LAKSHYA JEE

LAKSHYA KO HAR HAAL ME PAANA HAI

Electric Charges and Field

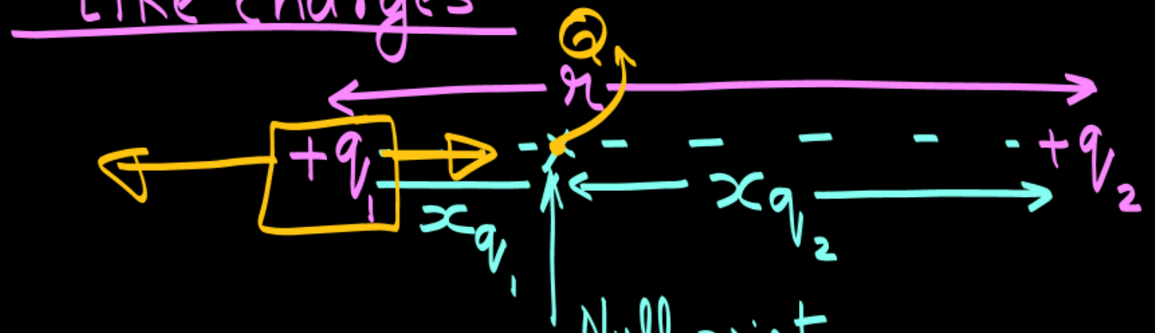
-Er. Rohit Gupta

Today's GOALS!

- Null point
- Electric field due to a group of charges
- Electric field due to continuous charge distribution (Ring)

NULL POINT

Like charges



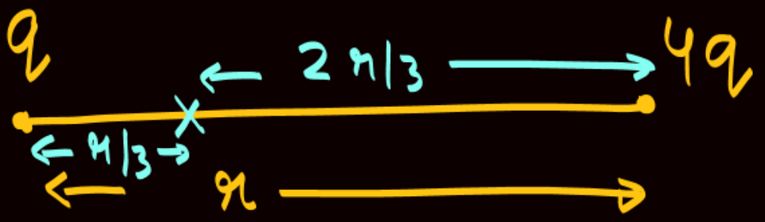
$$x_{q_1} = \frac{\sqrt{q_1}\, r}{\sqrt{q_1} + \sqrt{q_2}}$$

$$x_{q_2} = \frac{\sqrt{q_2}\, r}{\sqrt{q_1} + \sqrt{q_2}}$$

Net force Q is zero irrespective of its charge

Q must be unlike

$$Q = \frac{q_1 q_2}{\left(\sqrt{q_1} + \sqrt{q_2}\right)^2}$$



Find distance of null point from 'q'.

Also find the charge Q that should be placed at null point so that the whole system comes in equilibrium.

