed) ——— 9 m ——— $-3mC$, 1 g, rest → free to move

$v = 20\times 2\sqrt{15}$

$v = 40\sqrt{15}\ m/s$

Find speed of ($-3mC$) charge when distance b/w charges becomes 3m.

$$U_i = \frac{9\times10^9 \times 2\times10^{-6}\times(-3\times10^{-3}C)}{9} = -6J$$

$$K_i = 0$$

$$U_f = \frac{9\times10^9\times2\times10^{-6}\times(-3\times10^{-3})}{3}$$

$$U_f = -18J$$

$$K_f = \frac{1}{2}\times10^{-3}\times v^2$$

$$U_i + K_i = U_f + K_f$$

$$-6J + 0 = -18J + \frac{1}{2}\times10^{-3}v^2$$

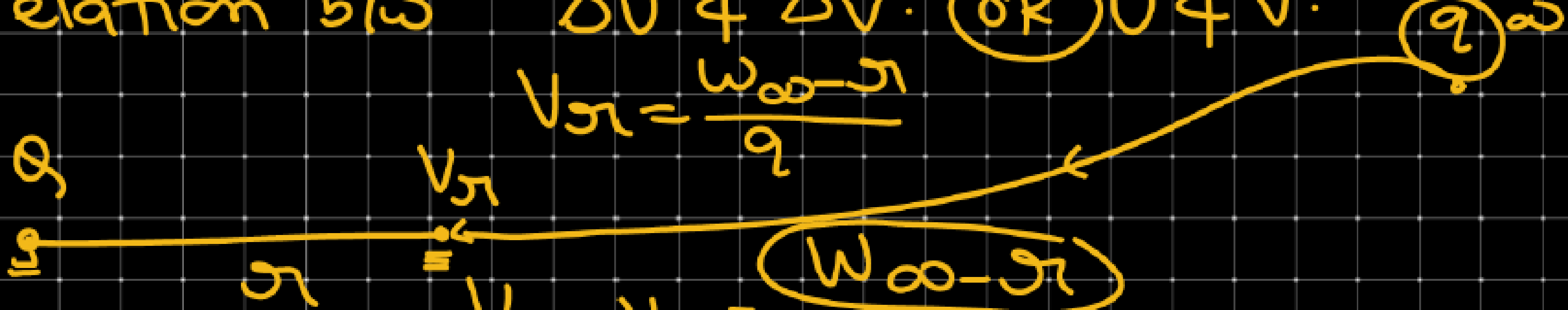
$$+12J = \frac{1}{2}\times10^{-3}v^2$$

$$24\times10^{+3} = v^2$$

$$v = \sqrt{24}\times10\times\sqrt{10}$$

$$= 2\sqrt{6}\times\sqrt{10}\times10 = 20\sqrt{60}\ m/s$$

Relation b/w ΔU & ΔV (OR) U & V.



$$V_r = \frac{W_{\infty-r}}{q}$$

$$V_r - V_\infty = \frac{W_{\infty-r}}{q}$$

$V_\infty = 0$

$$\boxed{\Delta U = W_{\infty-r}}$$

$$W_{ext} = \Delta U$$

$$W_{\infty-r} = U_r - U_\infty$$

$U_\infty = 0$

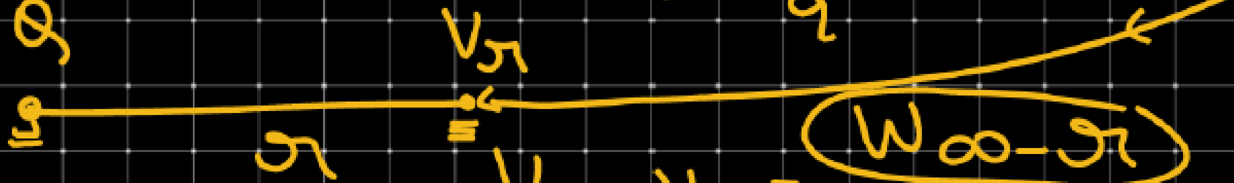
$$V_r = \frac{U_r}{q}$$

$$\boxed{U_r = qV_r}$$

Relation b/w ΔU & ΔV (OR) U & V.

