LAKSHYA

LAKSHYA KO HAR HAAL ME PAANA HAI

ELECTROSTATICS REVISION

LAKSHYA JEE

By

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Six charge particles with their coordinates are:

$+Q(-d, 0)$	$+Q(0, -d)$	$-Q(d, 0)$	$-Q(0, d)$
$+4Q(2d, 0)$	$-4Q(0, -2d)$		

Are placed on X-Y plane. Find the net dipole moment.

Total charge of System ← Monopole = $Q_T = 0$

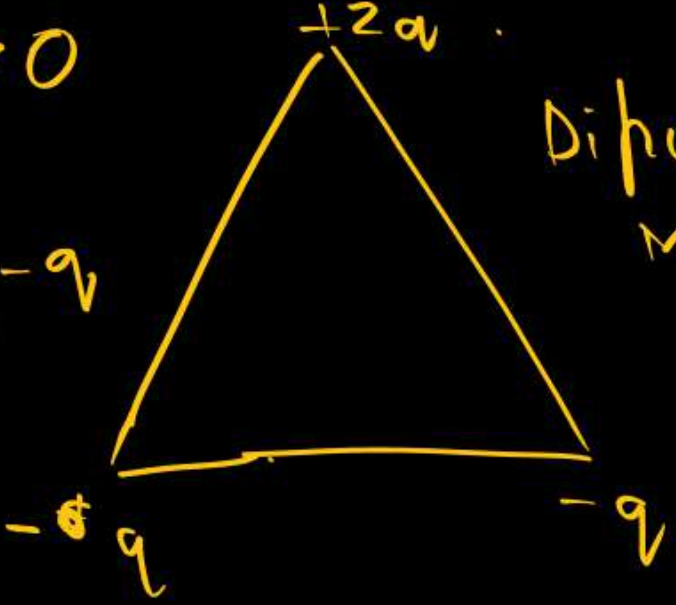
$\oplus$ - - - $\ominus$

q q

⊗ dipole → we can calculate dipole moment about any point

Monopole $Q_T = +q - q = 0$

$Q_T = 2q - q - q = 0$



Dipole moment

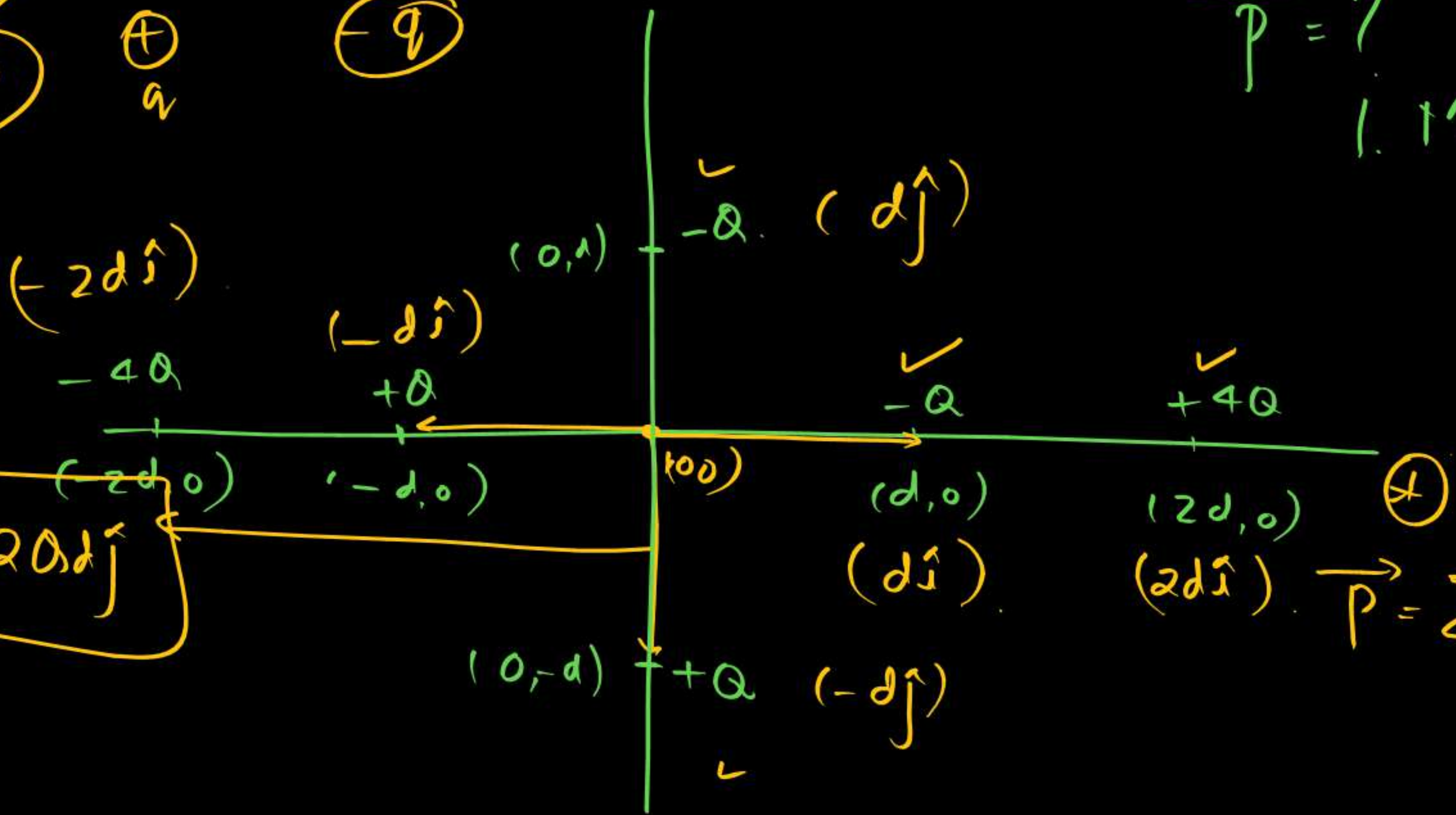
$Q_T = 0$ $+q$ $-q$

$\vec{P} = ?$

1. Monopole

$Q_T = 0$

$-4Q + 4Q - Q - Q + Q + Q = 0$



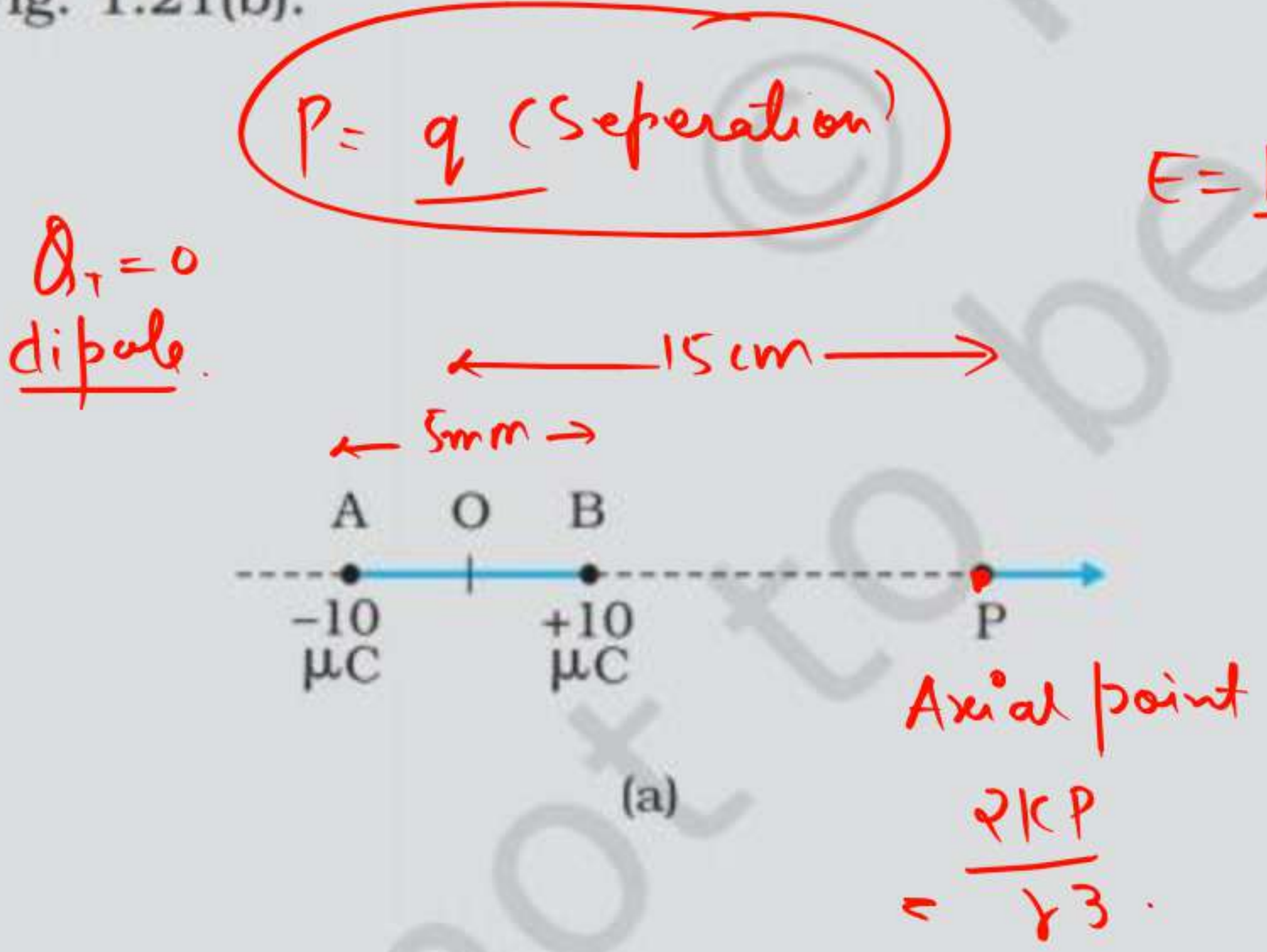
$\vec{P} = \sum$ (Charge with sign) (Position vector about any point)

$$\vec{P} = -Q(d\hat{i}) + 4Q(2d\hat{i}) + (-Q)d\hat{j} + Q(-d\hat{j}) + Q(-d\hat{i}) - 4Q(-2d\hat{i})$$