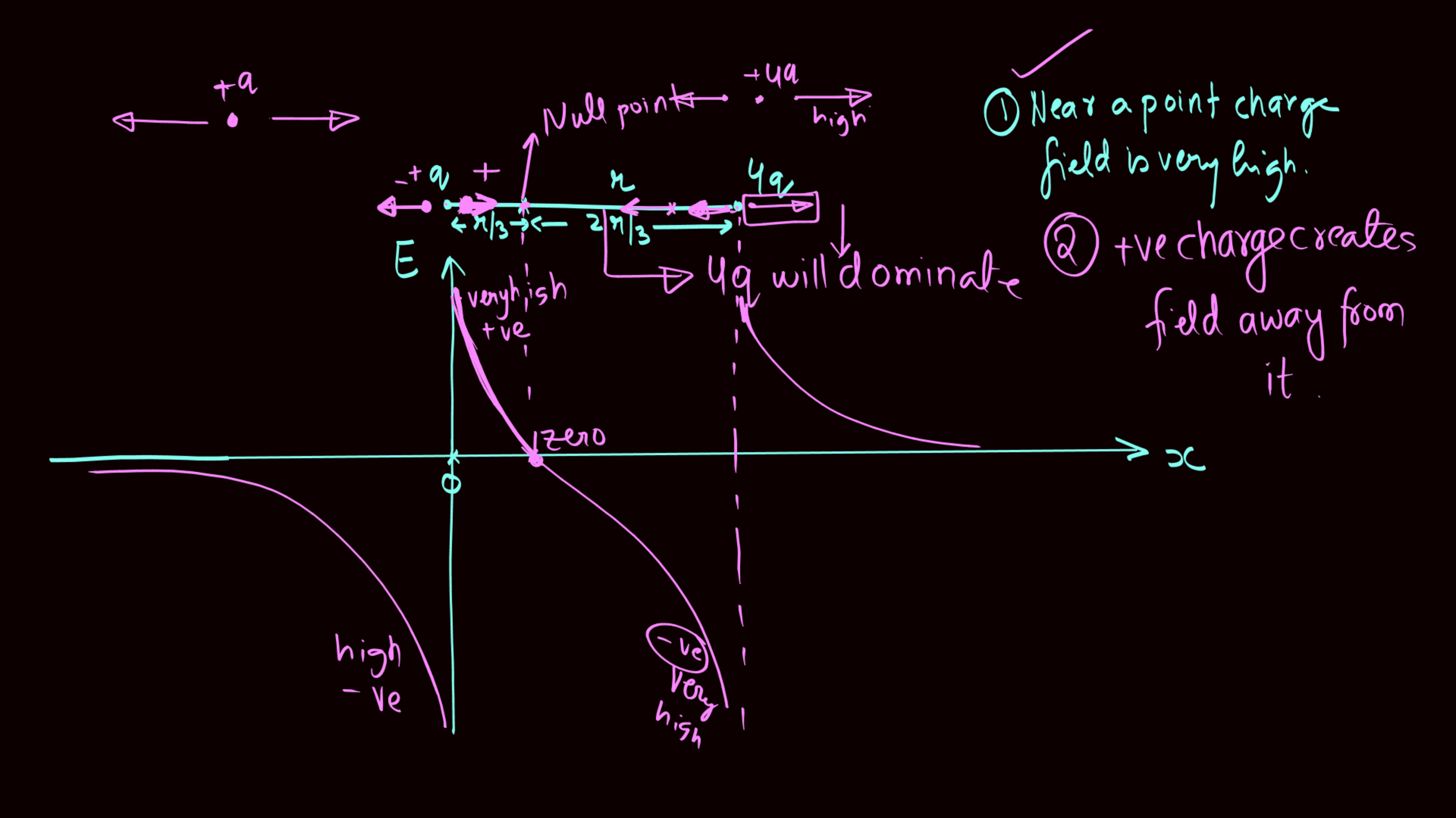
$$x_q = \frac{\sqrt{q}\, r}{\sqrt{q} + \sqrt{4q}}$$

$$= \frac{\sqrt{q}}{\sqrt{q}} \left(\frac{r}{1 + \sqrt{4}} \right)$$

$$\boxed{x_q = 1 \left(\frac{r}{3} \right)}$$

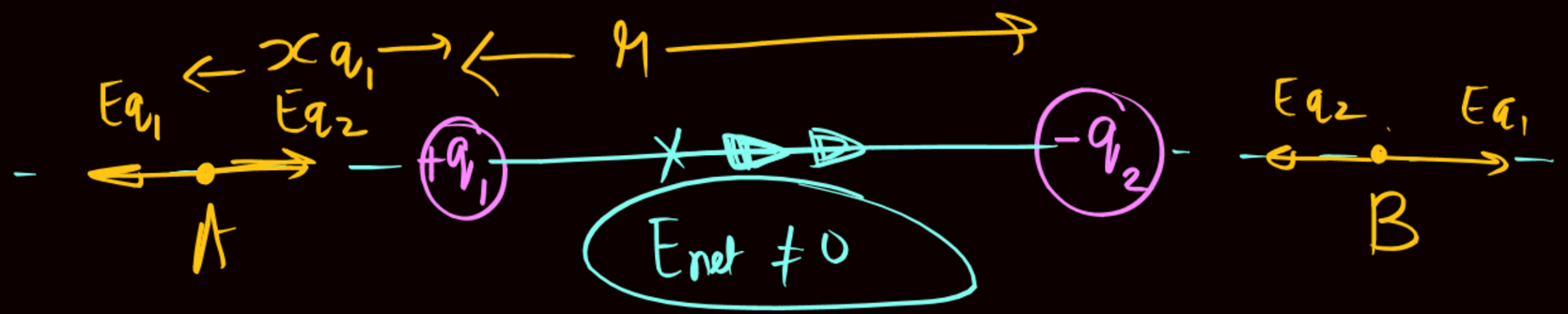
$$Q = - \frac{q\, 4q}{\left(\sqrt{q} + \sqrt{4q}\right)^2}$$

