LAKSHYA JEE

LAKSHYA KO HAR HAAL ME PAANA HAI

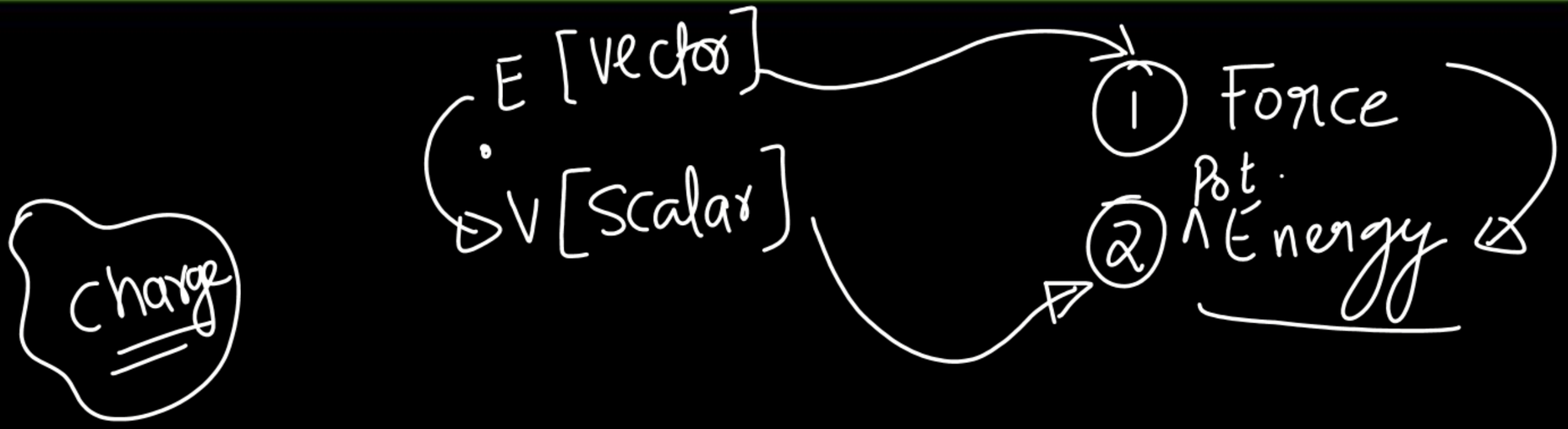
Electric Potential & Capacitance

-Er. Rohit Gupta

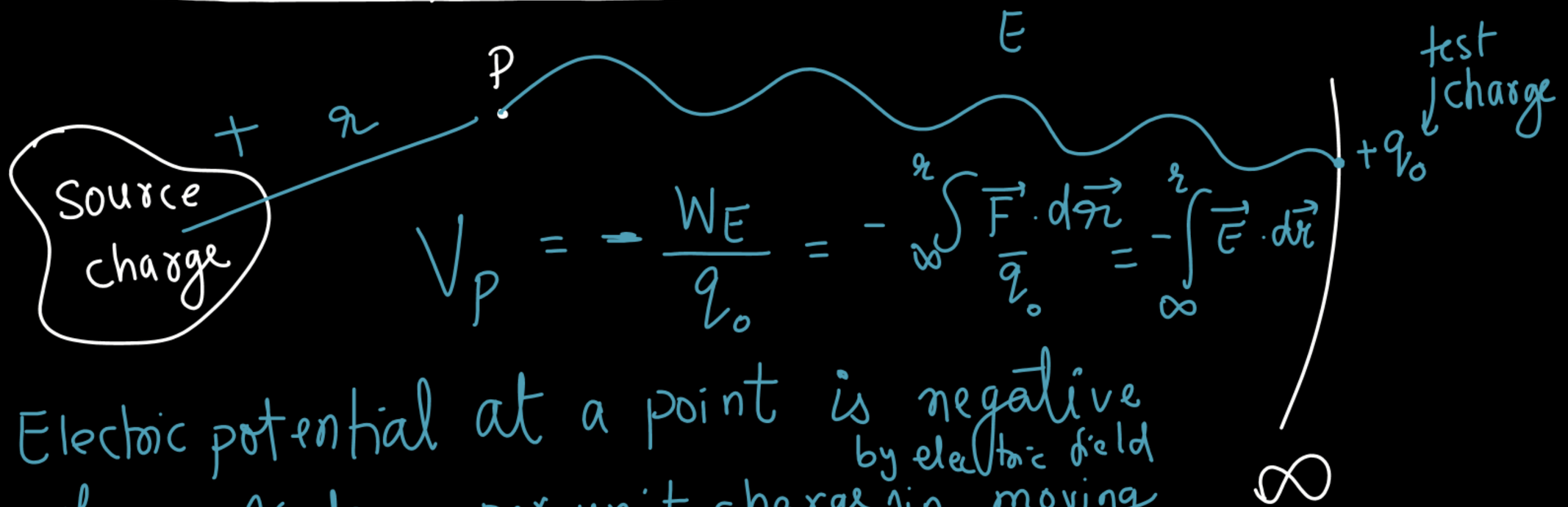
Today's GOALS!