q_{∞}

$$V_r = \frac{W_{\infty-r}}{q}$$



$$V_r - V_{\infty} = \frac{W_{\infty-r}}{q}$$

$V_{\infty} = 0$

$$\Delta U = W_{\infty-r}$$

$$W_{ext} = \Delta U$$

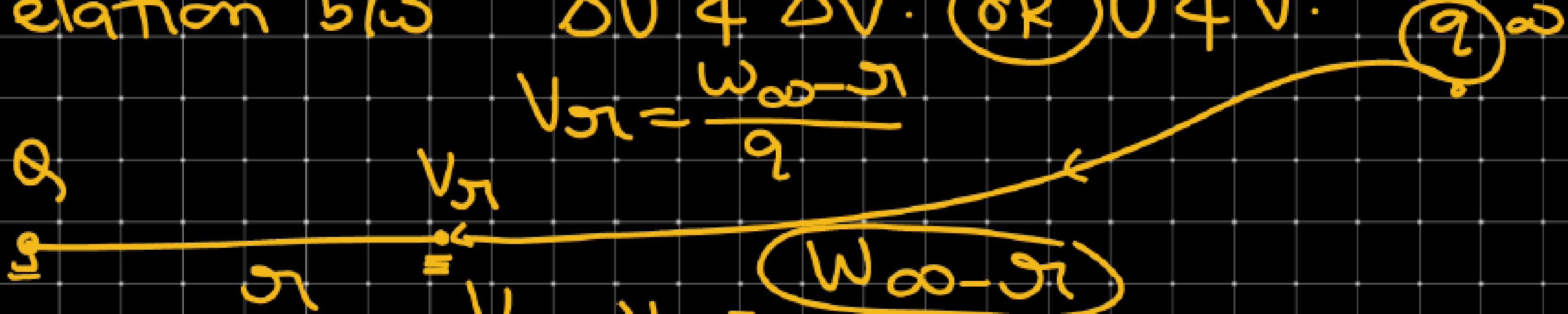
$$W_{\infty-r} = U_r - U_{\infty}$$

$U_{\infty} = 0$

$$V_r = \frac{U_r}{q}$$

$$U_r = qV_r$$

Relation b/w ΔU & ΔV (OR) U & V.



$$V_r = \frac{W_{\infty-r}}{q}$$

$$V_r - V_\infty = \frac{W_{\infty-r}}{q}$$

$V_\infty = 0$

$$\Delta U = W_{\infty-r}$$

$$W_{ext} = \Delta U$$

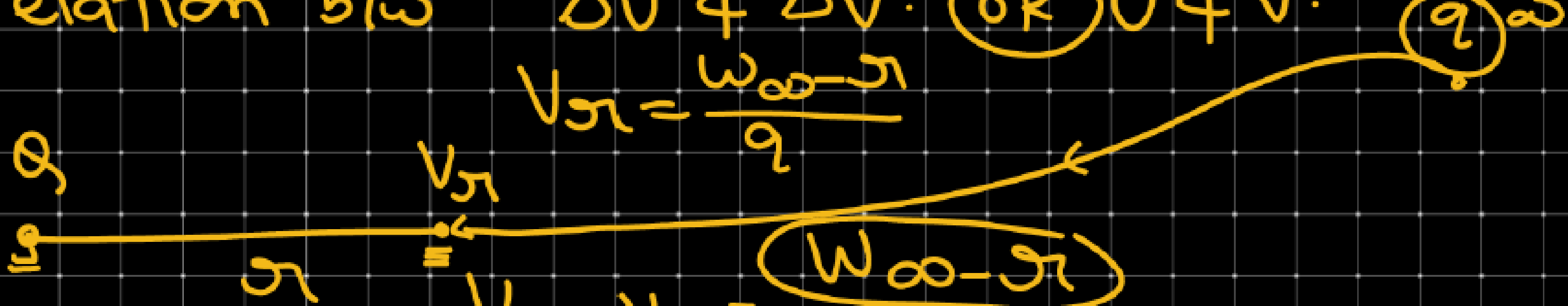
$$W_{\infty-r} = U_r - U_\infty$$

$U_\infty = 0$

$$V_r = \frac{U_r}{q}$$

$$U_r = q V_r$$

Relation b/w ΔU & ΔV (OR) U & V.