$$= - \frac{4q^2}{9q} = \frac{-4q}{9}$$



① Near a point charge field is very high.

② +ve charge creates field away from it.



If $\boxed{q_1 < q_2}$

then null point will be at A not at B.

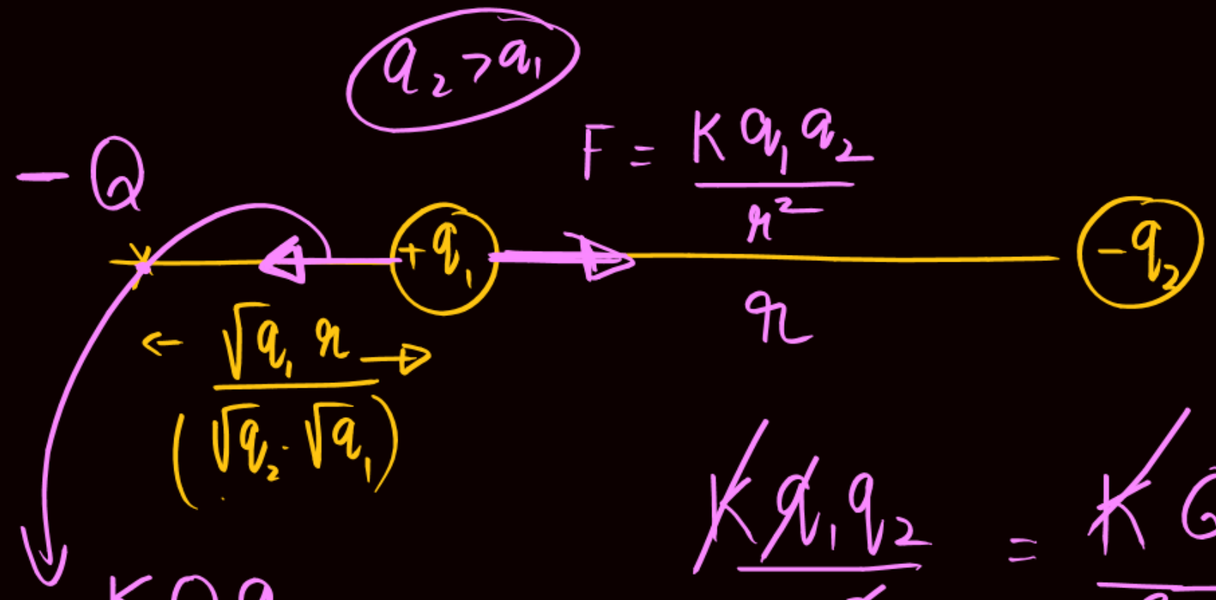
$$\frac{Kq_1}{x_{q_1}^2} = \frac{Kq_2}{(r + x_{q_1})^2}$$

$$\frac{\sqrt{q_1}}{x_{q_1}} = \frac{\sqrt{q_2}}{r + x_{q_1}}$$

$$\sqrt{q_1}(r + x_{q_1}) = \sqrt{q_2}\, x_{q_1}$$

$$\sqrt{q_1}\, r + \sqrt{q_1}\, x_{q_1} = \sqrt{q_2}\, x_{q_1}$$

$$\boxed{x_{q_1} = \frac{\sqrt{q_1}\, r}{\sqrt{q_2} - \sqrt{q_1}}}$$



Q will have the same sign as the bigger charge.

$$\frac{KQq_1}{\left(\frac{\sqrt{q_1}\, r}{\sqrt{q_2} - \sqrt{q_1}}\right)^2}$$

$$\frac{K q_1 q_2}{r^2} = \frac{KQq_1}{\frac{q_1 r^2}{(\sqrt{q_2} - \sqrt{q_1})^2}}$$

$$Q = \frac{q_1 q_2}{(\sqrt{q_2} - \sqrt{q_1})^2}$$

Find the distance of null point from the charge on the left & Q.