- Introduction to Electric Potential
- Potential due to point charges
- Potential due to multiple charges

Electric Potential



Electric potential



$$V_P = -\frac{W_E}{q_0} = -\int_{\infty}^{r} \frac{\vec{F}}{q_0} \cdot d\vec{r} = -\int_{\infty}^{r} \vec{E} \cdot d\vec{r}$$

Electric potential at a point is negative of work done per unit charge in moving by electric field the charge from infinity to that point.

$$V_p = -\int_{\infty}^{r} \vec{E} \cdot d\vec{r}$$

// ⇐ Mathmatical formula

$$V_p = \left. \frac{-W_E}{q_0} \right|_{\infty}^{r}$$

//

A V_A

$\Delta V = V_B - V_A$

$$\Delta V \Big|_{V_A}^{V_B} = \left. \frac{-W_E}{q} \right|_{A}^{B}$$

B V_B

$$V_B - V_A = -\int_{r_A}^{r_B} \vec{E} \cdot d\vec{r}$$

very slowly

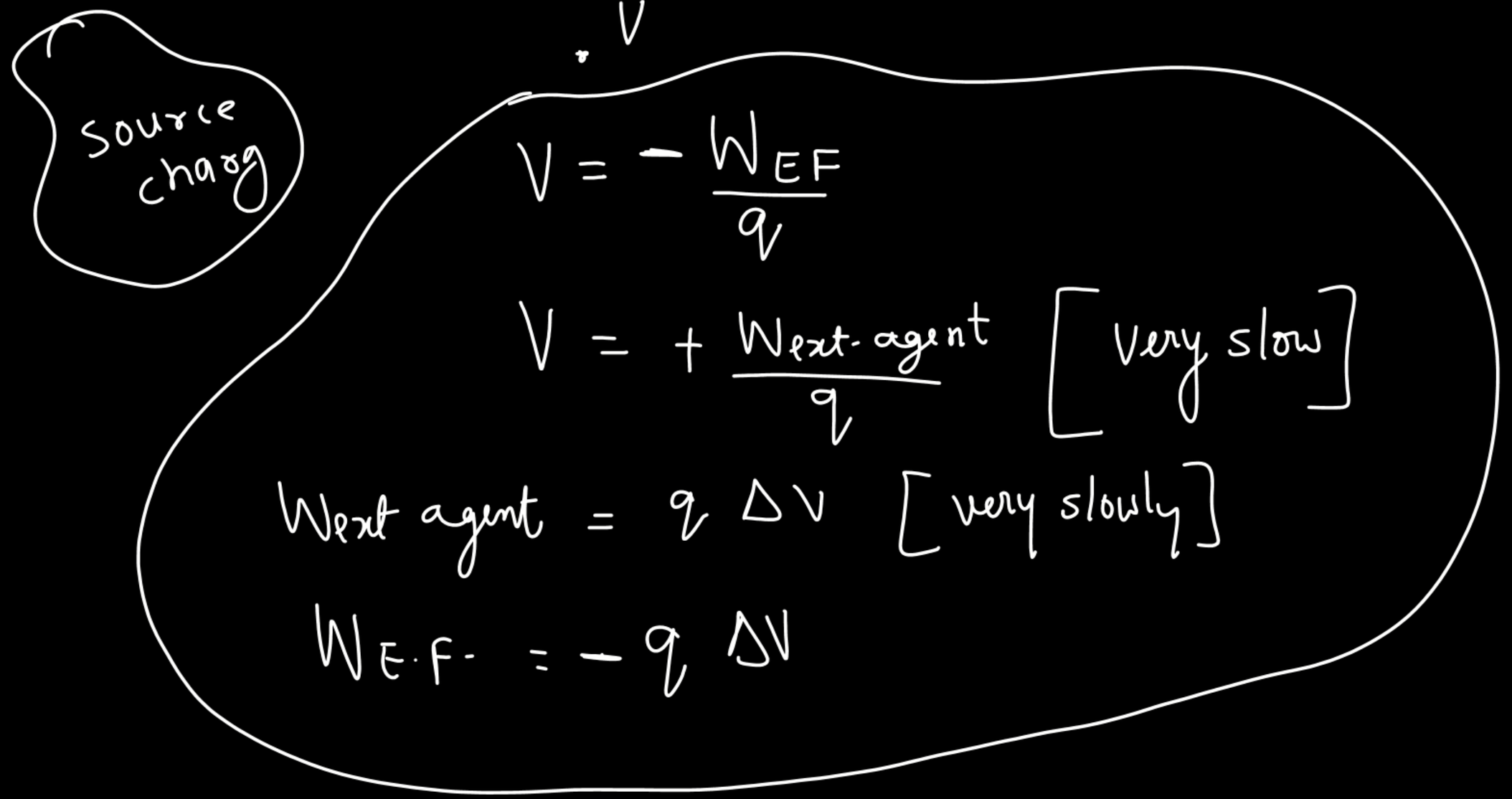
$$|F_E| \cong |F_{ext}|$$

$$\Delta V = -\frac{W_E}{q}\Big|_{r_A}^{r_B}$$

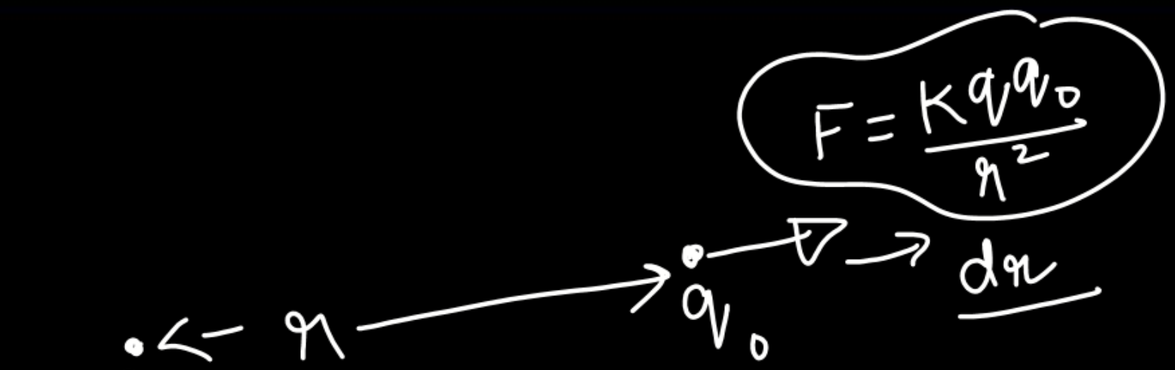
$$W_E = -W_{ext\ agent}.$$

$$\Delta V = \frac{W_{ext\ agent}}{q}\Big|_{r_A}^{r_B} \quad \text{(slowly)}$$

Change in potential is equal to work done per unit charge by external agent in moving the charge from one location to the other very slowly


source charg
. V
$V = -\frac{W_{EF}}{q}$
$V = +\frac{W_{ext\text{-}agent}}{q}$ [very slow]
$W_{ext\ agent} = q\,\Delta V$ [very slowly]
$W_{E\cdot F\cdot} = -q\,\Delta V$

Electric Potential due to a point charge



$V = 0$ at $r = \infty$

$$V\Big|_0^V = \int_\infty^r -\frac{dW_{E.F.}}{q_0} = \int_\infty^r -\frac{Kqq_0}{r^2 q_0}\,dr = -Kq\int_\infty^r \frac{1}{r^2}\,dr$$

