LAKSHYA JEE

LAKSHYA KO HAR HAAL ME PAANA HAI

Electric Charges and Field

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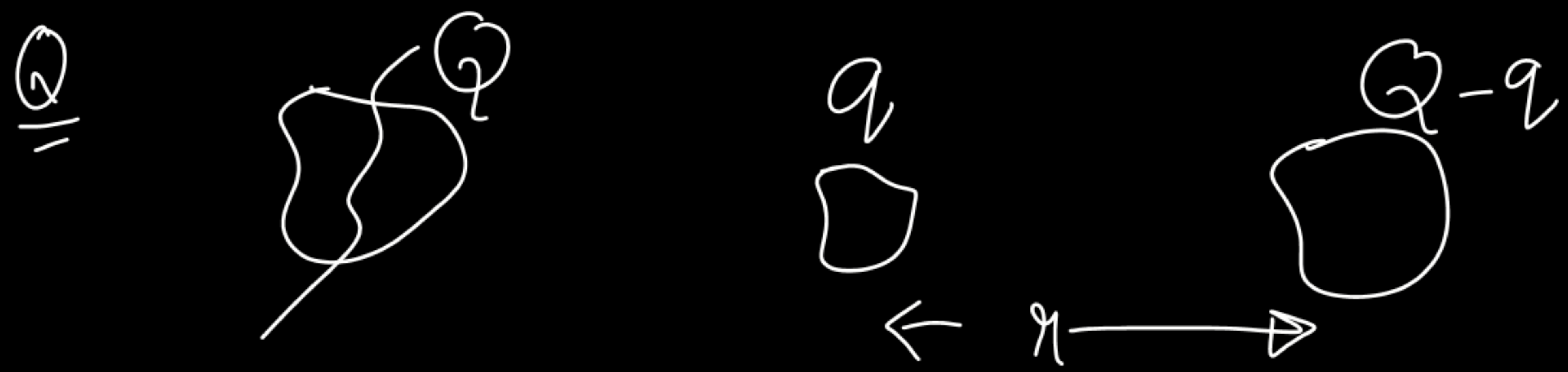
Today's GOALS!

- ❑ Electric field
- ❑ Electric field due to a point charge
- ❑ superposition principle
- ❑ Electric field due to a group of charges



Find 'q' so that the force between the charges is **maximum**.

$$F = \frac{K\,q\,(Q-q)}{r^2}$$

When $\frac{dF}{dq} = 0$ then F will be maximum.

$$F = \frac{K\, q(Q-q)}{r^2}$$

$$\frac{dF}{dq} = \frac{d}{dq}\left(\frac{K}{r^2}\left(Qq - q^2\right)\right)$$

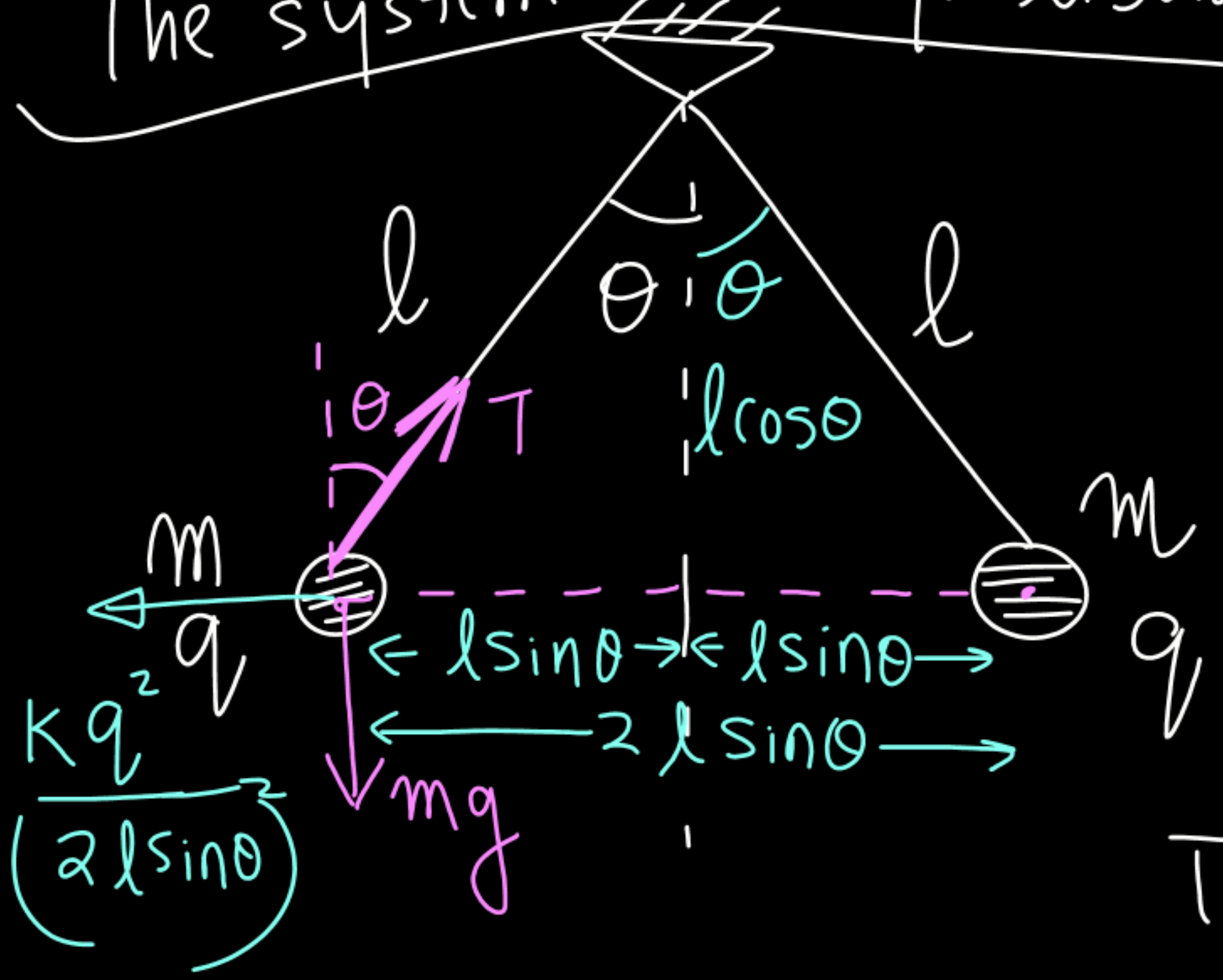
$$\frac{dF}{dq} = \frac{K}{r^2}\left(Q \times 1 - 2q\right) = 0$$