① Like charges (line ke under null pt. hoga).

$$x_{q_1} = \frac{\sqrt{q_1}\, r}{\sqrt{q_1} + \sqrt{q_2}}$$

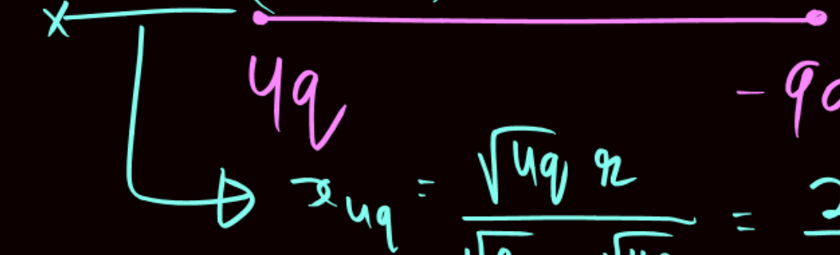
$$Q = \frac{q_1 q_2}{(\sqrt{q_1} + \sqrt{q_2})^2}$$ (Unlike)

② Unlike charges (line ke bahar Null pt. hoga)

$$x_{q_1} = \frac{\sqrt{q_1}\, r}{|\sqrt{q_2} - \sqrt{q_1}|}$$

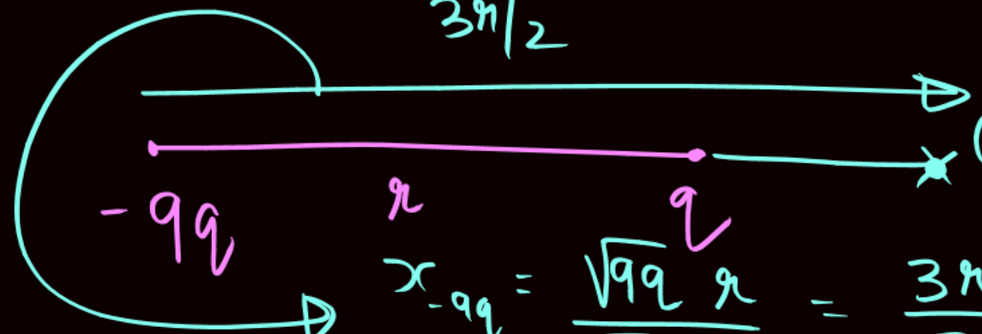
$$Q = \frac{|q_1 q_2|}{(\sqrt{q_2} - \sqrt{q_1})^2}$$ (sign of bigger charge).