$$V\Big|_0^V = -Kq\int_{\infty}^{r}\frac{dr}{r^2}$$

$$V-0 = -Kq\left[-\frac{1}{r}\right]_{\infty}^{r}$$

$$V = Kq\left[\frac{1}{r}-\frac{1}{\infty}\right]$$

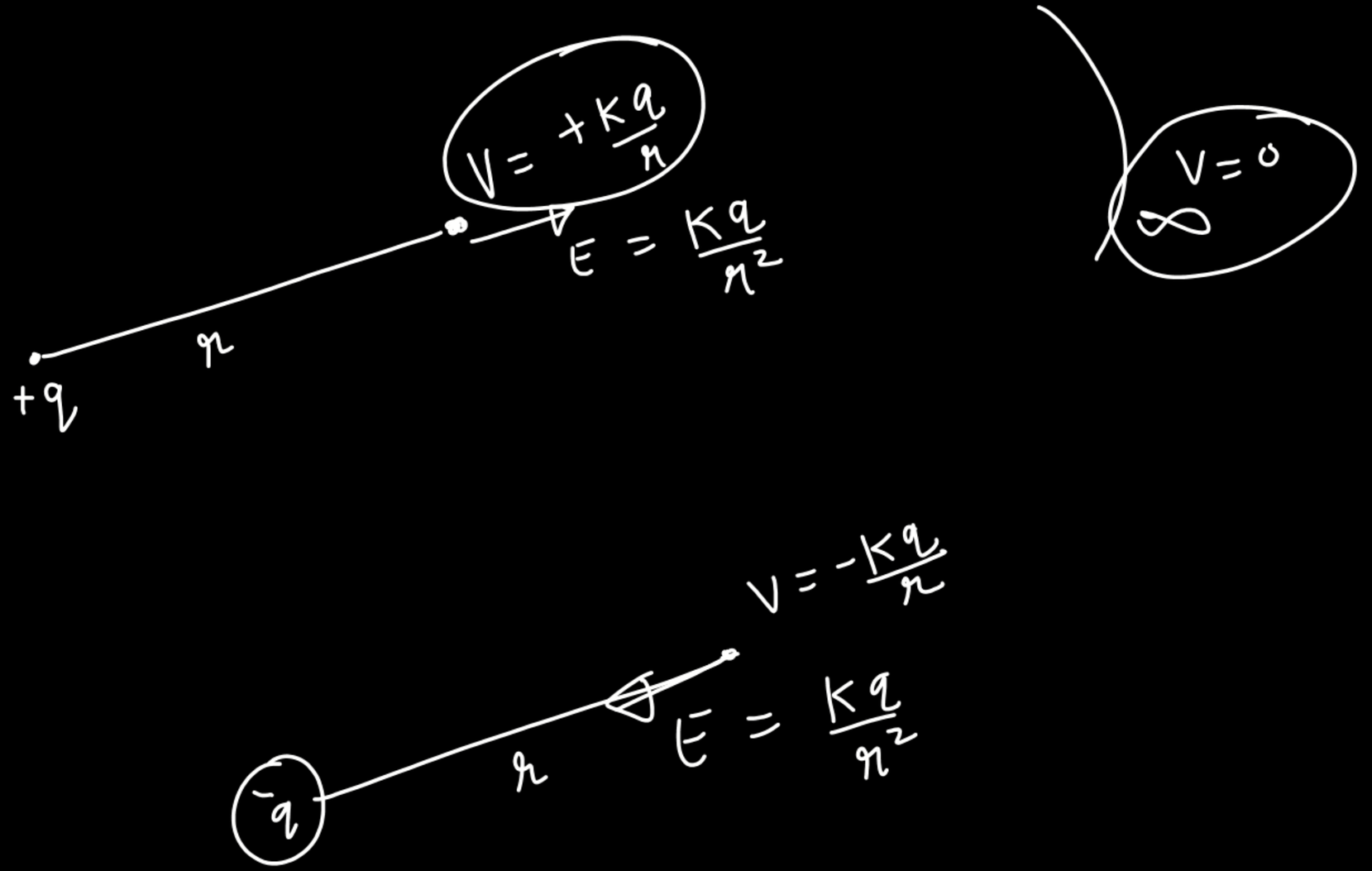
* $\boxed{V=\frac{Kq}{r}} \Longrightarrow \boxed{\text{with sign}}$