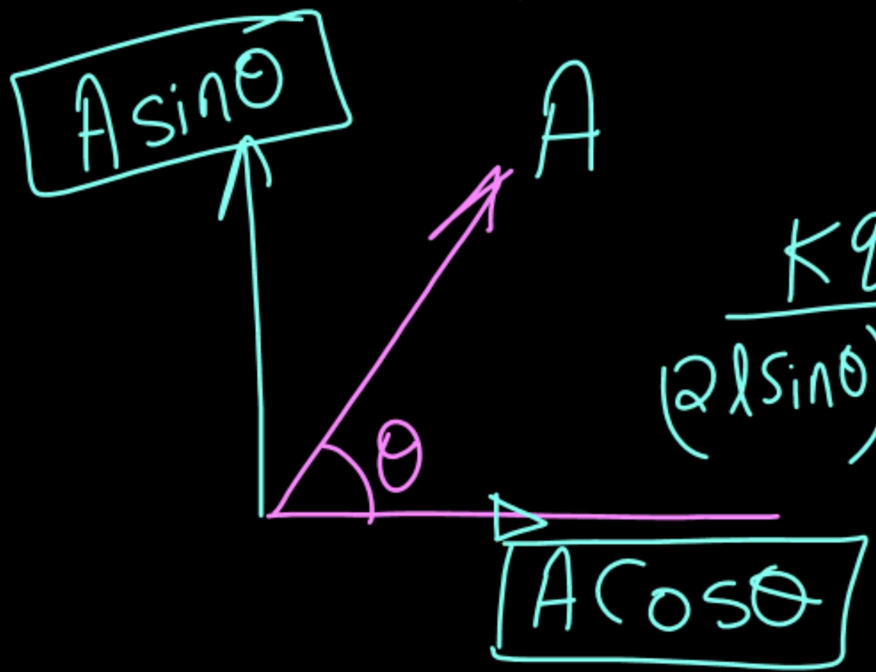
$$Q = 2q$$

$$\boxed{q = \frac{Q}{2}}$$

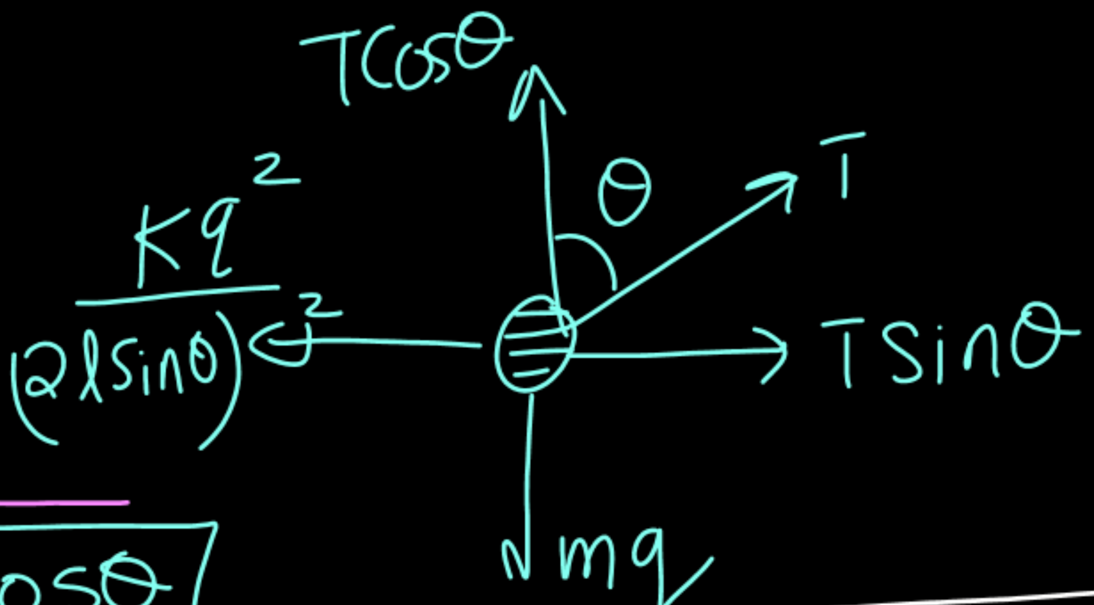
The system is in equilibrium.

Find q?





Method 1



$$T\cos\theta = mg \quad (1)$$

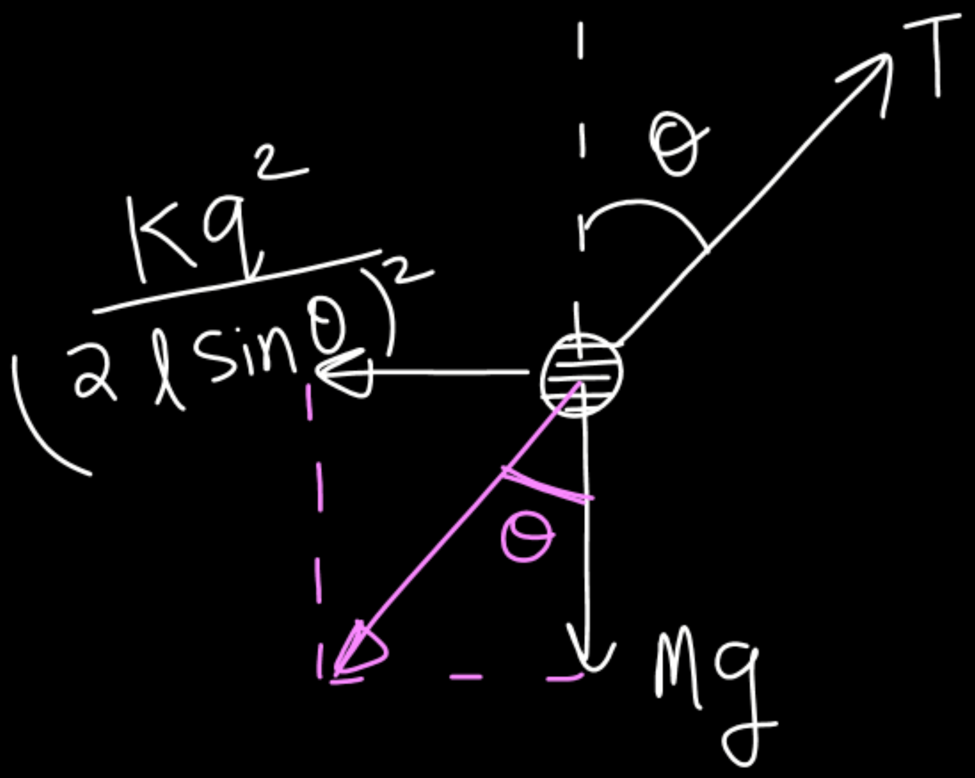
$$T\sin\theta = \frac{Kq^2}{4l^2\sin^2\theta} \quad (2)$$