① $Q = -\frac{4q \times 9q}{(\sqrt{9q} - \sqrt{4q})^2} = -36q$



$$x_{4q} = \frac{\sqrt{4q}\, r}{\sqrt{9q} - \sqrt{4q}} = \frac{2r}{1}$$

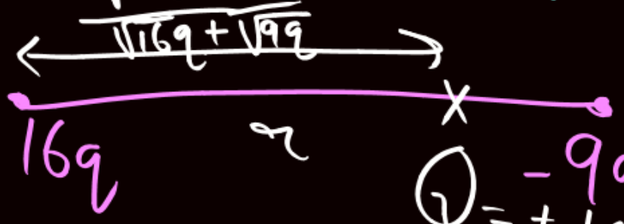
② $3\pi/2$



$$x_{-9q} = \frac{\sqrt{9q}\, r}{\sqrt{9q} - \sqrt{q}} = \frac{3r}{2}$$

$$Q = -\frac{9q^2}{(\sqrt{9q} - \sqrt{q})^2} = -\frac{9q}{4}$$

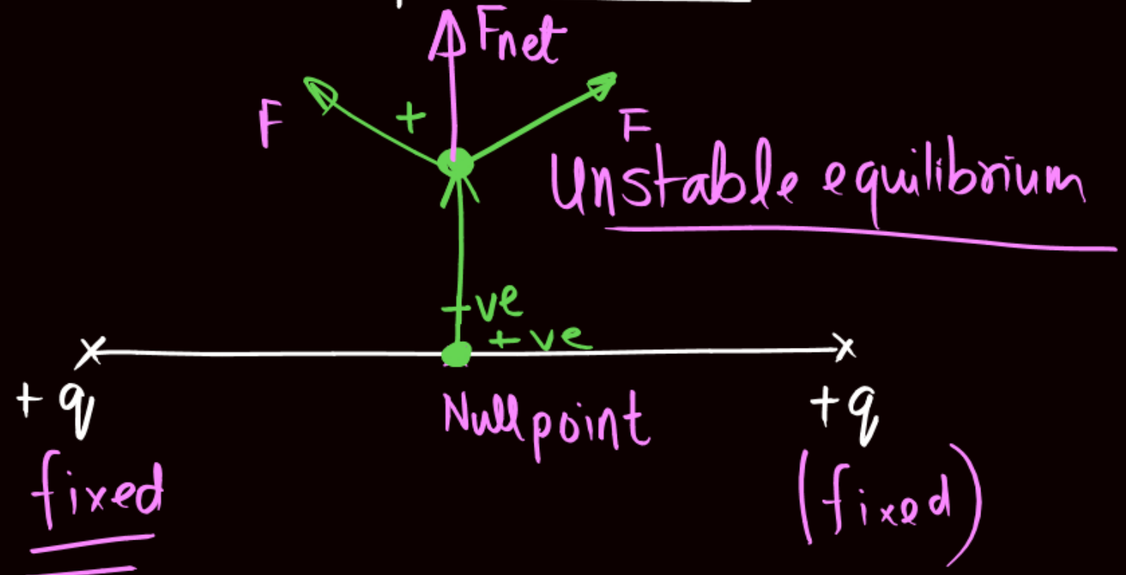
③



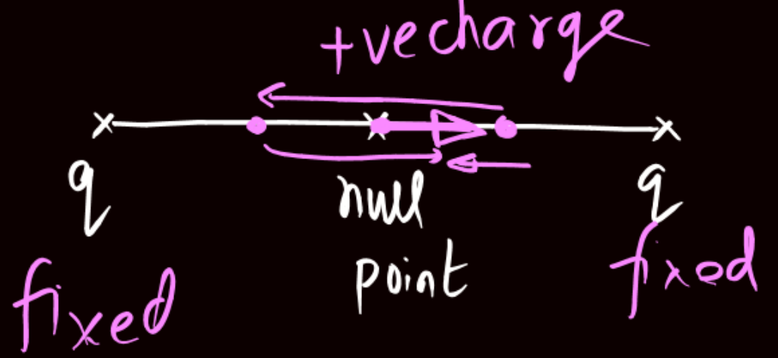
$$Q = +\frac{16q \cdot 9q}{(\sqrt{16q} + \sqrt{9q})^2}$$