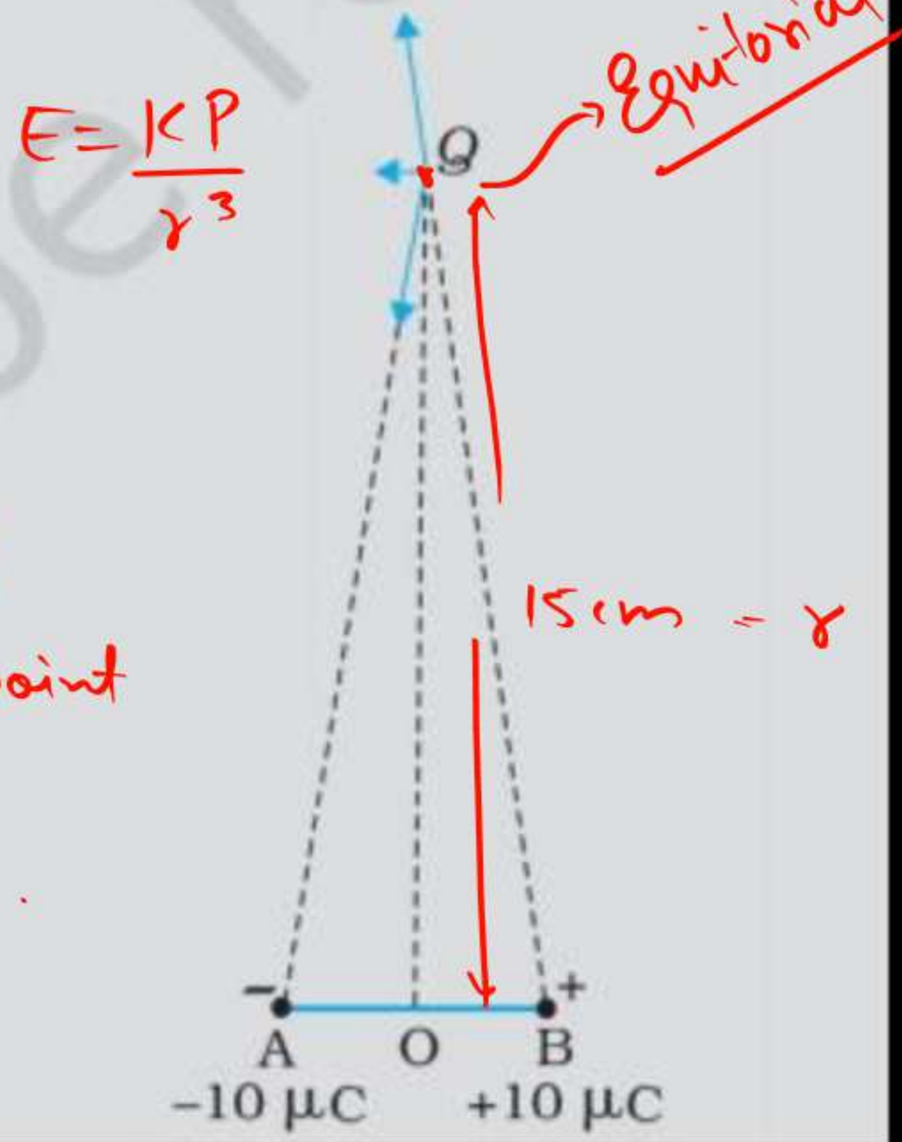
$$= -Qd\hat{i} + 8Qd\hat{i} - Qd\hat{j} - Qd\hat{j} - Qd\hat{i} + 8Qd\hat{i}$$

$$\vec{P} = 14Qd\hat{i} - 2Qd\hat{j}$$

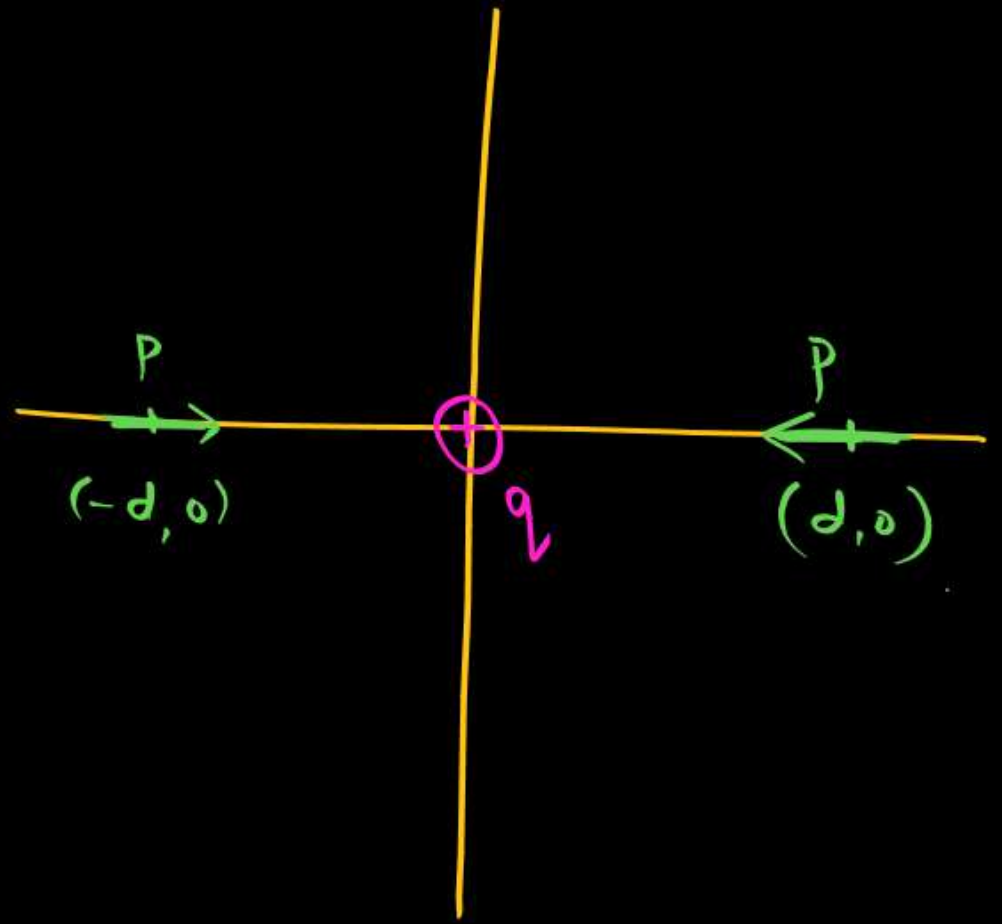
Example 1.10 Two charges ±10 μC are placed 5.0 mm apart. Determine the electric field at (a) a point P on the axis of the dipole 15 cm away from its centre O on the side of the positive charge, as shown in Fig. 1.21(a), and (b) a point Q, 15 cm away from O on a line passing through O and normal to the axis of the dipole, as shown in Fig. 1.21(b).

