# Electric potential & Capacitance

$V = 0$ at $\infty$

Electric potential due to point charge at distance $r$.

$q$ •———— $r$ ————•

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

$$V_r = \frac{W_{\infty - r}}{q_0}$$

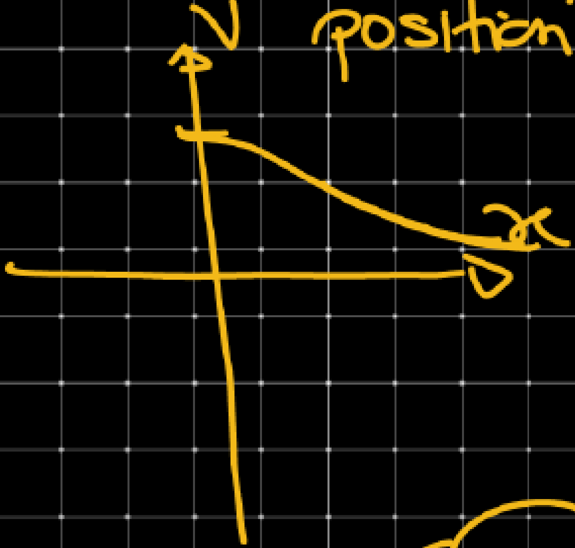
$$V_r - V_\infty = \frac{W_{\infty - r}}{q_0}$$

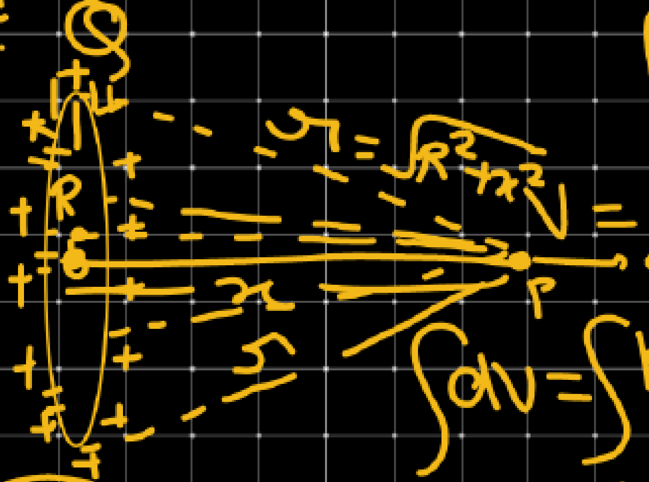
due to $\boxed{-q}$ at distance $r$.