$$V_r = \frac{W_{\infty - r}}{q}$$

$$V_r - V_\infty = \frac{W_{\infty - r}}{q}, \quad V_\infty = 0$$

$$\boxed{\Delta U = W_{\infty - r}}$$

$$W_{ext} = \Delta U$$

$$W_{\infty - r} = U_r - U_\infty, \quad U_\infty = 0$$

$$V_r = \frac{U_r}{q}$$

$$\boxed{U_r = q V_r}$$

$F = -\frac{\partial U}{\partial r}$

F = Force

$U = qV$

$U \rightarrow$ Potential Energy.

$r \rightarrow$ position vector.

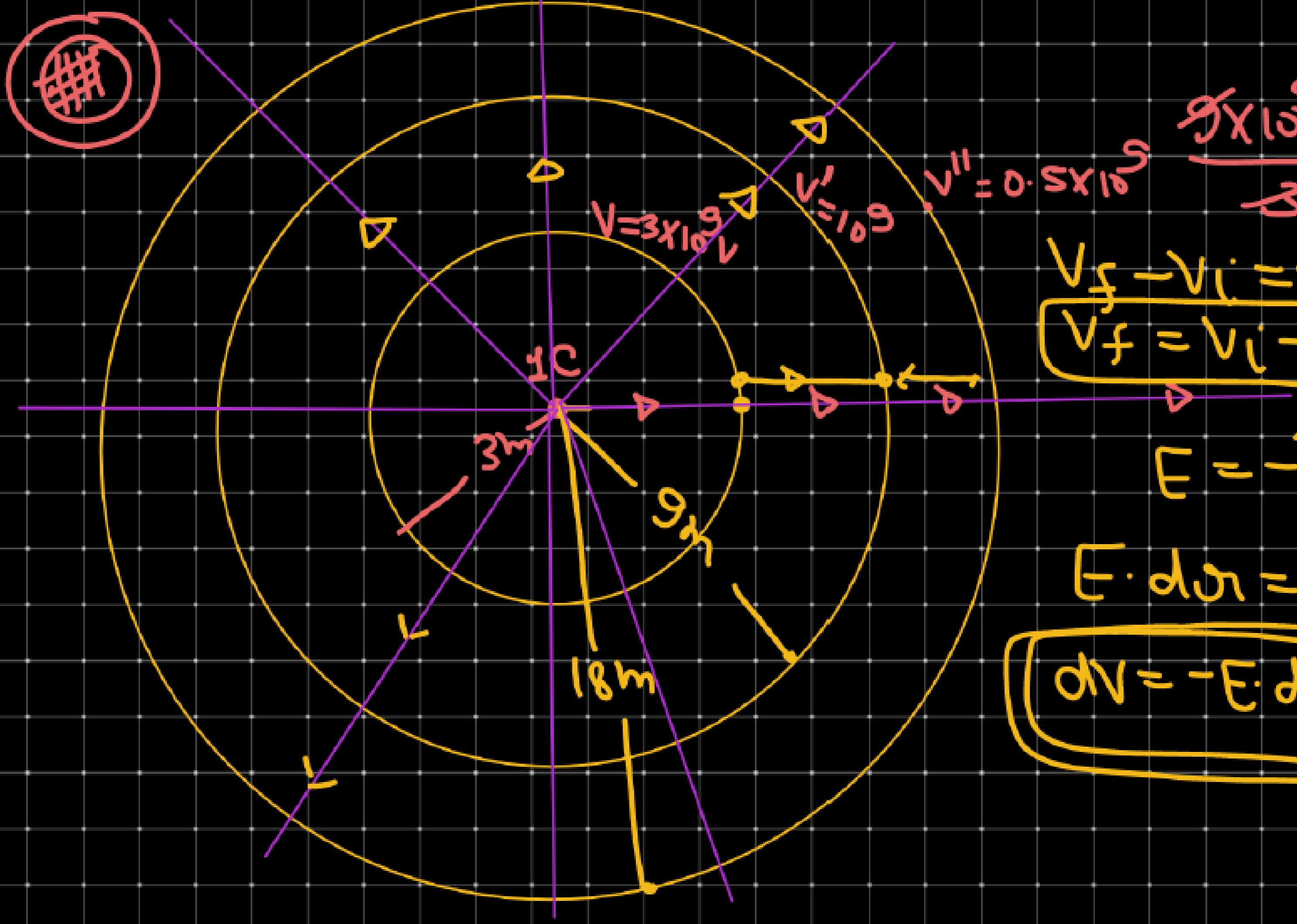
⇒ Relation b/w Electric field & Electric potential.