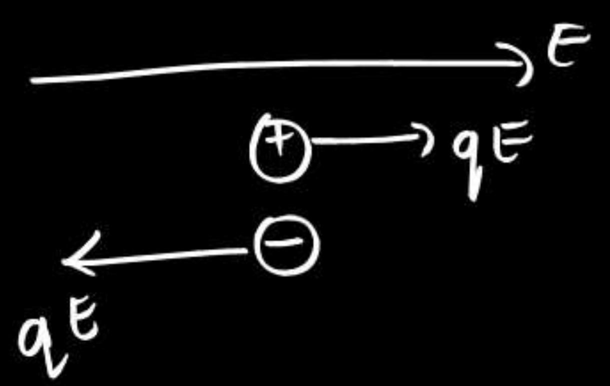


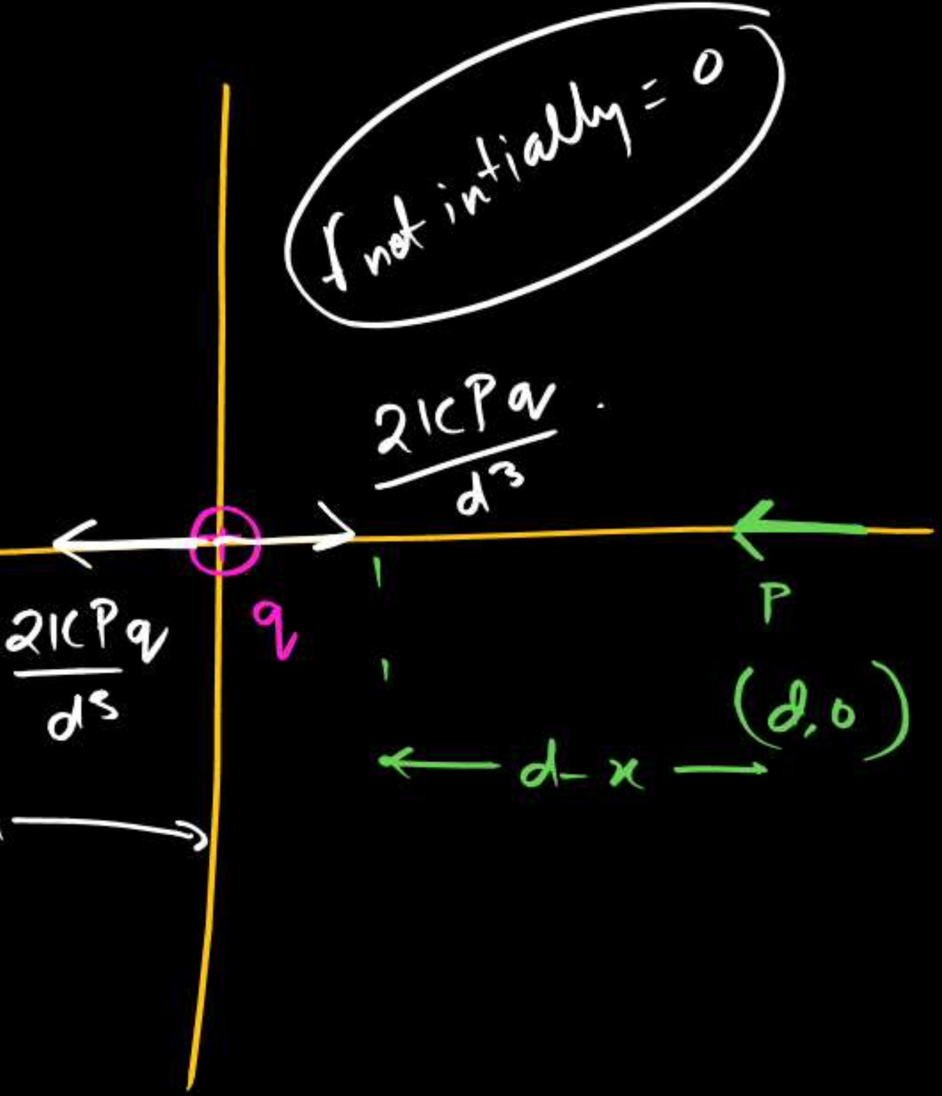
(a)

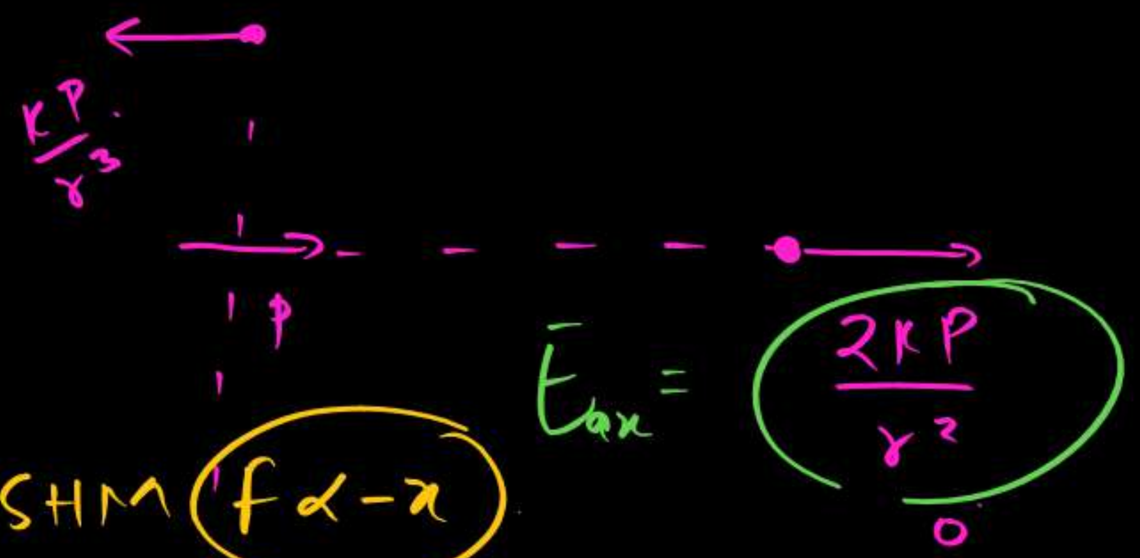


Two small dipoles of dipole moment P are placed at $(d, 0)$ and $(-d, 0)$. The direction of one of the dipole is along $+x$ axis and other one is along $-X$ axis. A small charge q is placed at origin and displaced by very small x $(x << d)$. Find the time period of oscillation of charge if mass of small charge is m.









for SHM $f \propto -x$

SHM - 1. Restoring fo

$$F = \frac{2KPq}{(d-x)^3}$$

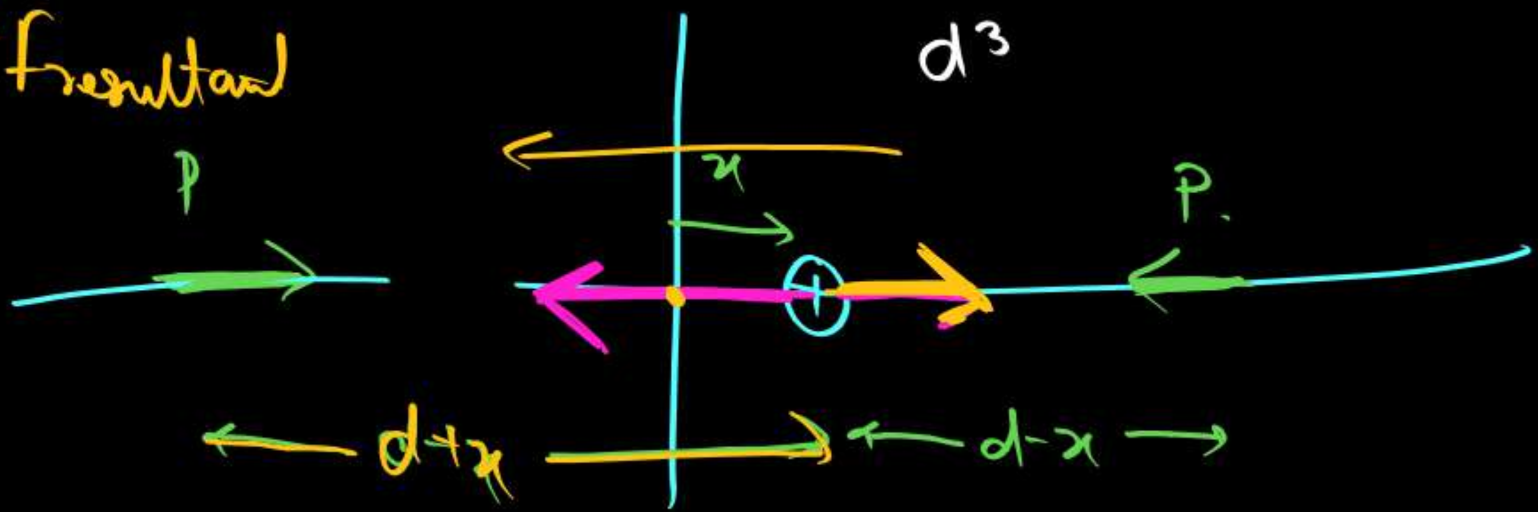
$$F = \frac{2KPq}{(d+x)^3} \text{ fresultant}$$

$$f = qE = q\frac{2KP}{d^3}$$

$$f_{net} = \frac{2KPq}{(d-x)^3} - \frac{2KPq}{(d+x)^3}$$

$$= 2KPq\left[(d-x)^{-3} - (d+x)^{-3}\right]$$

$$= \frac{2KPq}{d^3}\left[\left(1-\frac{x}{d}\right)^{-3} - \left(1+\frac{x}{d}\right)^{-3}\right]$$



$$(1+\square)^n \approx 1+n\square$$

$\square \rightarrow 0$

$$F_r = \frac{2kPq}{d^3}\left[\left(1-\frac{x}{d}\right)^{-3} - \left(1+\frac{x}{d}\right)^{-3}\right]$$