(2) ÷ (1)

$$\tan\theta = \frac{Kq^2}{4l^2\sin^2\theta\, mg}$$

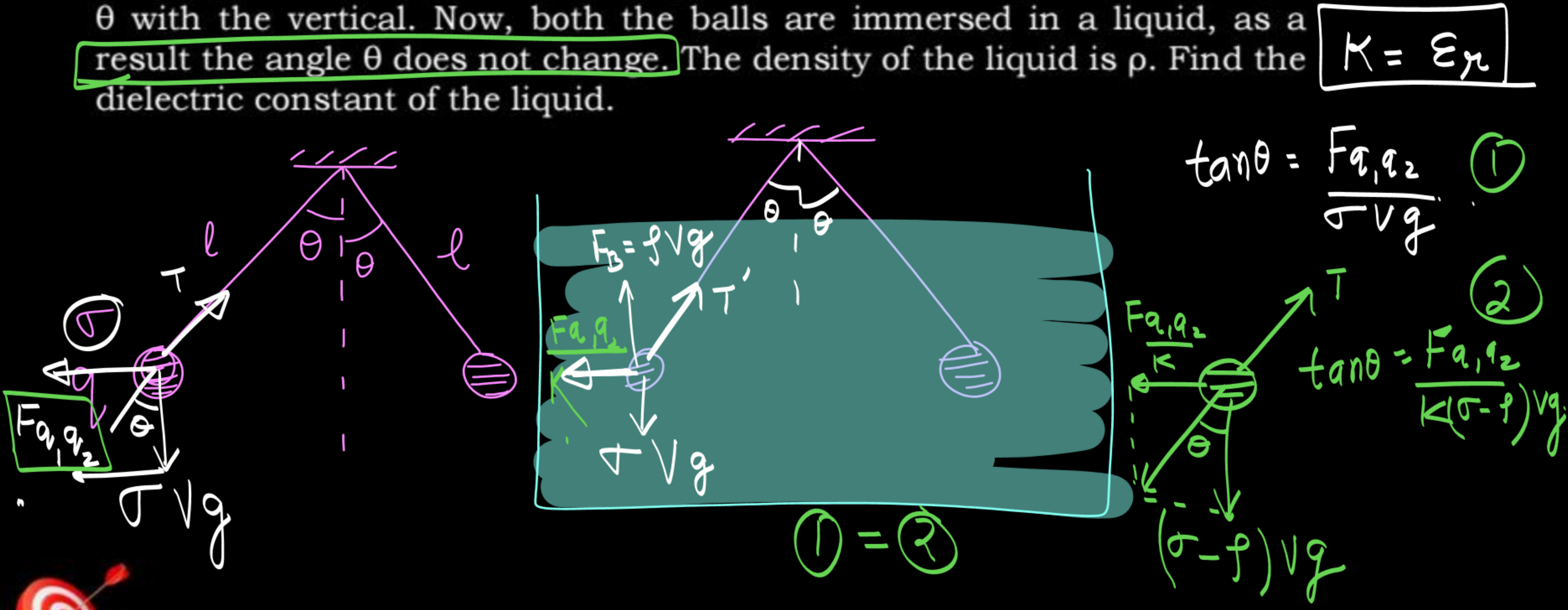
$$\boxed{q = \sqrt{\frac{4l^2\sin^2\theta\, mg}{K}}}$$

Method 2



$$\tan\theta = \frac{Kq^2}{4l^2\sin^2\theta \, mg}$$

Two identical balls each having a density σ are suspended from a common point by two insulating strings of equal length. Both the balls have equal mass and charge. In equilibrium each string makes an angle θ with the vertical. Now, both the balls are immersed in a liquid, as a result the angle θ does not change. The density of the liquid is ρ. Find the dielectric constant of the liquid.