Equilibrium of charges

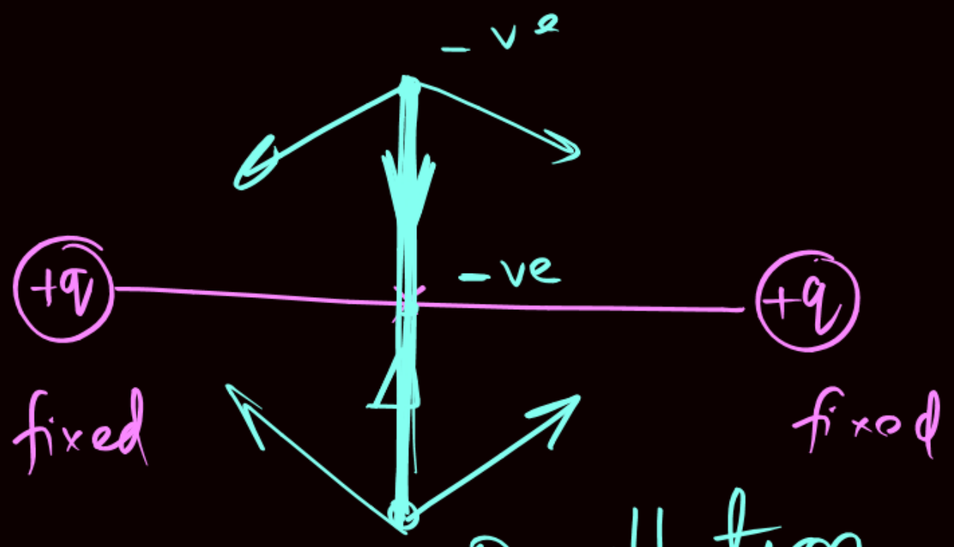
Positive charge

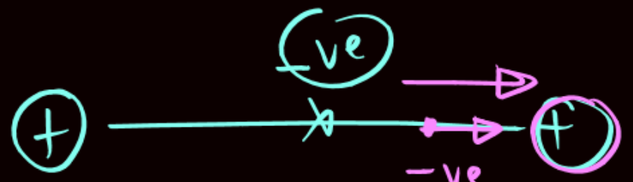


Unstable equilibrium



Find Time period of oscillation

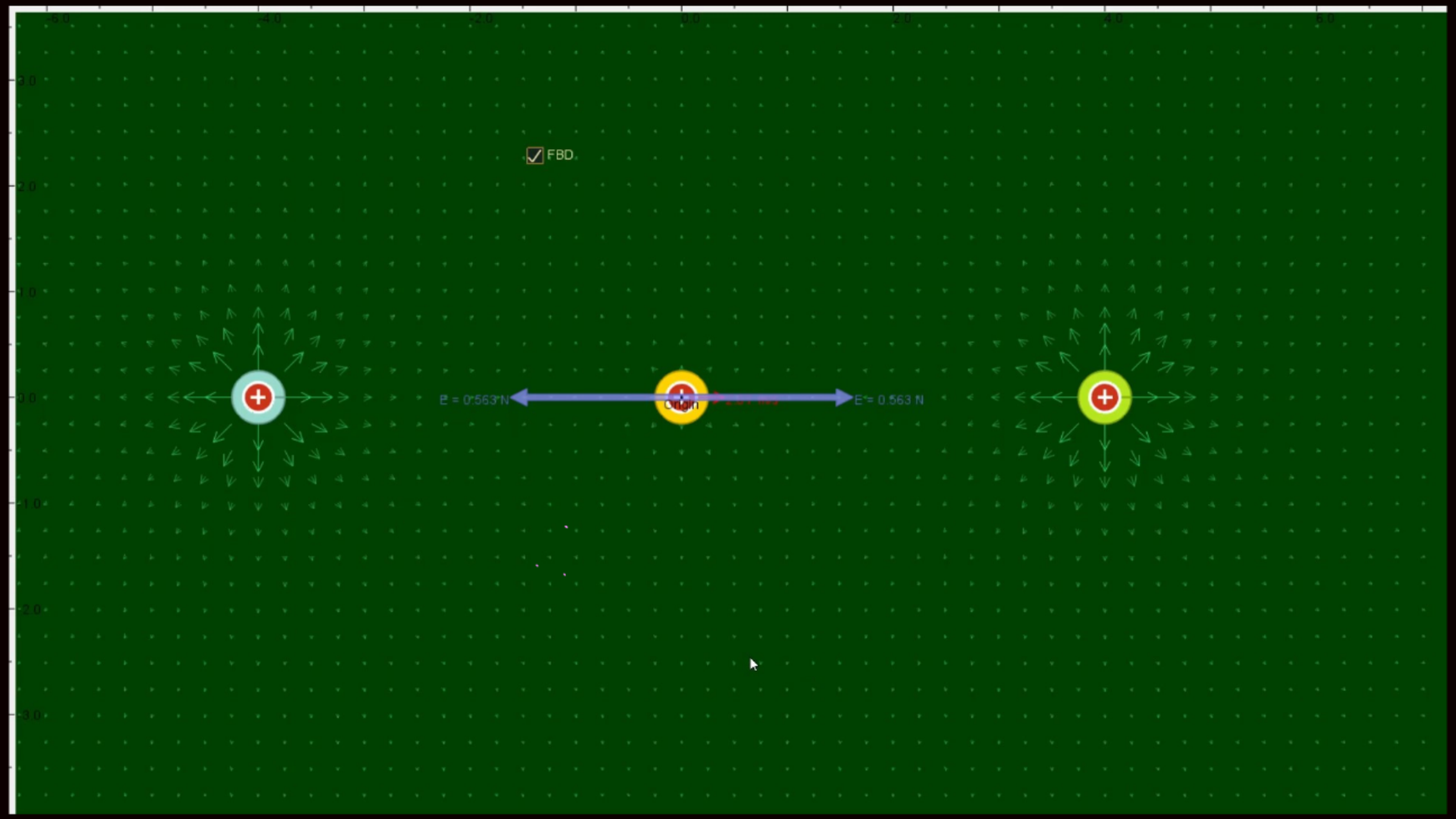


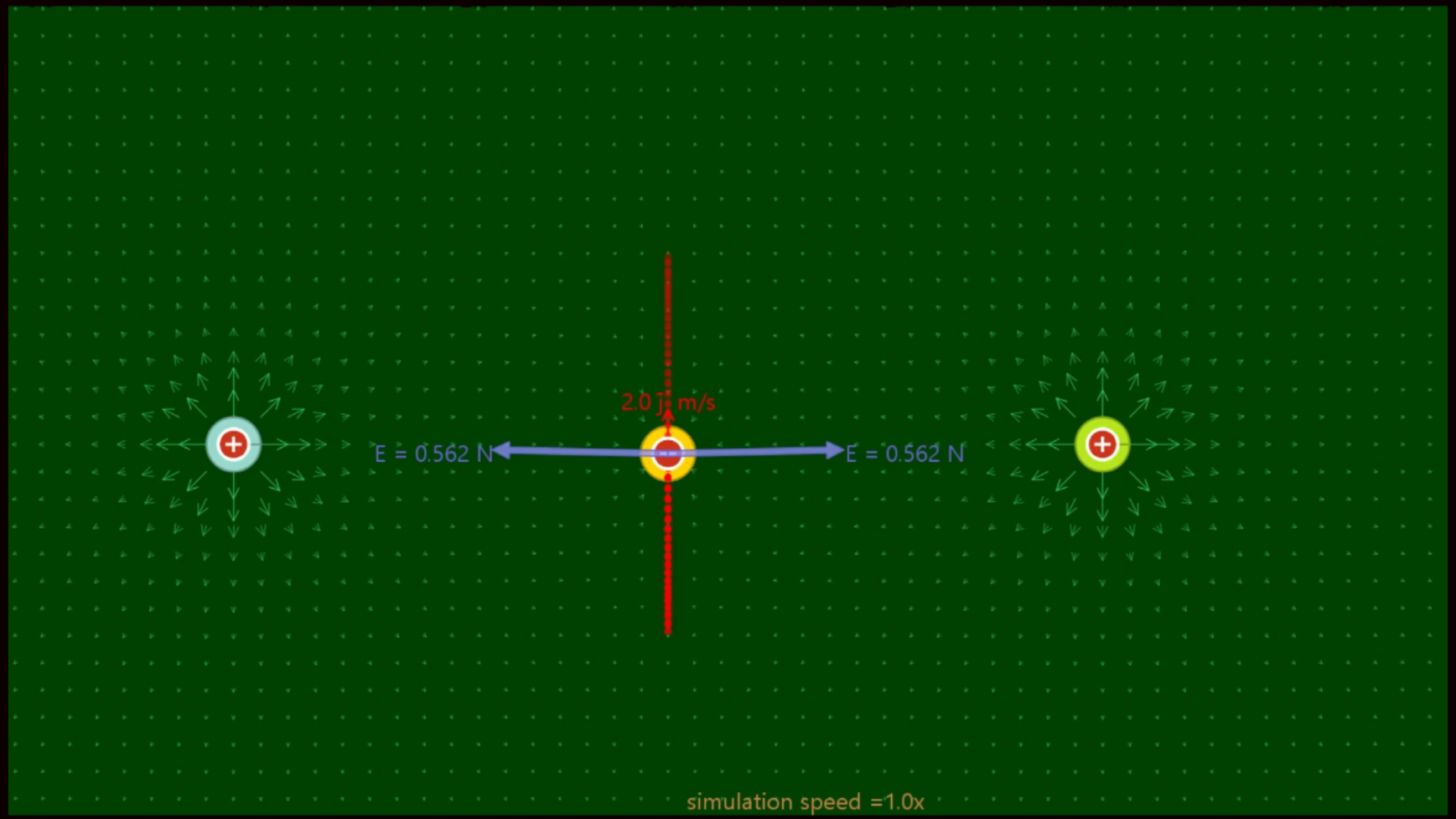


Oscillation

Stable equilibrium

Oscillation of charges




2.0 j m/s
E = 0.562 N
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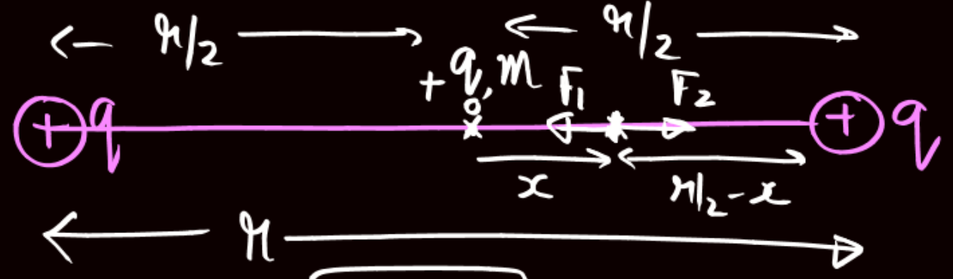
simulation speed =1.0x



$x \ll r$

Jis dir. me x hai us dir. wale force ko +ve lenge.