$-q$ ———— $r$ ————•

$$-\frac{Kq}{r}$$

# Electric potential due to charge ring at axial position:





$$\boxed{V_c = \frac{KQ}{R}\ (\max)}$$

$r = \sqrt{R^2 + x^2}$

$V = dv + dv + dv + dv + \dots$

$$\int dV = \int \frac{K\,dq}{r}$$

$$V = \frac{K\int dq}{r} = \frac{KQ}{r}$$

$$V = \frac{KQ}{\sqrt{R^2 + x^2}}$$

If $x \gg R$

$$V = \frac{KQ}{x}$$

$x \gg R$

$V \propto \frac{1}{x}$

8 Electric Potential due to dipole at axial, Equitorial & General point.

[Equitorial Point] • $V = 0$

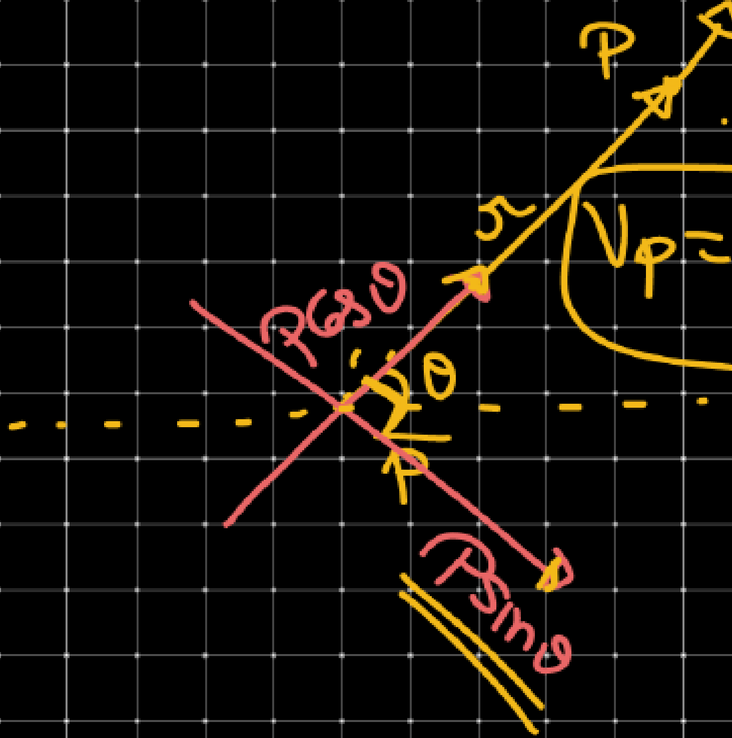
• $V = \dfrac{kp\cos\theta}{r^2}$ $[r >> l]$

(General point)


$V = \dfrac{kp}{r^2}$ $[r >> l]$

(Axial point)


=




$$V = \frac{KP\cos\theta}{r^2} + 0$$

$$\boxed{V_P = \frac{KP\cos\theta}{r^2}}$$

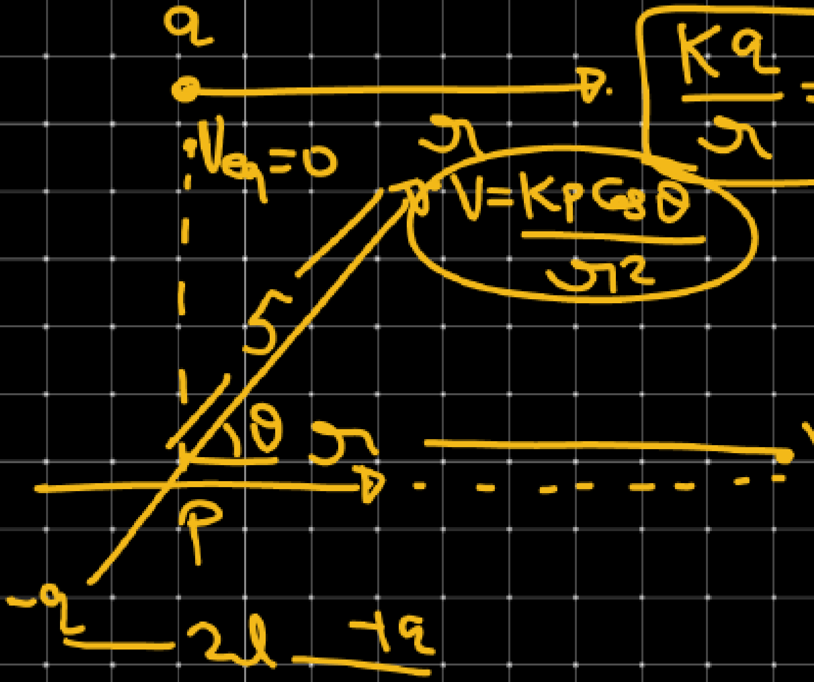
\# For equitorial point.

$V = V_{+q} + V_{(-q)}$


$$V = \frac{Kq}{\sqrt{l^2+r^2}} + \frac{K(-q)}{\sqrt{l^2+r^2}} = \underline{\underline{0}}$$