$$\tan\theta = \frac{F a_1 a_2}{\sigma v g} \quad (1)$$

$$\tan\theta = \frac{F a_1 a_2}{K(\sigma - \rho) v g} \quad (2)$$

$$(1) = (2)$$

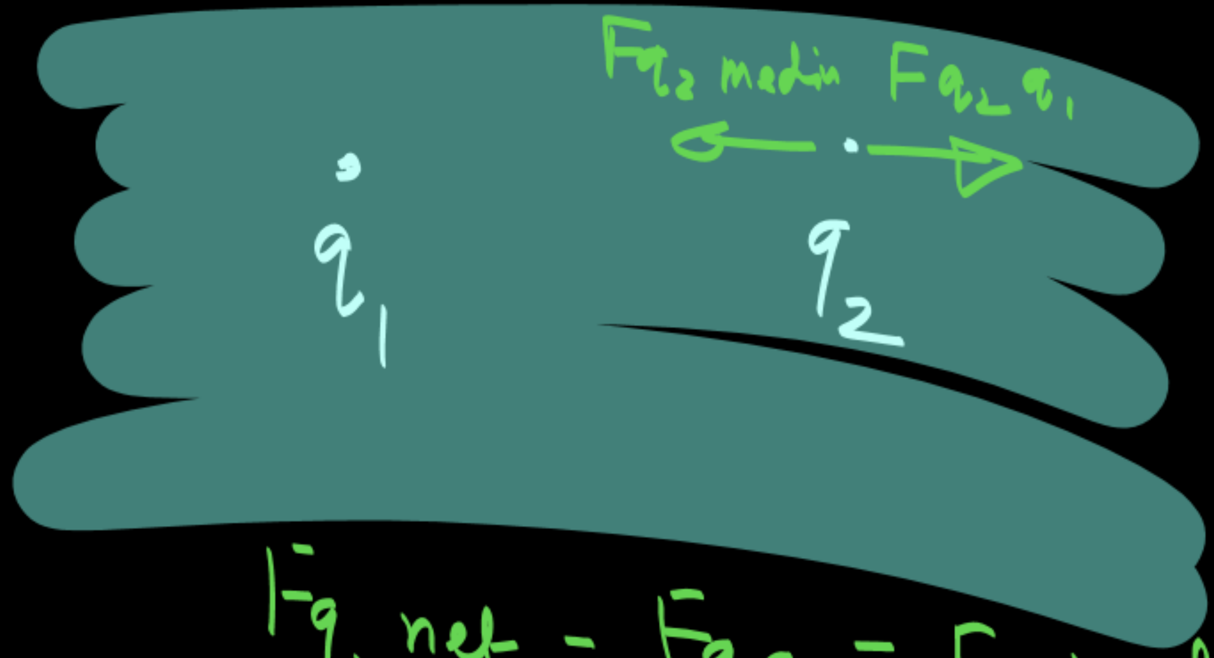
$$\frac{F a_1 a_2}{\sigma v g} = \frac{F a_1 a_2}{K(\sigma - \rho) v g}$$

$$\boxed{K = \frac{\sigma}{\sigma - \rho}}$$ Ans

Buoyant force

$$F_B = \rho_{liq} V_{object}\, g$$

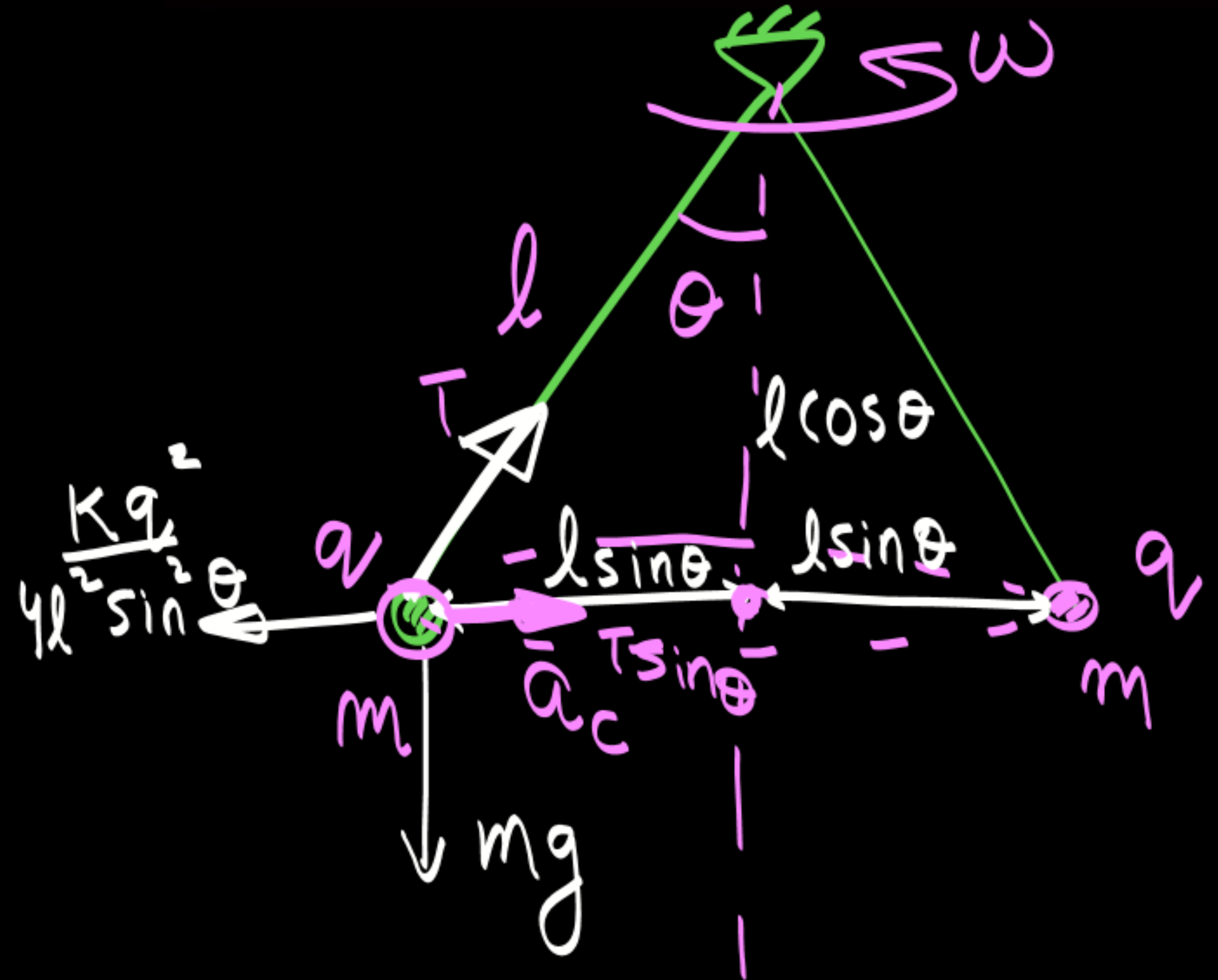
Vacuum



$$F_{q_2\,net} = F_{q_1 q_2} - F_{q_2\,medium}$$

$$F_{q_2\,net} = \frac{F_{q_1 q_2}}{K} = \frac{F_{q_1 q_2}}{\varepsilon_r}$$

Conical Pendulum



Find 'ω' so that the angle made by the string is θ.