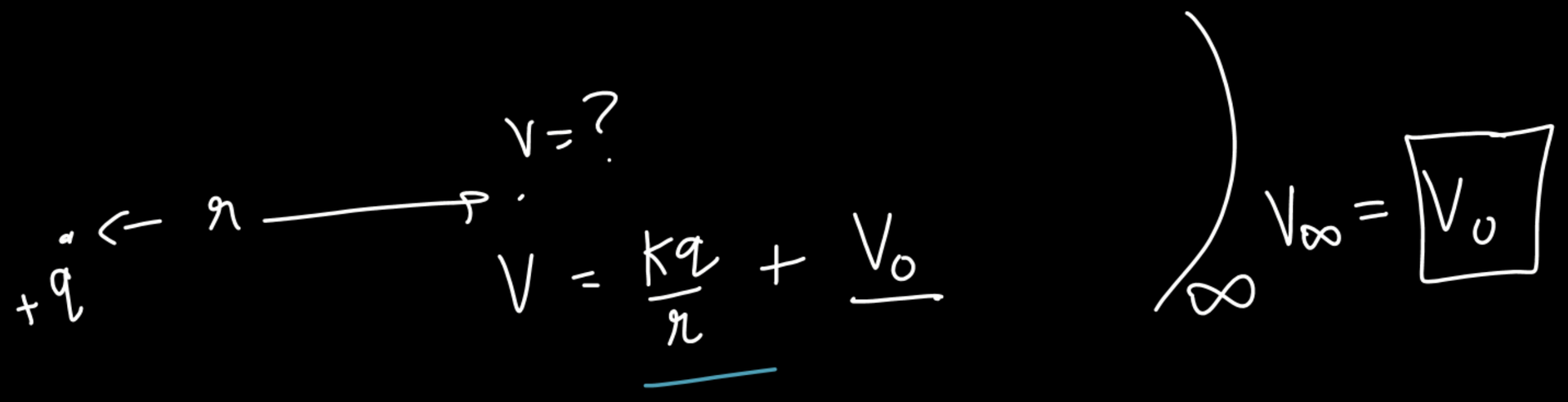
$$\int\frac{1}{r^2}\,dr$$

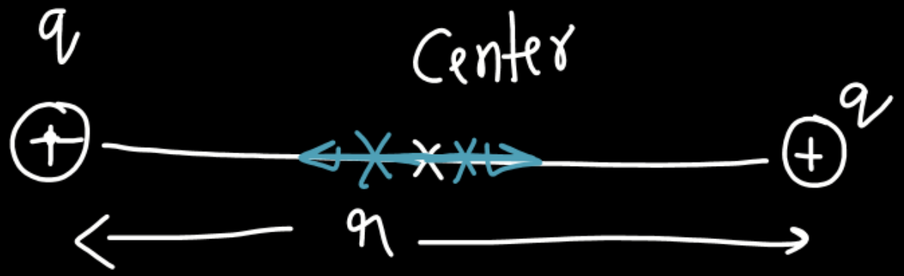
$$=\int r^{-2}\,dr$$

$$=\frac{r^{-2+1}}{-2+1}=\frac{r^{-1}}{-1}$$

$$=-\frac{1}{r}$$

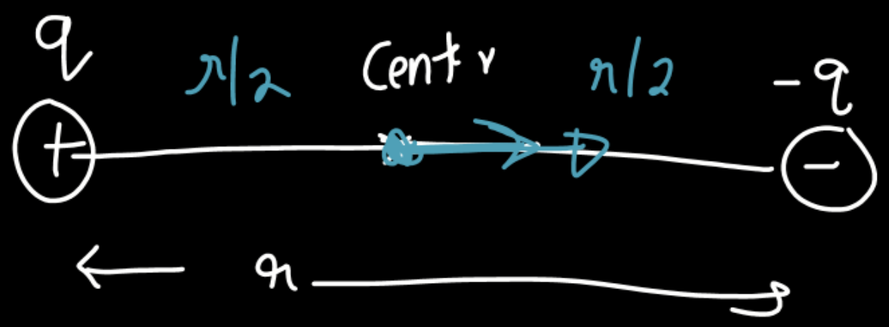

V = +Kq/r
E = Kq/r²
+q
r
V = 0