$$= \frac{2kPq}{d^3}\left[1+\frac{3x}{d} - 1 + \frac{3x}{d}\right]$$

$F \propto -x$

$$F_r = \frac{12kPqx}{d^4} = m\omega^2 x$$

$$\sqrt{\frac{12kPq}{md^4}} = \omega = \frac{2\pi}{T}$$

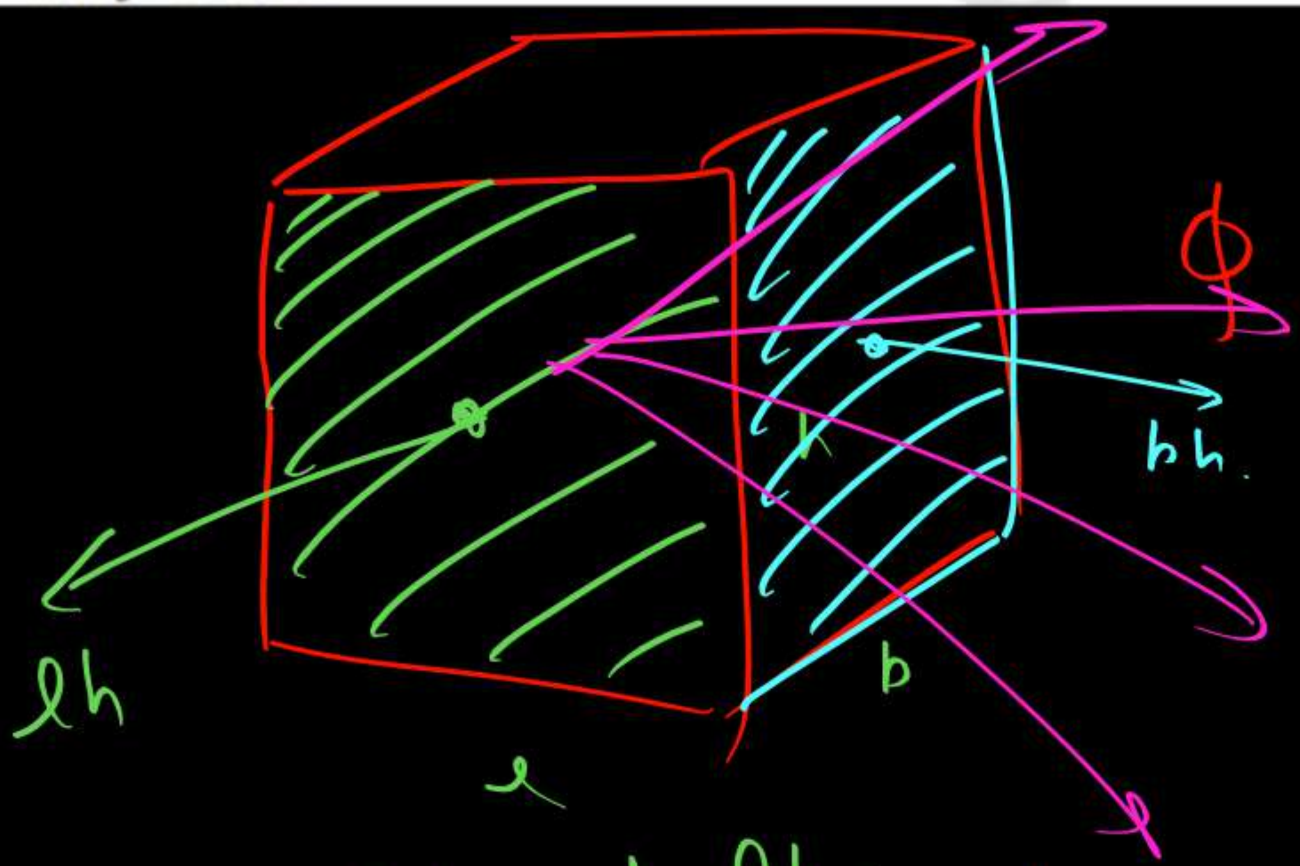
3. $F = m\omega^2 x$

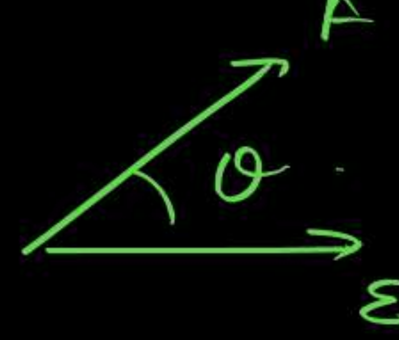
$F = ma$

for SHM

$a = -\omega^2 x$

1.17 Careful measurement of the electric field at the surface of a black box indicates that the net outward flux through the surface of the box is 8.0×10^3 Nm^2/C. (a) What is the net charge inside the box? (b) If the net outward flux through the surface of the box were zero, could you conclude that there were no charges inside the box? Why or Why not?





$\phi = 8 \times 10^3$ Nm^2/C

In physics we take $\vec{A}$: θ = Acute, ϕ = +ve

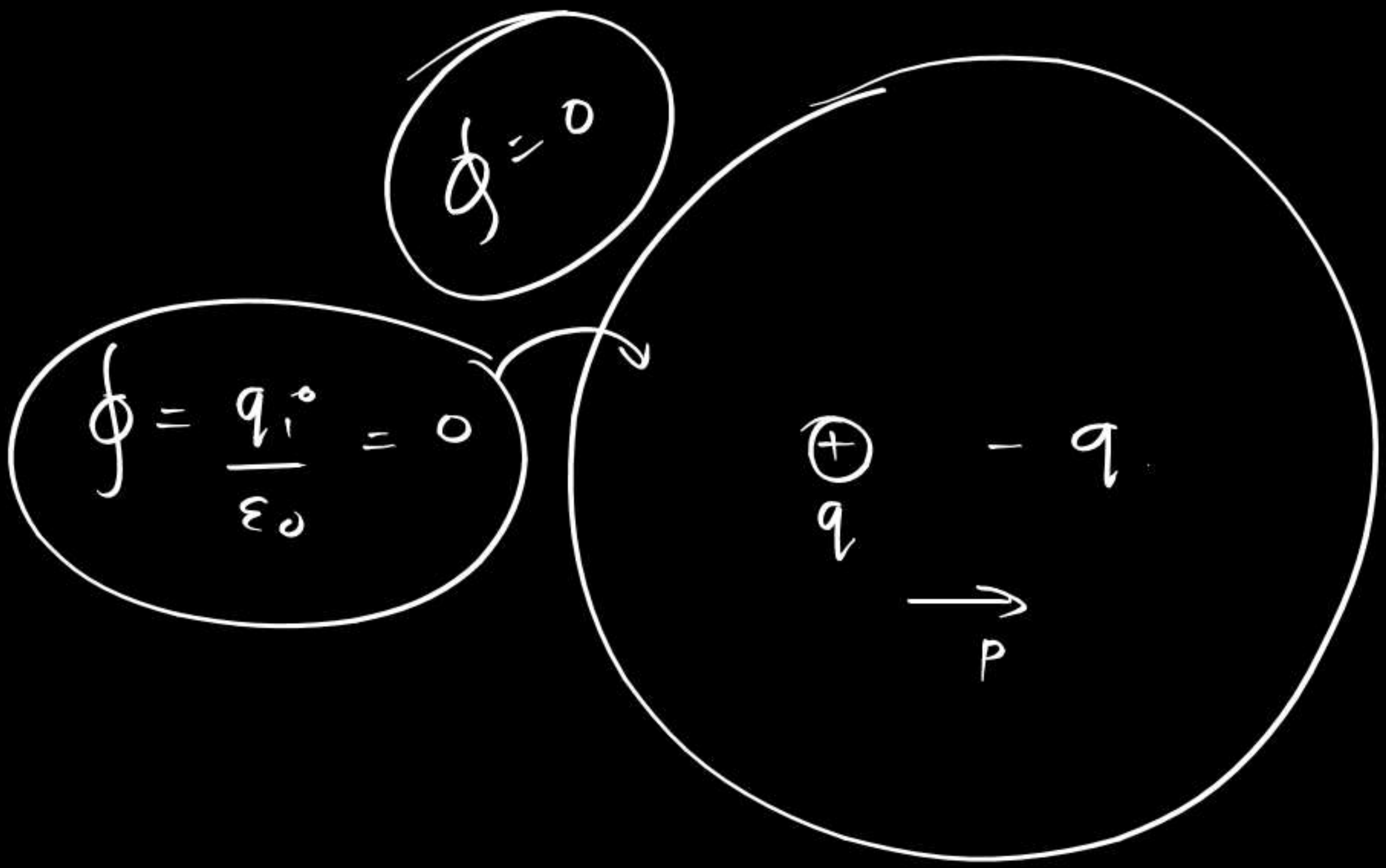
$\phi = \vec{E} \cdot \vec{A} = EA\cos\theta$

θ = Obtuse, ϕ = −ve

$\phi = \frac{q_i}{\varepsilon_0}$ $q_i = 8 \times 10^3 \times \varepsilon_0$

Outward flux = +ve

Inward flux = −ve


$\phi = 0$
$\phi = \frac{q_i}{\varepsilon_0} = 0$
+
q
-q
P

HCV

13. *A uniform electric field E is created between two parallel, charged plates as shown in figure (29-W9). An electron enters the field symmetrically between the plates with a speed v_0. The length of each plate is l. Find the angle of deviation of the path of the electron as it comes out of the field.*