Circular Motion :- $a_c = \omega^2 r = \frac{v^2}{r}$

$$T\cos\theta = mg \quad (1)$$

$$T\sin\theta - \frac{Kq^2}{4l^2\sin^2\theta} = m\omega^2 (l\sin\theta) \quad (2)$$

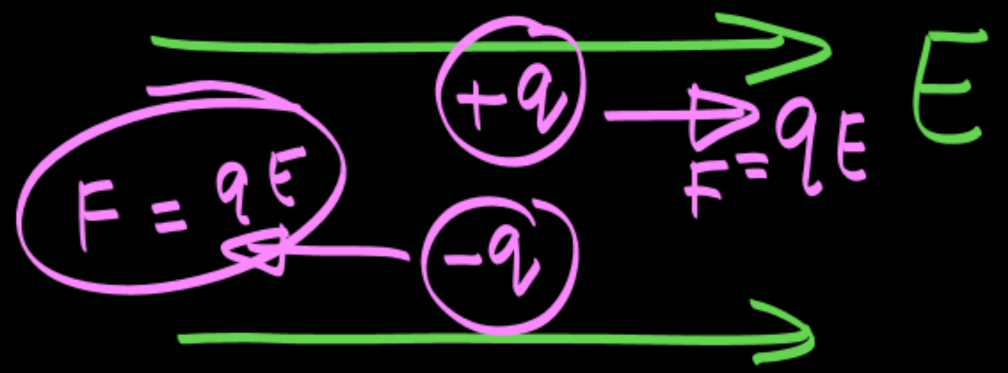
Electric field

$$F = qE$$

$$E = \frac{F}{q_{\text{test charge}}}$$

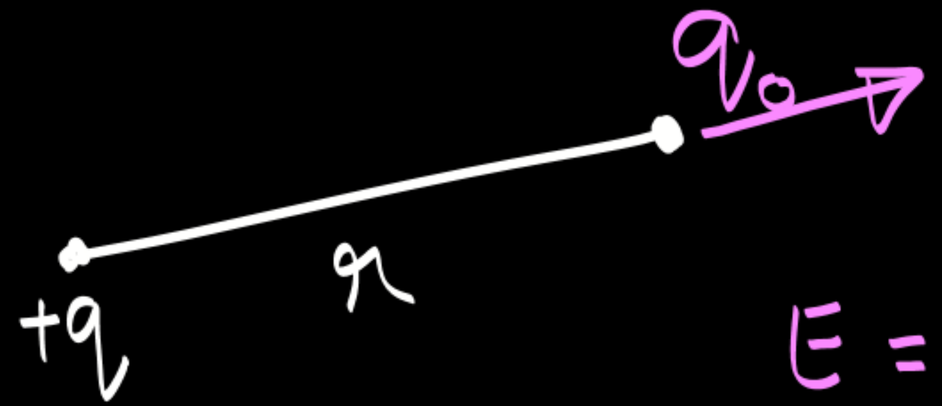
test charge is a very small positive charge.

Electric field at any point is the force experienced by a unit positive charge placed at that point. → Electric field intensity



NOTE :- Force on a +ve charge is parallel to the field & vice-versa.