$$F_{net} = F_2 - F_1$$

$$= \frac{Kqq_0}{\left(\frac{r}{2}+x\right)^2} - \frac{Kqq_0}{\left(\frac{r}{2}-x\right)^2}$$

$$= Kqq_0\left[\frac{1}{\left(\frac{r}{2}+x\right)^2} - \frac{1}{\left(\frac{r}{2}-x\right)^2}\right]$$

$$= Kqq_0\left[\frac{\left(\frac{r}{2}-x\right)^2 - \left(\frac{r}{2}+x\right)^2}{\left[\left(\frac{r}{2}+x\right)\left(\frac{r}{2}-x\right)\right]^2}\right]$$

$$= Kqq_0\left[\frac{\left(\frac{r}{2}-x+\frac{r}{2}+x\right)\left(\frac{r}{2}-x-\frac{r}{2}-x\right)}{\left(\left(\frac{r}{2}\right)^2 - x^2\right)^2}\right]$$

$$= \frac{-Kqq_0 \, r \, 2x}{\left(\frac{r}{2}\right)^4}$$

→ neglect

$$F_{net} = -\frac{2kqq_0 x}{\left(\frac{x}{2}\right)^4}$$

$$ma = -\frac{32kqq_0 x}{x^3}$$

$$a = -\left(\frac{32kqq_0}{mx^3}\right)x$$

$$* \boxed{a = -\omega^2 x} \leftarrow \text{equation of SHM}$$

→ On comparing.

$$\omega^2 = \frac{32kqq_0}{mx^3}$$

$$\omega = \sqrt{\frac{32kqq_0}{mx^3}}$$

$$T = 2\pi\sqrt{\frac{mx^3}{32kqq_0}}$$

$$* \boxed{T = \frac{2\pi}{\omega}}$$

Thank You Lakshyians