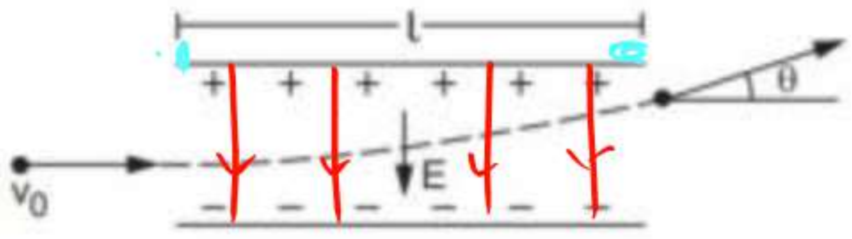
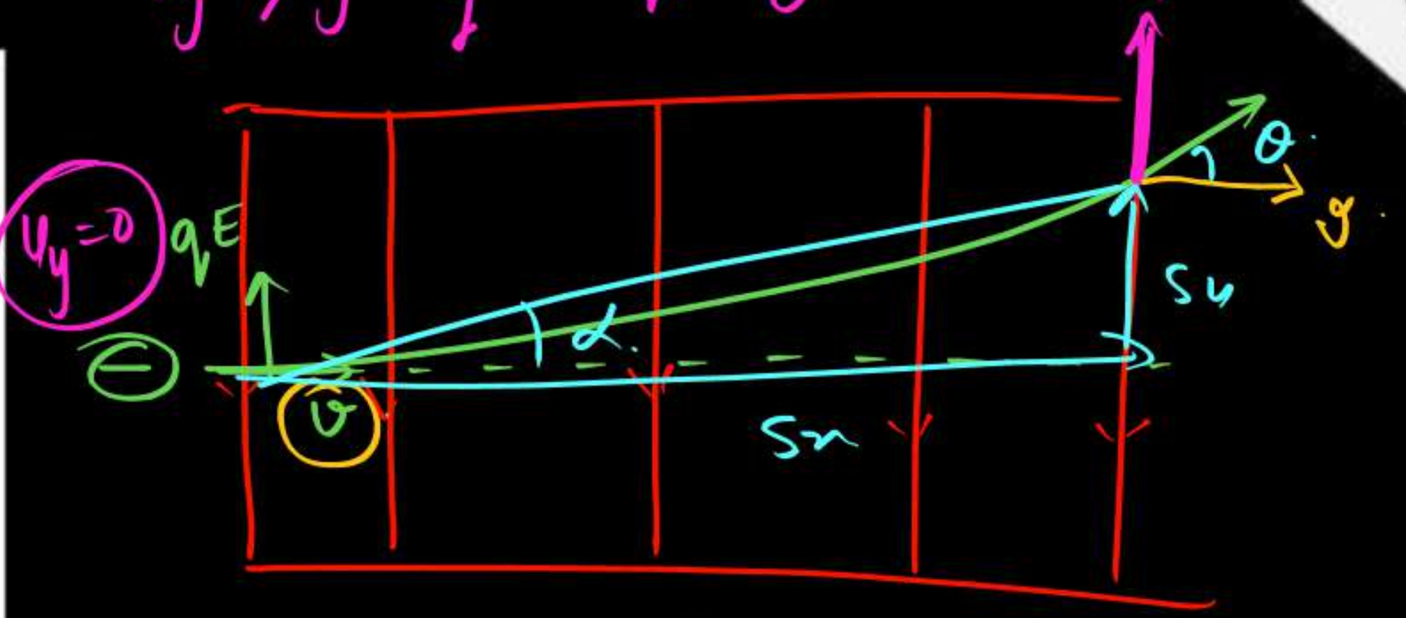


Figure 29-W9

$v_y = u_y + a_y t = \frac{qE}{m} \cdot \frac{l}{v}$



2D (X, Y)

There is force along Y.

$a_y = \frac{f_y}{m} = \frac{qE}{m}$ $a_x = ?$ $v_x = u_x + a_x t$

$v_x = v$

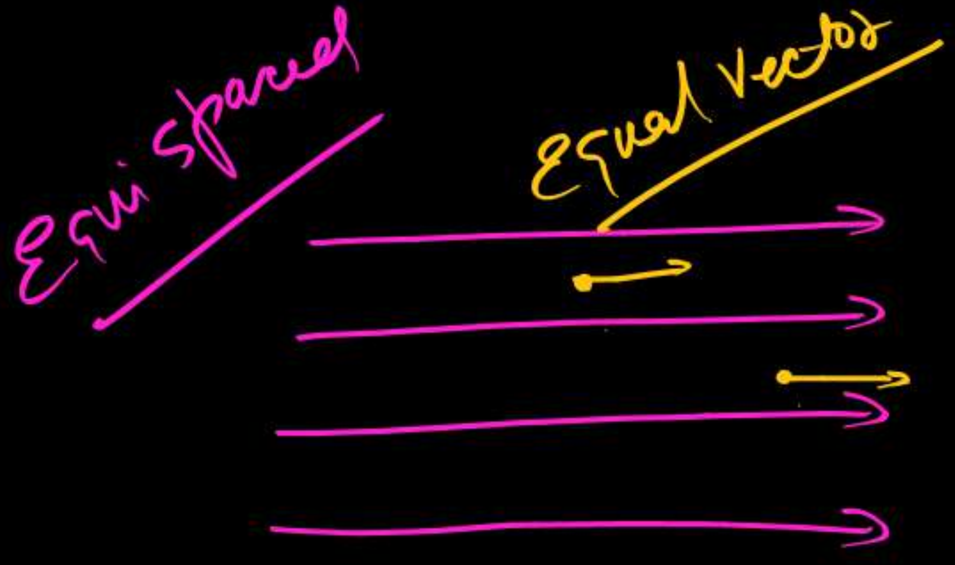
along x speed is constant

$s = D/t$ $t = \frac{l}{v}$

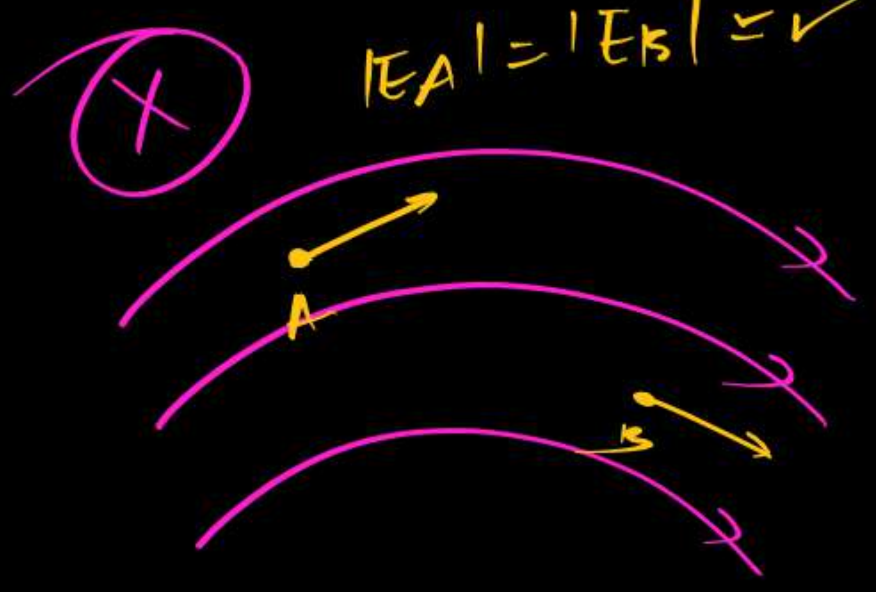
E → ; ← ⊖ qE

θ = ∠ of deviation

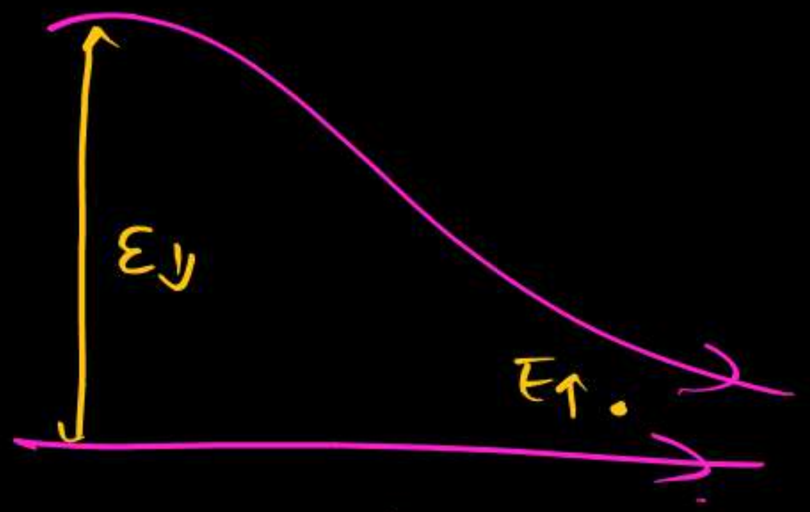
$$\tan\theta = \frac{P}{B} = \frac{v_y}{v_x} = \frac{qE}{m}\frac{l}{v^2}$$



(a)