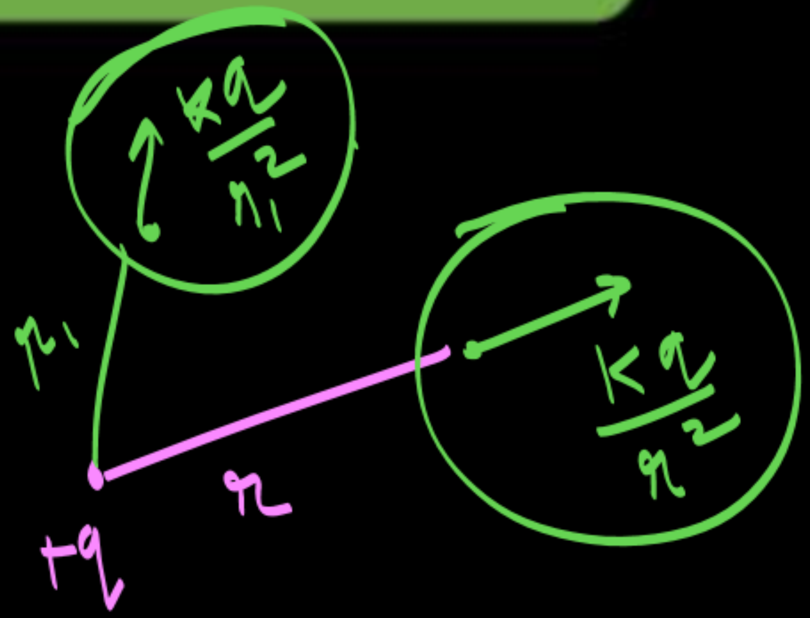
Electric field due to point charge



$$F_{q_0} = K\frac{q q_0}{r^2}$$

$$E = \frac{F_{q_0}}{q_0} = \frac{K q \cancel{q_0}}{r^2 \cancel{q_0}}$$

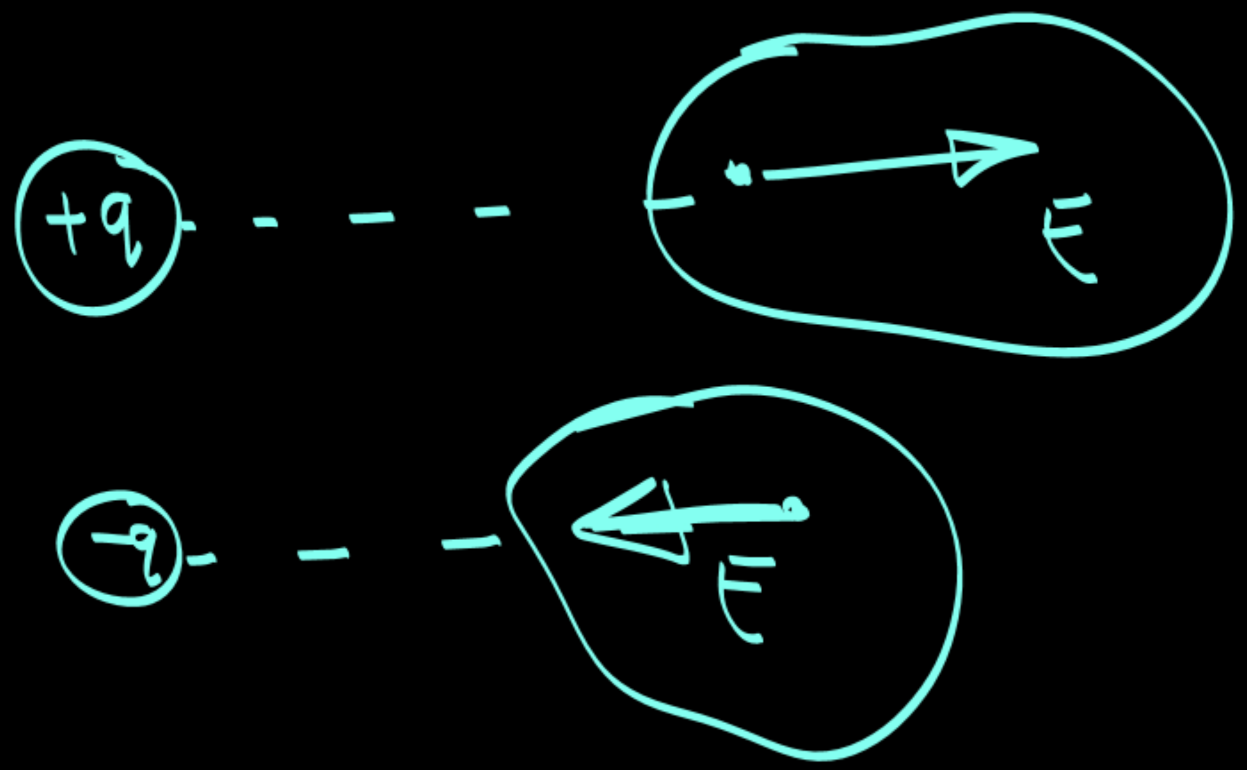
$$\boxed{E = \frac{Kq}{r^2}}$$

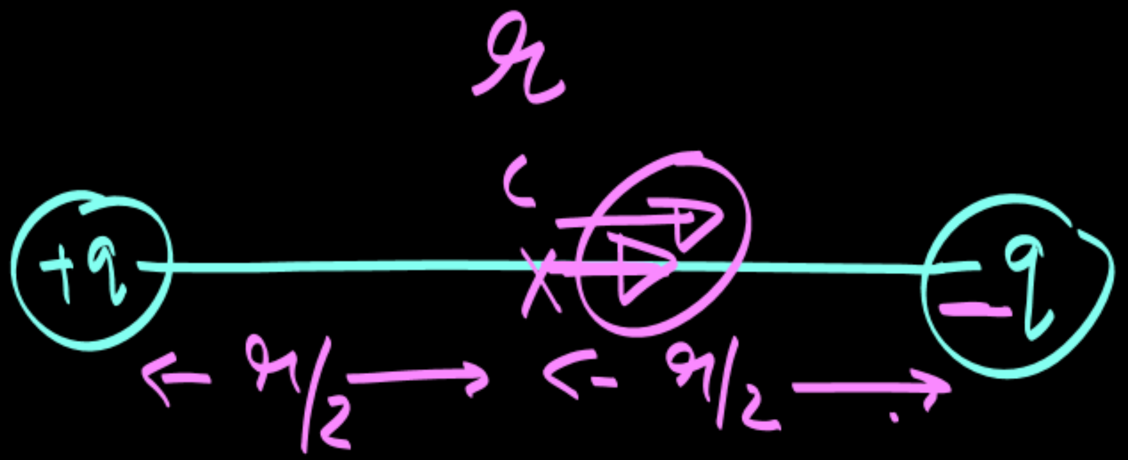


Direction of electric field

Positive charge creates a field away from it.

Negative charge creates a field towards it.

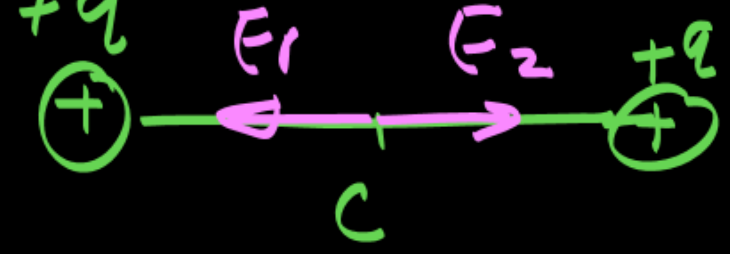




Find the field at point C?