∞
V = -Kq/r
E = Kq/r²
-q
r


V = ?
+q
r
$V = \frac{kq}{r} + V_0$
$V_\infty = V_0$



E_{center} = 0

$V_{center} = \frac{Kq}{(r/2)} \times 2 = 4\frac{Kq}{r}$



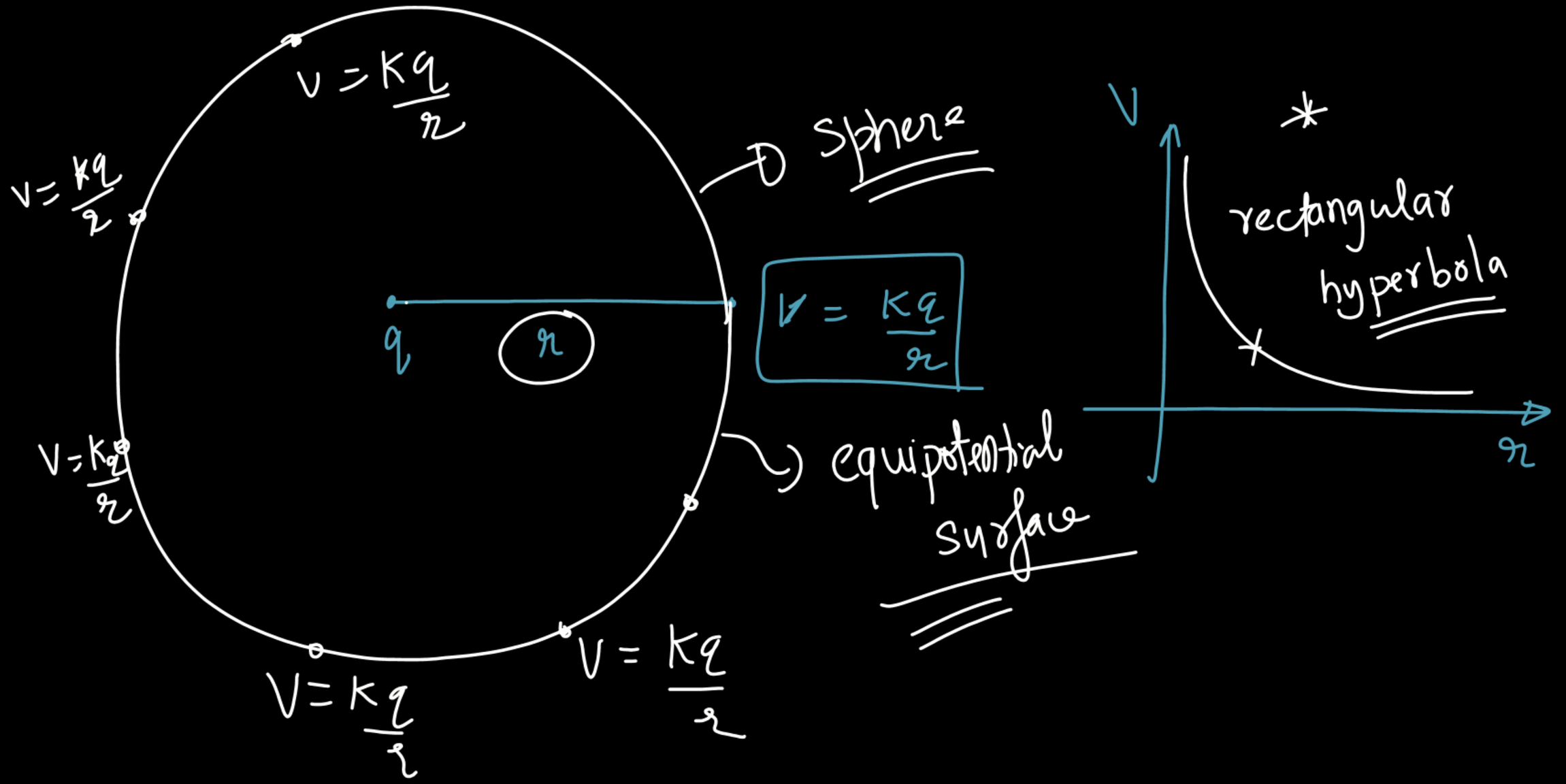
$E_{center} = \frac{Kq}{(r/2)^2} \times 2 = \frac{8Kq}{r^2}$