$P = (q \times 2l)$

(Short dipole)




$$\boxed{\frac{Kq}{r} = V}$$

$V_{eq} = 0$

$$V = \frac{Kp\cos\theta}{r^2}$$

$$V_{axial} = \frac{KP}{r^2}.$$

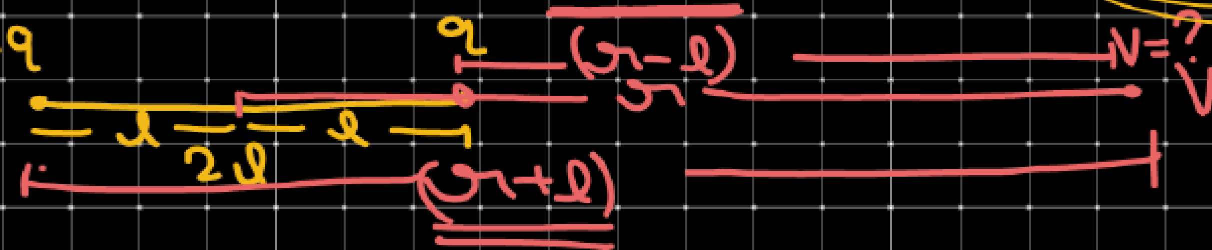
$$P = q(2l)$$

$P = q[2l]$

$P = q(2l)$

If dipole is short: $(r >> l)$ $l^2 \to 0$

$$\boxed{V = \frac{KP}{r^2}}$$



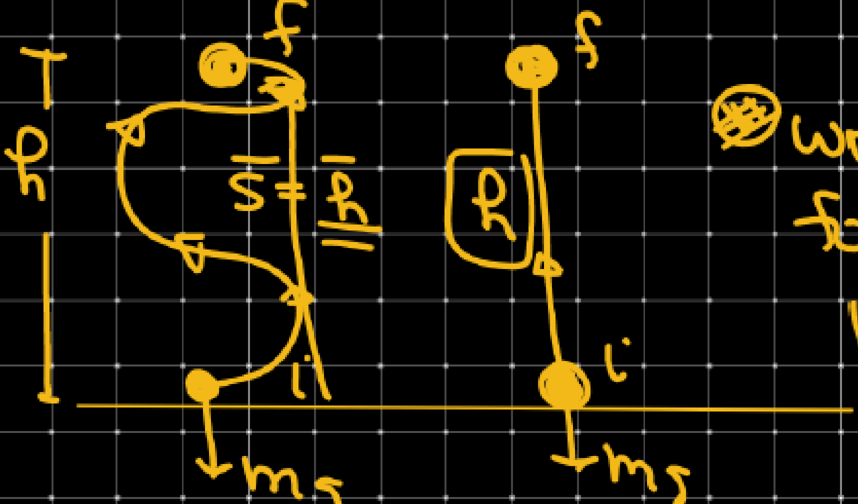

$V_{net} = V_q + V_{(-q)}$.

$$V_{net} = \frac{Kq}{r-q} + \frac{K(-q)}{(r+l)} = \frac{Kq}{r-l} - \frac{Kq}{r+l} = Kq\left[\frac{1}{r-l} - \frac{1}{r+l}\right]$$

$$V_{net} = Kq\left[\frac{\cancel{r}+l-\cancel{r}+l}{(r-l)(r+l)}\right] = \frac{Kq(2l)}{r^2-l^2} = \frac{K[2ql]}{r^2-l^2} = \frac{KP}{r^2-l^2}$$