$$E_{net} = \frac{kq}{(r/2)^2} + \frac{kq}{(r/2)^2}$$

$$\boxed{E_{net} = 8\frac{kq}{r^2}}$$



$E_{center} = ?$

$E_{net} = 0$

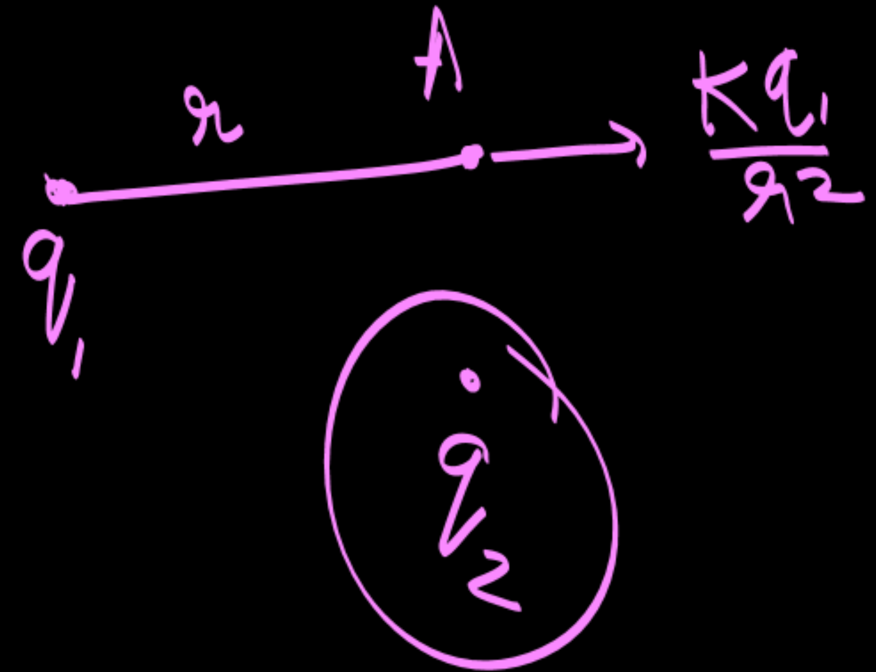
⇓

Null point

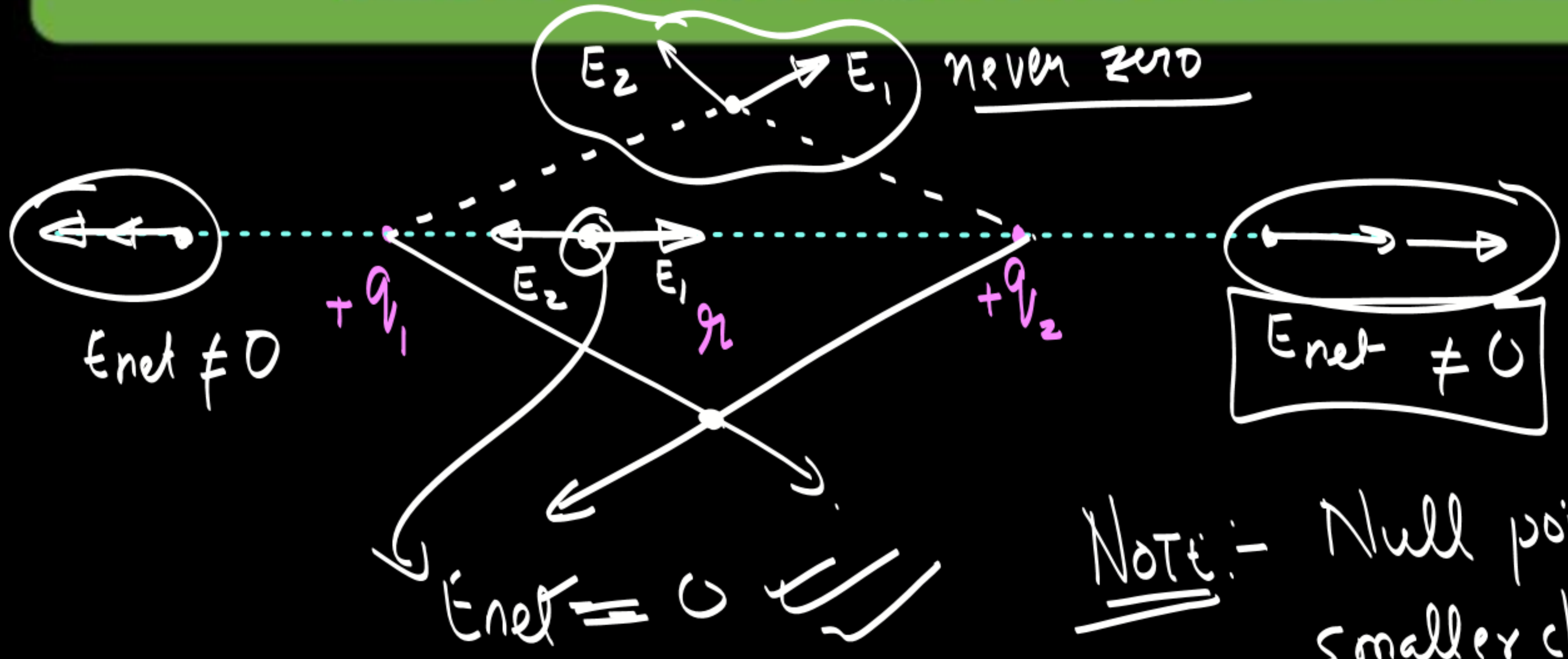
Where net field is zero.

Principle of Superposition

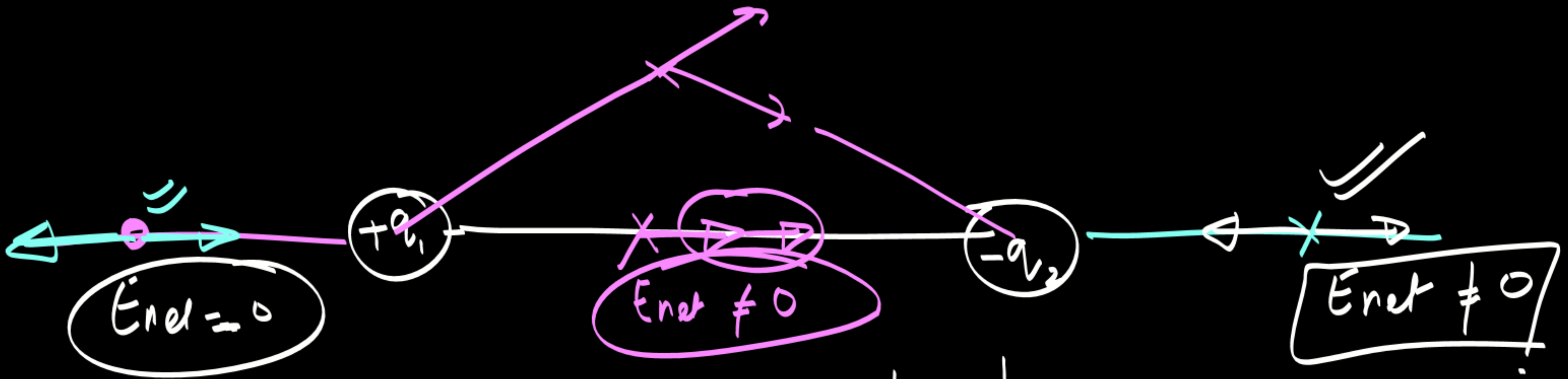
Ak point par ek charge ke dwara jo field hoti hai wo kisi aur charge particle ki presence or absence se effect nahi hoti.