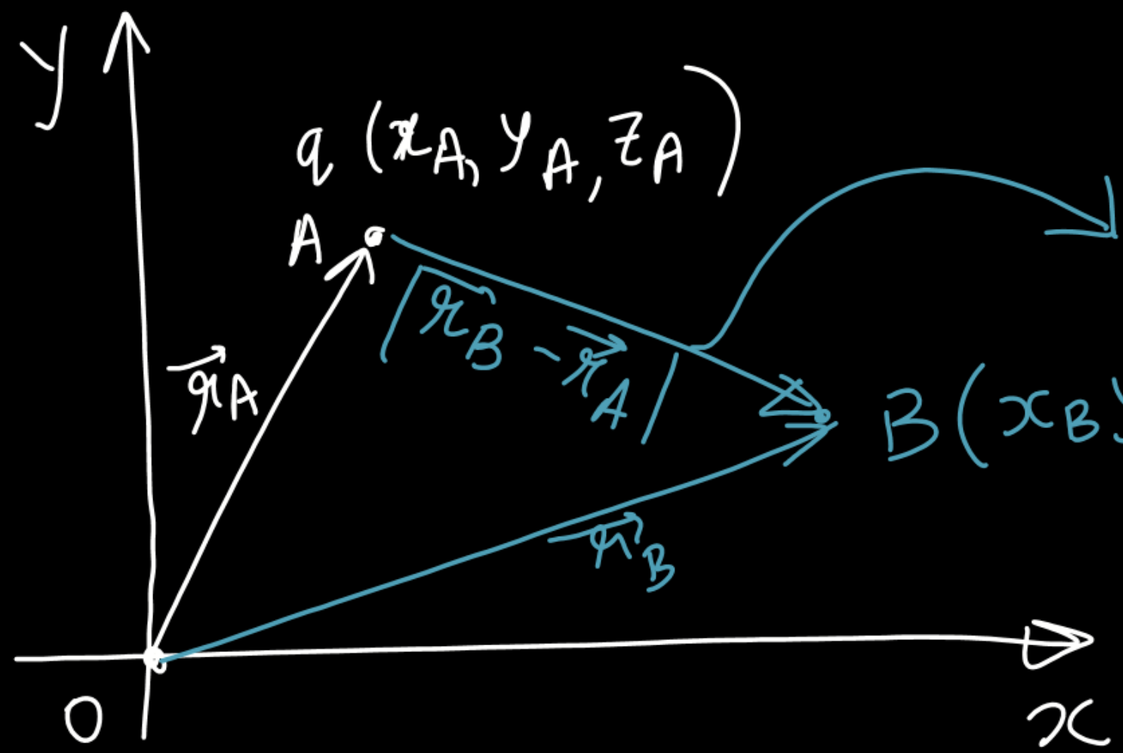
$V_{center} = 0$

$$V = -\int_{\infty}^{R} \vec{E} \cdot d\vec{r}$$

$V \neq 0$

$E = 0$


$V = \frac{Kq}{r}$
$V = \frac{Kq}{r}$
$V = \frac{Kq}{r}$
$V = \frac{Kq}{r}$
$V = \frac{Kq}{r}$
q
r
Sphere
$V = \frac{Kq}{r}$
equipotential surface
V
r
rectangular hyperbola