11th - mech

## I Conservative force :- [Ex - Gravitational force, Electrostatic force, spring force]



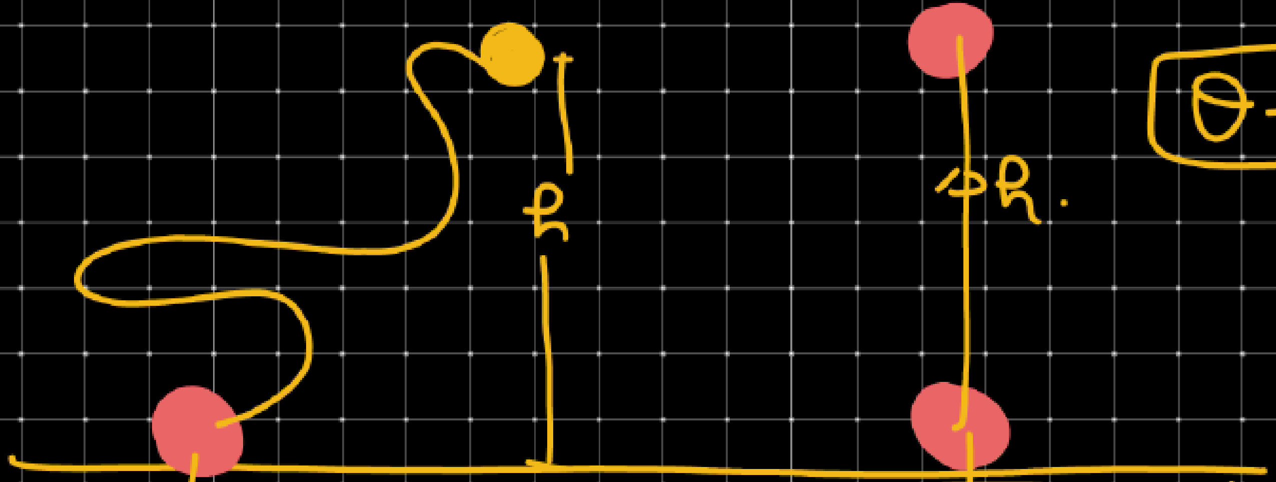

$W_g = -mgh$ $W_g = -mgh$

Work done by gravitational force in case (I & II)

$$W = \vec{F}\cdot\vec{S} = FS\cos\theta$$

$$W = mg \times h\cos 180 = \underline{-mgh}$$

$\theta \Rightarrow 180^\circ$




$W = -mgh$ $\qquad$ $\boxed{W_g = -mgh}$

$mg$ $\qquad$ $mg$

# Potential Energy only define for conservative Force.

Conservative Force

# Electric Force is conservative in nature.

↳ Electric potential energy.

Ex-:

$q_1 \quad r \quad q_2 \quad \dfrac{Kq_1q_2}{r^2} = F_{el} = F_{ext} \quad q_2' \quad \infty$

$v = 0$

$x \quad F_{ext}$

$\dfrac{Kq_1q_2}{x^2} = F_{electro} \quad q_2$

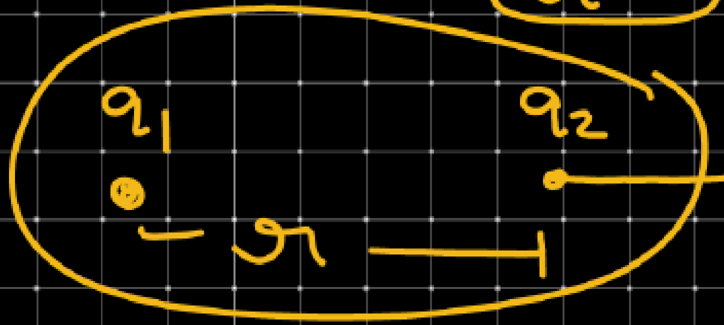
Imp

$$\boxed{W_{ext} = -W_c}$$

$$\boxed{\Delta U = U_f - U_i = W_{ext}}$$

W

$\boxed{U_i = 0}$




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

$q_2^{\infty}$

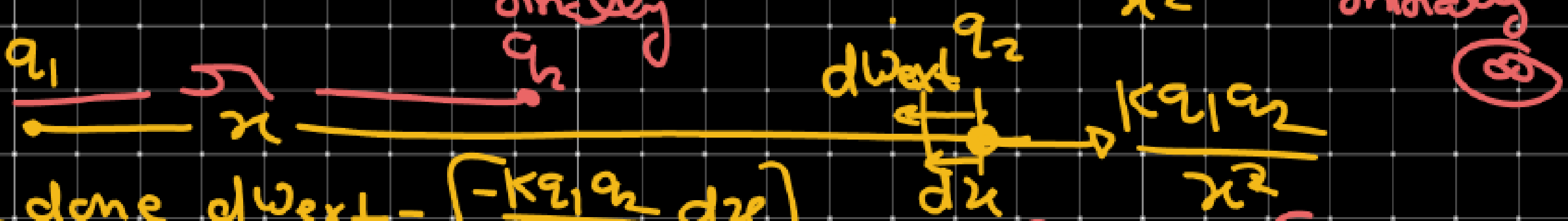
$\Delta K = 0$

$W_{ext} = \Delta U$

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

# #1 Prove-1

$$F_{ext} = -\frac{kq_1q_2}{x^2}$$




work done $dW_{ext} = \left(-\frac{kq_1q_2}{x^2}dx\right)$

$$\int dW_{ext} = -kq_1q_2\int_{\infty}^{r}\frac{dx}{x^2}$$

$$\int\frac{1}{x^2}dx = \int x^{-2}dx = \frac{x^{-2+1}}{-2+1} = \frac{x^{-1}}{-1} = -\frac{1}{x}$$