Two charge system and Null Point



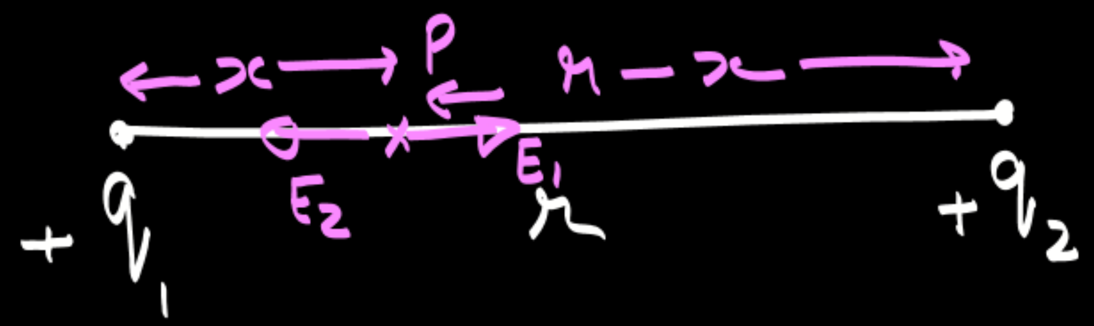
Note:- Null point will lie near the smaller charge.



If $|q_1| < |q_2|$.

Null point will be nearer to the small charge.

$q_1 < q_2$



$E_{net} = E_1 - E_2 = 0$

find the distance of null point from q_1.

For P to be the null point.

$E_1 = E_2$

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

$$\frac{\sqrt{q_1}}{x} = \frac{\sqrt{q_2}}{r-x}$$

$$\sqrt{q_1}(r-x) = \sqrt{q_2}(x)$$

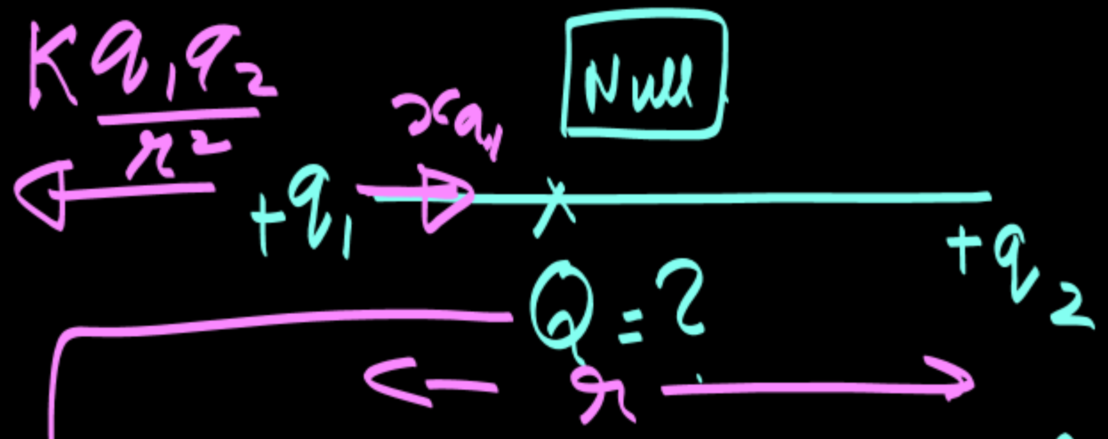
$$\sqrt{q_1}\, r - \sqrt{q_1}\, x = \sqrt{q_2}\, x$$

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

$$r - x = r - \frac{\sqrt{q_1}}{\sqrt{q_1} + \sqrt{q_2}} r = r\left(\frac{\sqrt{q_2}}{\sqrt{q_1} + \sqrt{q_2}}\right)$$

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

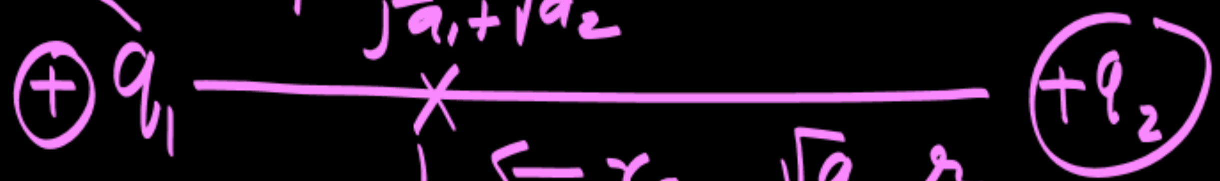
$$x_{q_2} = \frac{\sqrt{q_2}\, r}{\sqrt{q_1} + \sqrt{q_2}}$$



Find Q so that the whole system comes in equilibrium.

→ Q should be -ve.

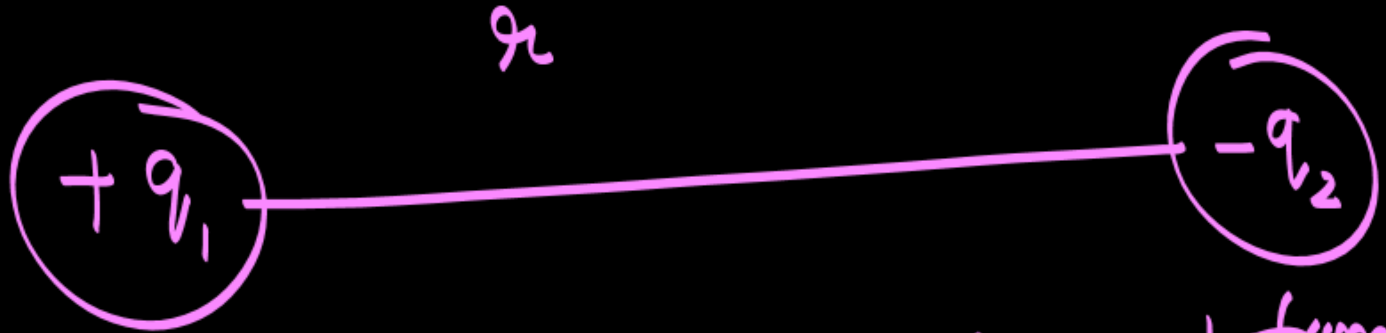
$$\frac{K q_1 q_2}{r^2} = \frac{K\, Q\, q_1}{\left(\frac{\sqrt{q_1}\, r}{\sqrt{q_1} + \sqrt{q_2}}\right)^2} \Rightarrow \boxed{Q = \frac{q_1 q_2}{\left(\sqrt{q_1} + \sqrt{q_2}\right)^2}}$$



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

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

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



($|q_1| < |q_2|$.

Find the distance of null point from q_1

& Find the charge that should be placed at the null point so that the whole system comes in equilibrium)

Thank You Lakshyians