$$V_B = ?$$

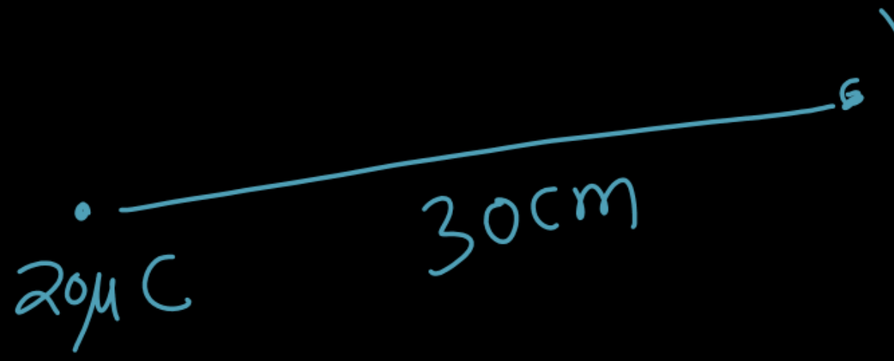
$$d = \sqrt{(x_B - x_A)^2 + (y_B - y_A)^2 + (z_B - z_A)^2}$$

$$V_B = \frac{kq}{|\vec{r}_B - \vec{r}_A|}$$

Scalar $\Leftarrow$

$$V_B = \frac{kq}{\sqrt{(x_B - x_A)^2 + (y_B - y_A)^2 + (z_B - z_A)^2}}$$

Numerical

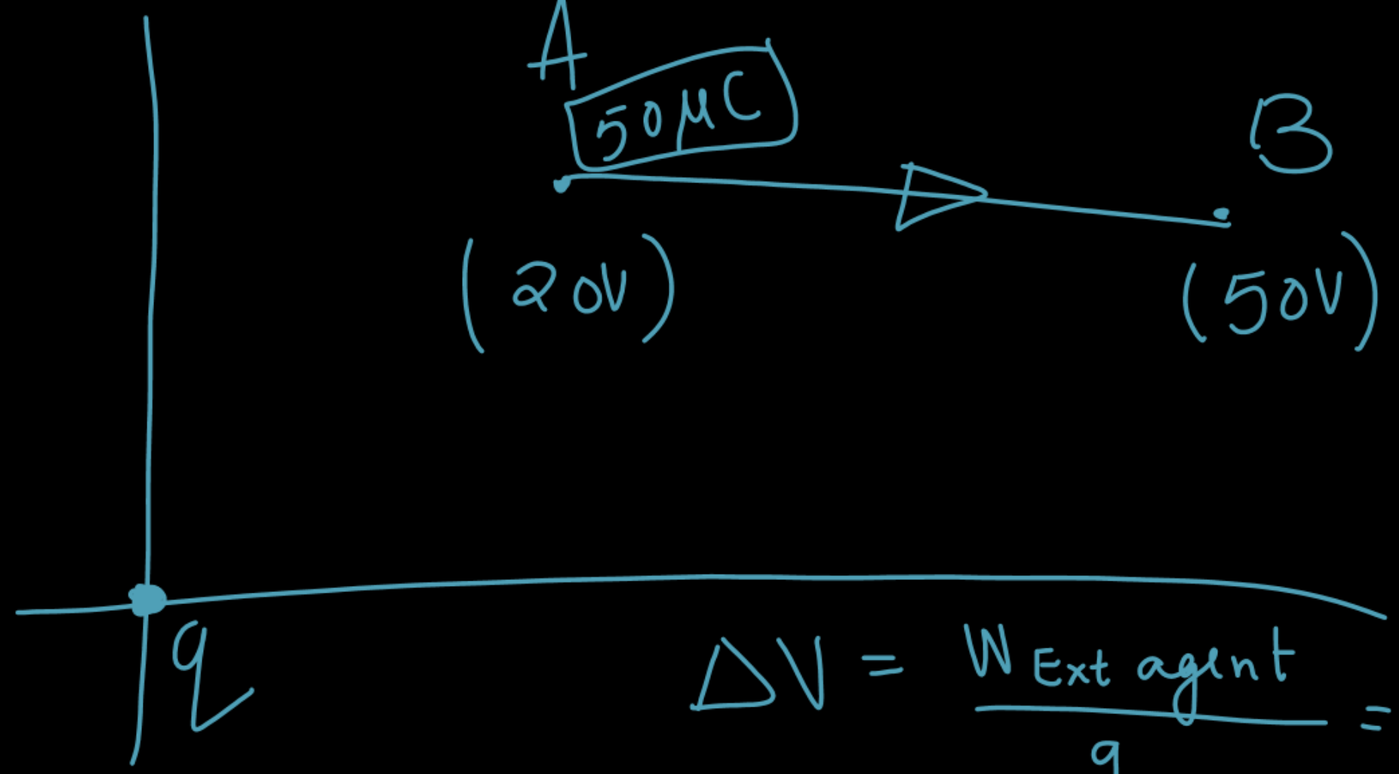


$$V = \frac{9 \times 10^9 \times 20 \times 10^{-6}}{30 \times 10^{-2}} \text{ J/C}$$

$$= 6 \times 10^5 \text{ V}$$

V ⇒ volt

$V = -\frac{W}{q}$ ⇒ J/C



Find the work done by (1) E.F. (2) Ext. agent in moving the charge from A to B slowly?