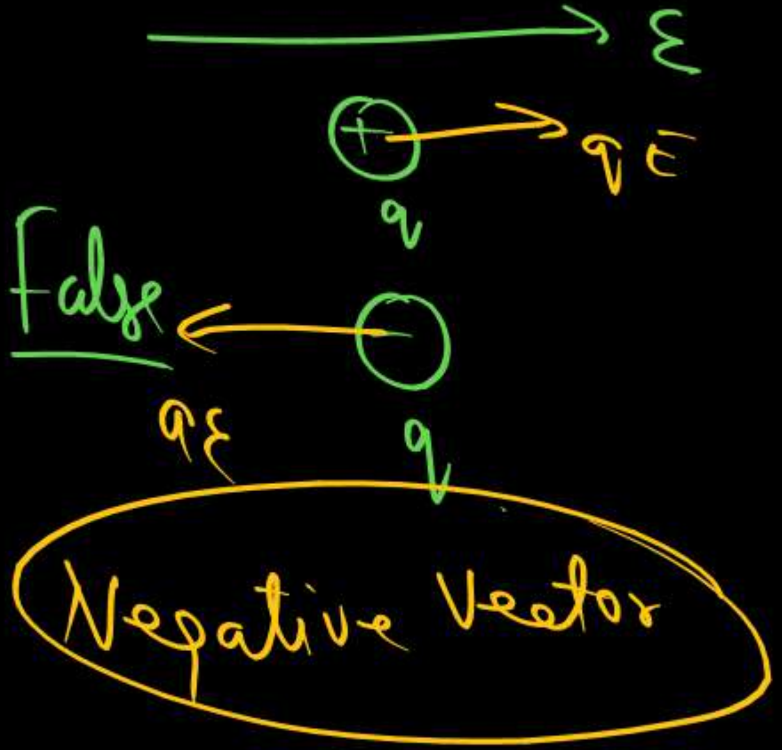
(b)



(c)

Uniform EF

Non-uniform



Force will be equal true or false

1.14 Figure 1.33 shows tracks of three charged particles in a uniform electrostatic field. Give the signs of the three charges. Which particle has the highest charge to mass ratio?