$$W_{ext} = -kq_1q_2\left[-\frac{1}{x}\right]_{\infty}^{r} = kq_1q_2\left[\frac{1}{x}\right]_{\infty}^{r}$$

$$W_{ext} = kq_1q_2\left(\frac{1}{r}-\frac{1}{\infty}\right)$$

$$W_{ext} = \frac{kq_1q_2}{r}$$

$$W_{ext} = U_f - U_i = U_r - U_{\infty} = W_{ext}$$

$$U_r - U_{\infty} = \frac{kq_1q_2}{r}$$

$$U_r - U_\infty = \frac{k q_1 q_2}{r}$$

$$\boxed{U_\infty = 0}$$

$$\boxed{U_r = \frac{k q_1 q_2}{r}}$$

$q_1$ •—— $r$ ——• $q_2$

$$\boxed{U = \frac{k q_1 q_2}{r}}$$

# In This Formula.

$q_1$ —— $r$ —— $q_2$

$\Rightarrow U = \dfrac{k q_1 q_2}{r^2}$ [$q_1$ & $q_2$ put with sign)

$\Rightarrow U$ [+ve) $\rightarrow$ repulsion Force.

$\Rightarrow U$ [-ve] $\rightarrow$ Attraction Force.

2μC •—— 3m ——• 3mC

Find U = ?

$$\boxed{U = \frac{Kq_1q_2}{r}}$$

$$\Rightarrow U = \frac{Kq_1q_2}{r} = \frac{\cancel{9}\times10^{9}\times(2\times10^{-6})(3\times10^{-3})}{\cancel{3}}$$

$$= 18\times\cancel{10^{9}}\times\cancel{10^{-9}}$$

$$= \underline{\underline{18 \text{ Jule}}}$$

final

$\Delta U = 12\,J$

$\boxed{W_{ext} = 12\,J}$

$2\mu C$ ——— 3m ——— $3mC$

9m

$3mC$

Initial

$$\boxed{U_f - U_i = ?}$$

$$U_i = \frac{k(2\times10^{-6}\times3\times10^{-3})}{9}$$

$$U_i = \frac{\cancel{9}\times10^{9}\times6\times10^{-9}}{\cancel{9}} = 6\,J.$$

$$U_f = \frac{k(2\times10^{-6})(\cancel{3}\times10^{-3})}{\cancel{3}}$$

$$= 9\times10^{9}\times2\times10^{-9}$$

$$U_f = 18\,J$$

$$U_f - U_i = 18 - 6\,J$$

$$U_f - U_i = 12\,J$$

#

2μC   finally   −3mC   −3mC

3m

9m   initial

$$\boxed{U_f - U_i = ?}$$

$$U_i = \frac{\cancel{9}\times\cancel{10^9}\times 2\times\cancel{10^{-6}}\times(-3\times\cancel{10^{-3}})}{\cancel{9}}$$

$$\boxed{U_i = -6J}$$

$$U_f = \frac{9\times\cancel{10^9}\times 2\times\cancel{10^{-6}}\times -\cancel{3}\times\cancel{10^{-3}}}{\cancel{3}}$$

$$U_f = -18J$$

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

$$= -18 - (-6J) = -18+6$$

$$= -12J$$

$$\boxed{W_{ext} = -W_c}$$ ***

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

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

***

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

$$\Rightarrow \quad U_f - U_i = -W_c$$

$$\Rightarrow \quad \Delta U = -W_c$$

$$\boxed{\boxed{W_c = -\Delta U}}$$

$$\boxed{\boxed{W_c = -\Delta U}}$$