$qE = -\frac{\partial (qV)}{\partial r}$

$$E = -\frac{\partial V}{\partial r}$$

$$\vec{E} = -\frac{\partial V}{\partial r}\hat{r}$$

$$\vec{E} = -\frac{\partial V}{\partial x}\hat{i} - \frac{\partial V}{\partial y}\hat{j} - \frac{\partial V}{\partial z}\hat{k}$$



$$\frac{9\times10^9 \times 1}{3}$$

$$V_f - V_i = -E\,dr$$

$$\boxed{V_f = V_i - E\,dr}$$

$$E = -\frac{\partial V}{\partial r}$$

$$E\cdot dr = -\partial V$$

$$\boxed{dV = -E\cdot dr}$$

(#) In dirⁿ of Electric field potential will be decreases.

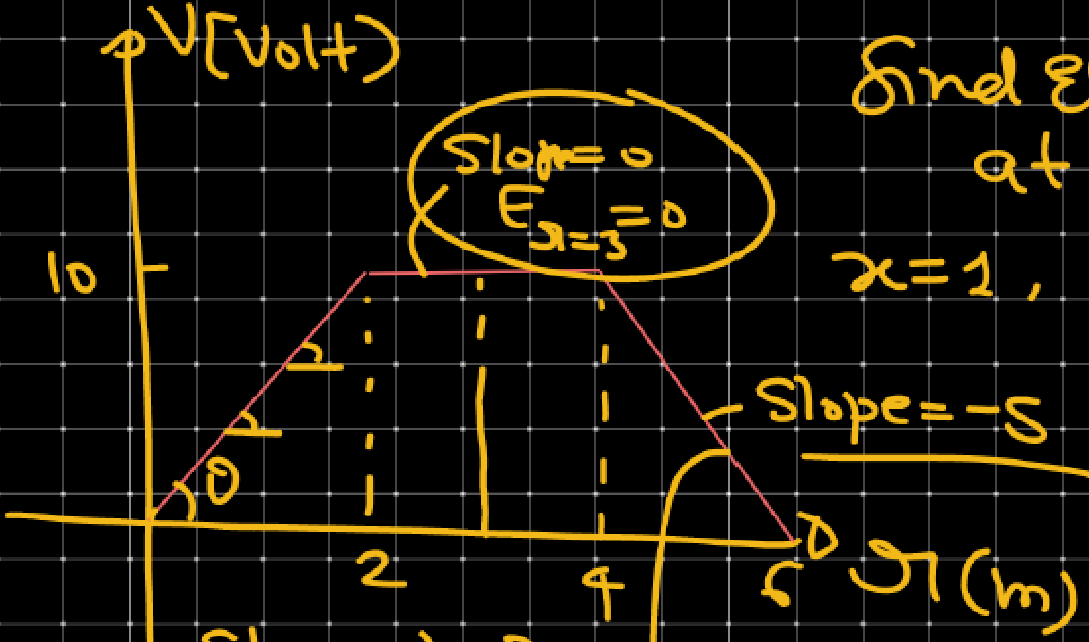
(#) $$E = -\frac{\partial V}{\partial r}$$

$$E = -\frac{dV}{dr}$$

⇒ [- Slope of V (Electric potential) V/s distance graph gives value of Electric field]

#

Find Electric field at $x = 1m, 3m, 5m$.