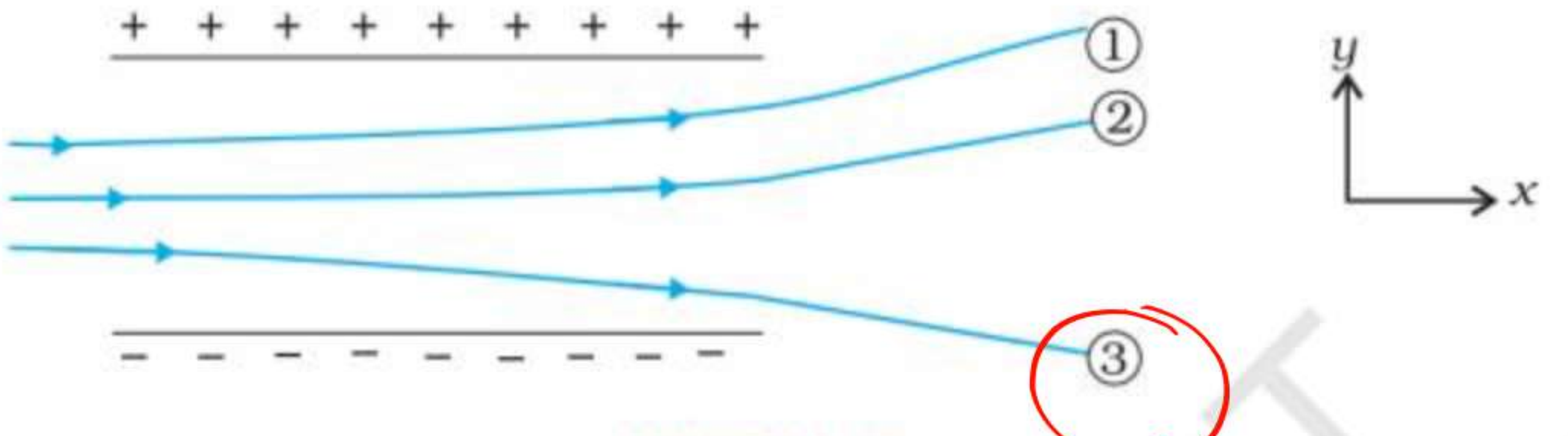


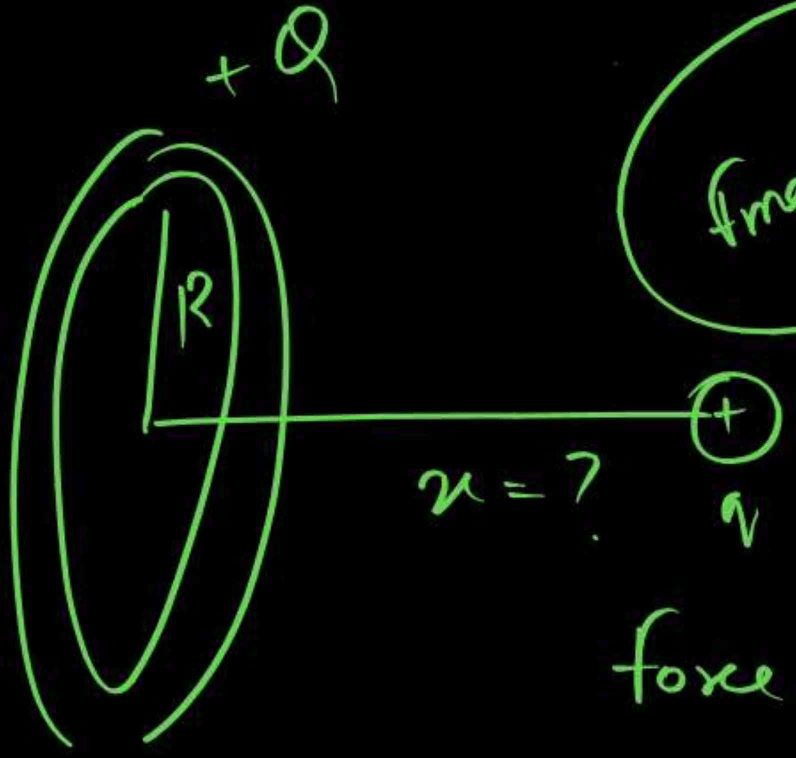
FIGURE 1.33

$\frac{e}{m}$ ratio more

$$\tan\theta = \frac{qE}{m}\frac{l}{u^2}$$

$e/m \propto \tan\theta$

deviation



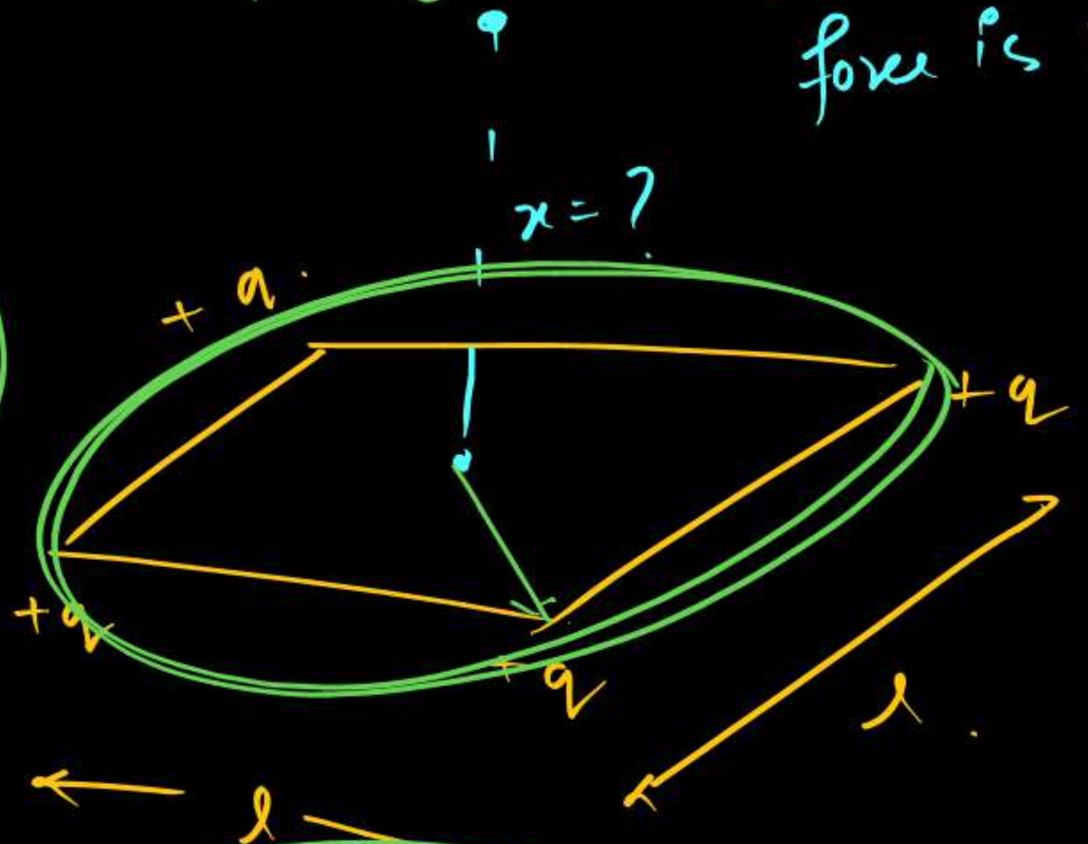
$f_{max} = ?$

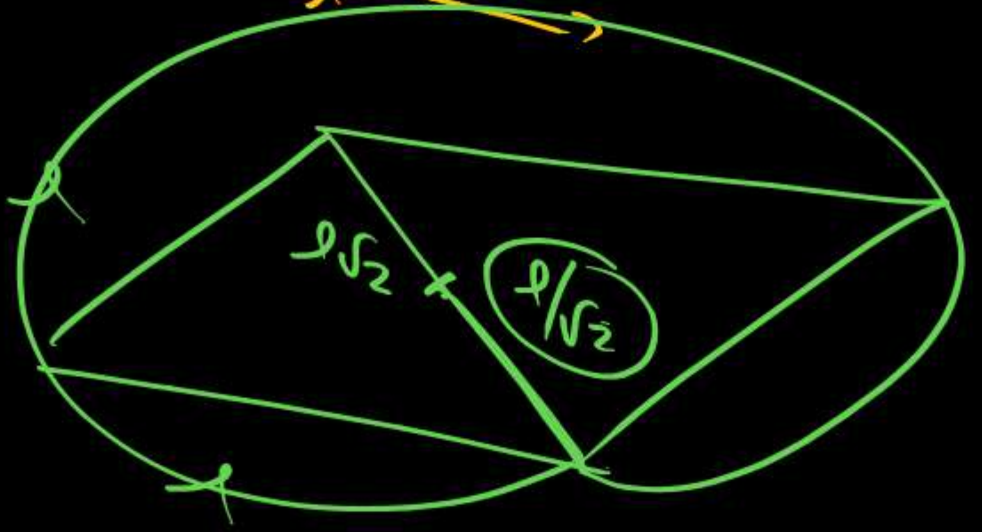
$\frac{\text{Radius}}{\sqrt{2}}$

force Maximum hota hai?

$x = \frac{l/\sqrt{2}}{\sqrt{2}} = l/2$

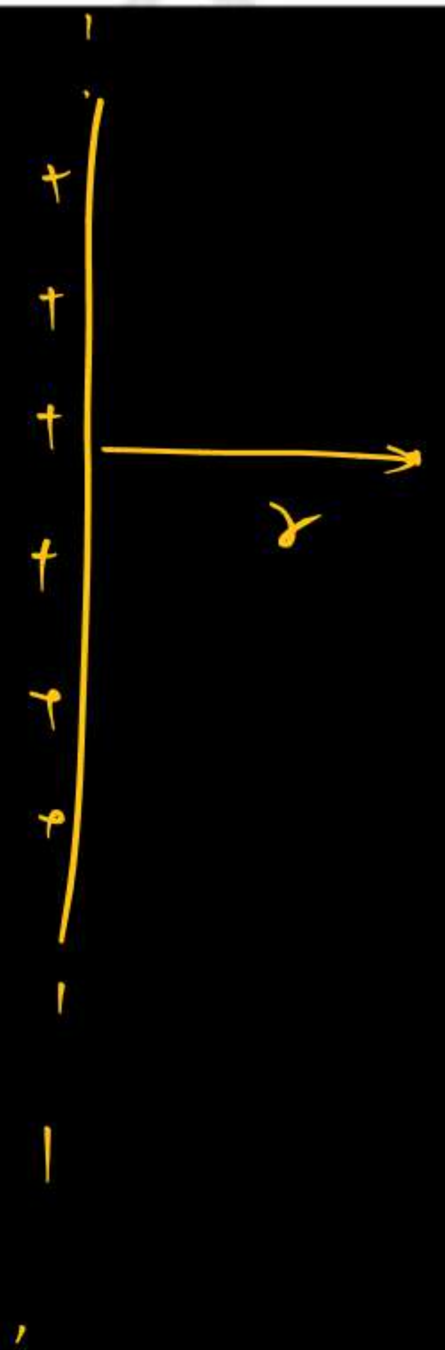
So that force is max?





$R = l/\sqrt{2}$

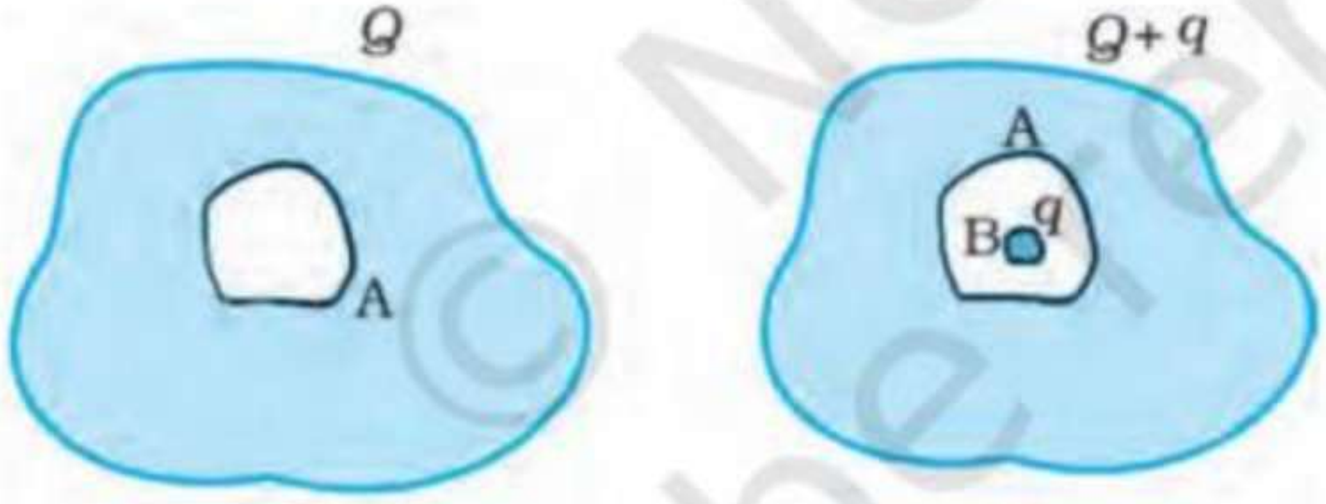
1.23 An infinite line charge produces a field of 9×10^4 N/C at a distance of 2 cm. Calculate the linear charge density.



$$E = \frac{2k\lambda}{r}$$

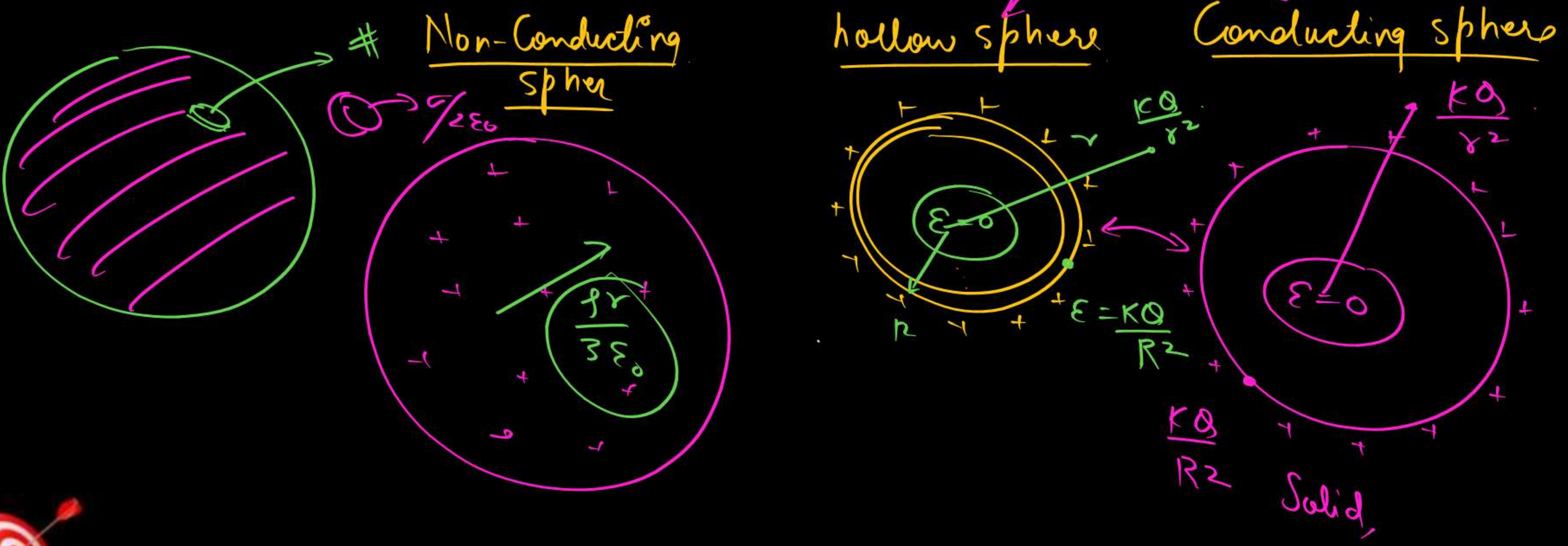
$$9 \times 10^4 = \frac{2 \times 9 \times 10^9 \times \lambda}{2/100}$$