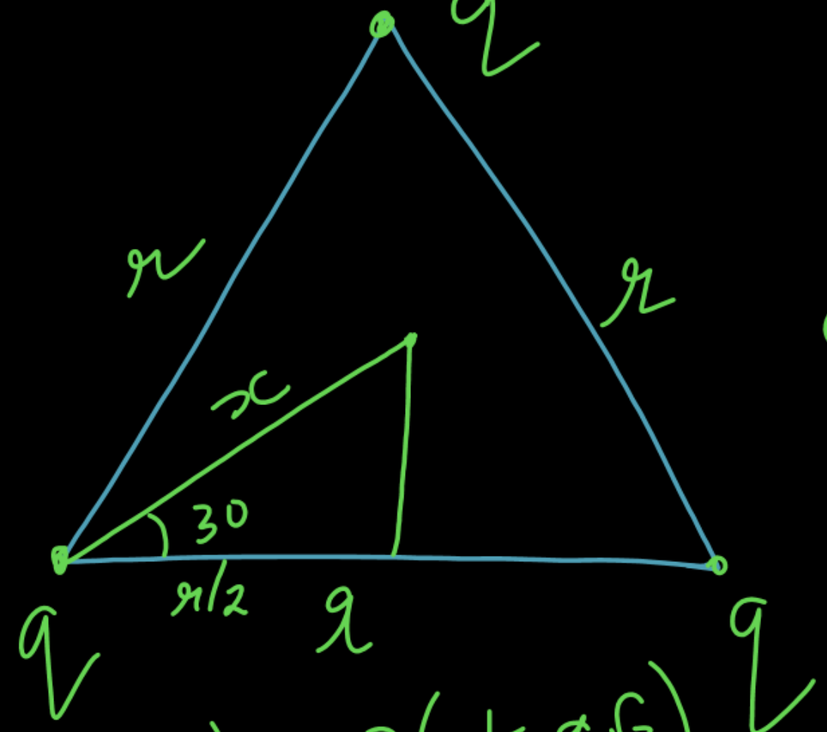
$$\Delta V = \frac{W_{\text{Ext agent}}}{q} = -\frac{W_{EF}}{q}$$

$$50 - 20 = \frac{W_{\text{ext agent}}}{50\,\mu C} = -\frac{W_{EF}}{50\,\mu C}$$

$W_{\text{ext agent}} = +1500\,\mu J$

$W_{E.F.} = -1500\,\mu J$

Electric potential due to multiple charges



$V = 3\left(\frac{kq\sqrt{3}}{r}\right)$

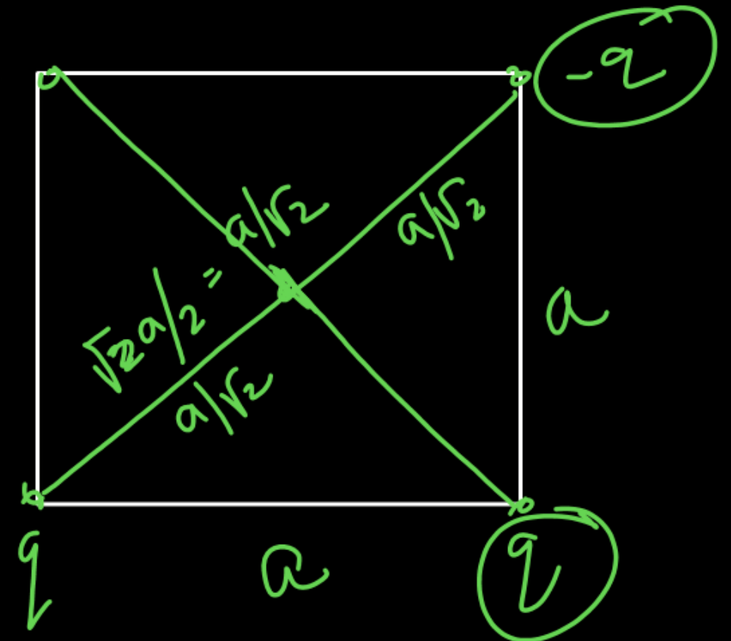
$V = \frac{3\sqrt{3}kq}{r}$

V_{center}

$\cos 30 = \frac{r_2}{2x}$

$x = \frac{r}{2\sqrt{3}/2}$

$x = \frac{r}{\sqrt{3}}$



$V_{center} = 2\left(\frac{kq}{a/\sqrt{2}}\right)$

$= 2\sqrt{2}\frac{kq}{a}$

Thank You Lakshyians