$x = 1$, $E = -5$ Volt/m

$E = -5$ N/c

Slope $= \tan\theta$

$= \frac{10}{2}$ V/m

$= 5$ Volt/m

$x = 5$, $E = -(-5)$

$= 5$ V/m

Q1) In a region $V = 8x^2$

find electric field at $x = 1$ & 4 m.

Sol) $\bar{E} = -\frac{\partial V}{\partial x} i$

$\bar{E} = -\frac{\partial [8x^2]}{\partial x} i$

$\bar{E} = -16x i$

$x = 1$ $\bar{E} = -16 i$ V/m

$x = 4$ m $\bar{E} = -64 i$ V/m

$\bar{E} = -\frac{\partial V}{\partial r} \hat{r}$

$\bar{E} = -\frac{\partial V}{\partial x} i - \frac{\partial V}{\partial y} j - \frac{\partial V}{\partial z} k$

Q) $V = x^2y - yz^3 - 3x^2yz$. Find Electric field at $(1,1,1)$.

Sol) $\bar{E} = -\frac{\partial V}{\partial x}\hat{i} - \frac{\partial V}{\partial y}\hat{j} - \frac{\partial V}{\partial z}\hat{k}$

$\bar{E} = \bar{E}_x + \bar{E}_y + \bar{E}_z$

$\vec{E}_x = 4\hat{i}$

$\bar{E}_z = -\frac{\partial V}{\partial z} = -\left[\frac{\partial}{\partial z}(x^2y - yz^3 - 3x^2yz)\right]\hat{k}$

$\bar{E}_z = -\left[0 - 3yz^2 - 3x^2y\right]\hat{k}$

$\bar{E}_z = -\left[-3\times1\times1 - 3\times1\times1\right]\hat{k}$

$= -\left[-3-3\right] = 6\hat{k}$

$\bar{E}_y = -\frac{\partial V}{\partial y}\hat{j}$

$\bar{E}_y = -\frac{\partial}{\partial y}\left[x^2y - yz^3 - 3x^2yz\right]\hat{j}$

$= -\left[x^2 - z^3 - 3x^2z\right]\hat{j}$

$\bar{E}_y = -\left[1 - 1 - 3\times1\times1\right]\hat{j}$

$\bar{E}_y = -\left[-3\hat{j}\right] = 3\hat{j}$

$\bar{E}_x = 4\hat{i}$

$\bar{E}_y = 3\hat{j}$

$\bar{E}_z = +6\hat{k}$

$\bar{E} = 4\hat{i} + 3\hat{j} + 6\hat{k}$

Q) For a Rutherford scattering experiment when projectile of charge Z_1 & mass m_1 approaches a target nucleus of charge Z_2 & mass m_2. the distance of closest approach is r_0. The Energy of projectile is

(a) directly pro to $Z_1 Z_2$

(b) inversely pro to Z_1

(c) $\propto m_1$

(d) $\propto m_1 m_2$

m_1, Z_1

$\rightarrow v$

$\underline{K.E_i = K}$

$$K_i + U_i = K_f + U_f$$

$$K_i + 0 = \frac{K(Z_1)(Z_2)}{r_0} + 0$$

$$K_i = \frac{K Z_1 Z_2}{r_0}$$

Q7.)

2 μC (fixed) • ←v • 9 m • −3 mC, 1 g, rest → free to move

$v = 20 \times 2\sqrt{15}$

$v = 40\sqrt{15}$ m/s

find speed of (−3 mC) charge when distance b/w charges becomes 3 m.

$U_i = \frac{9\times10^{9} \times 2\times10^{-6} \times (-3\times10^{-3}\,C)}{9} = -6J$

$K_i = 0$

$U_f = \frac{9\times10^{9} \times 2\times10^{-6} \times (-3\times10^{-3})}{3}$

$U_f = -18J$

$K_f = \frac{1}{2}\times10^{-3}\times v^2$

$U_i + K_i = U_f + K_f$

$-6J + 0 = -18J + \frac{1}{2}\times10^{-3}v^2$

$+12J = \frac{1}{2}\times10^{-3}v^2$

$24\times10^{+3} = v^2$

$v = \sqrt{24}\times10\times\sqrt{10}$

$= 2\sqrt{6}\times\sqrt{10}\times10 = 20\sqrt{60}$ m/s