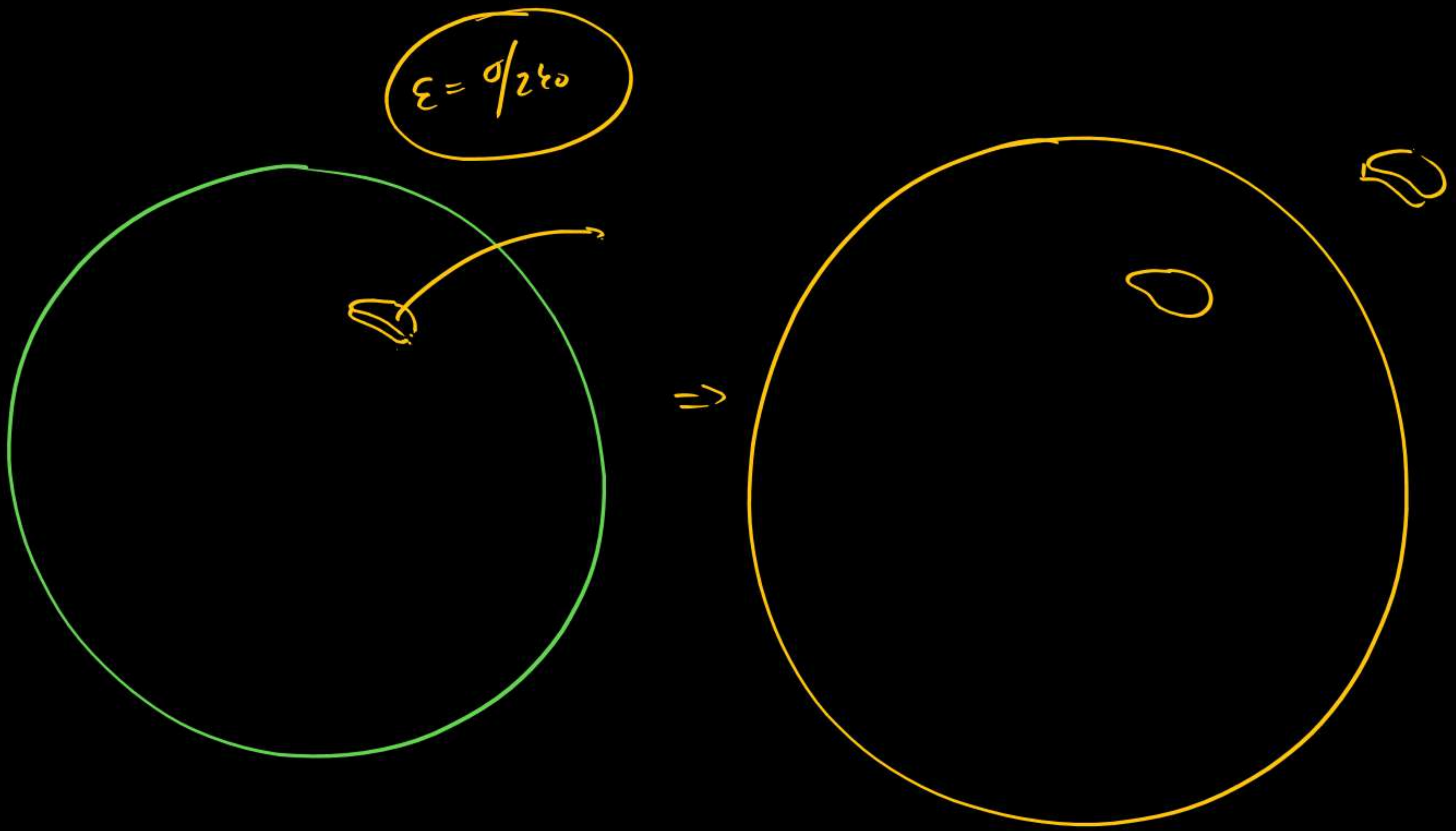
1.28 (a) A conductor A with a cavity as shown in Fig. 1.36(a) is given a charge Q. Show that the entire charge must appear on the outer surface of the conductor. (b) Another conductor B with charge q is inserted into the cavity keeping B insulated from A. Show that the total charge on the outside surface of A is $Q + q$ [Fig. 1.36(b)]. (c) A sensitive instrument is to be shielded from the strong electrostatic fields in its environment. Suggest a possible way.

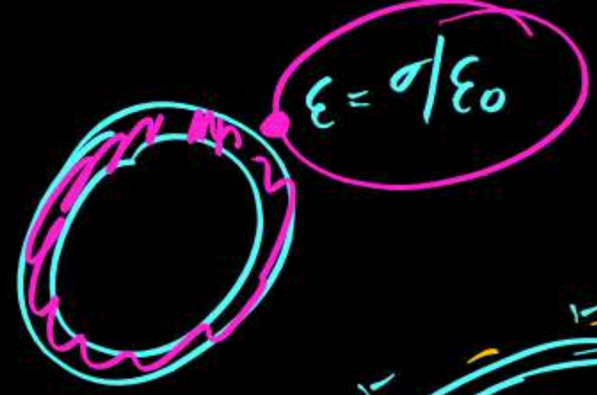


(a) (b)

1.29 A hollow charged conductor has a tiny hole cut into its surface. Show that the electric field in the hole is $(\sigma/2\varepsilon_0)\ \hat{\mathbf{n}}$, where $\hat{\mathbf{n}}$ is the unit vector in the outward normal direction, and σ is the surface charge density near the hole.




$\varepsilon = \sigma/2\varepsilon_0$



Thin → Shell (Conducting)

Surface charge density = $\sigma = q/A$

$$E_{side} = E = \sigma/\varepsilon_0$$

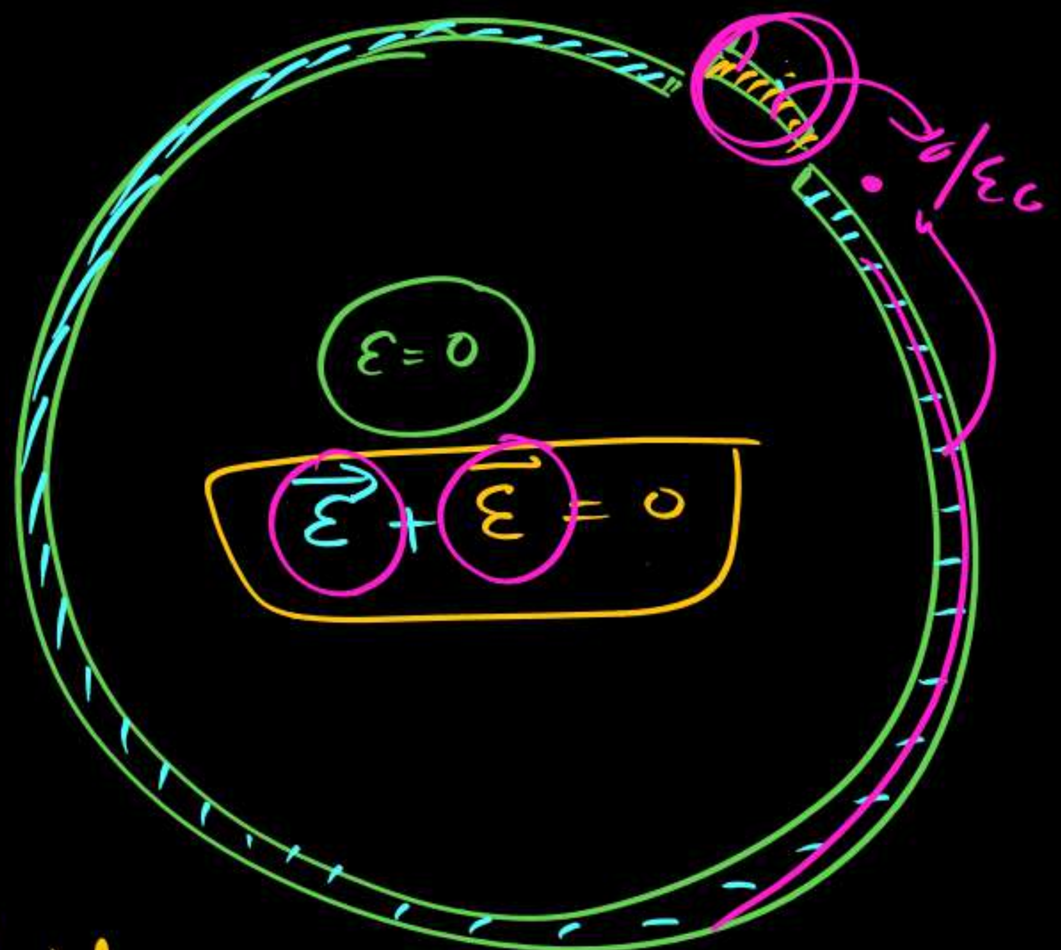
$$\oint E \cdot ds = \frac{q_i}{\varepsilon_0}$$

$$E \cdot \oint ds = \frac{\sigma \int ds}{\varepsilon_0}$$

$$E = \frac{\sigma}{\varepsilon_0}$$

Near a Conductor

$$\vec{E} = \sigma/\varepsilon_0$$



Inside

Out

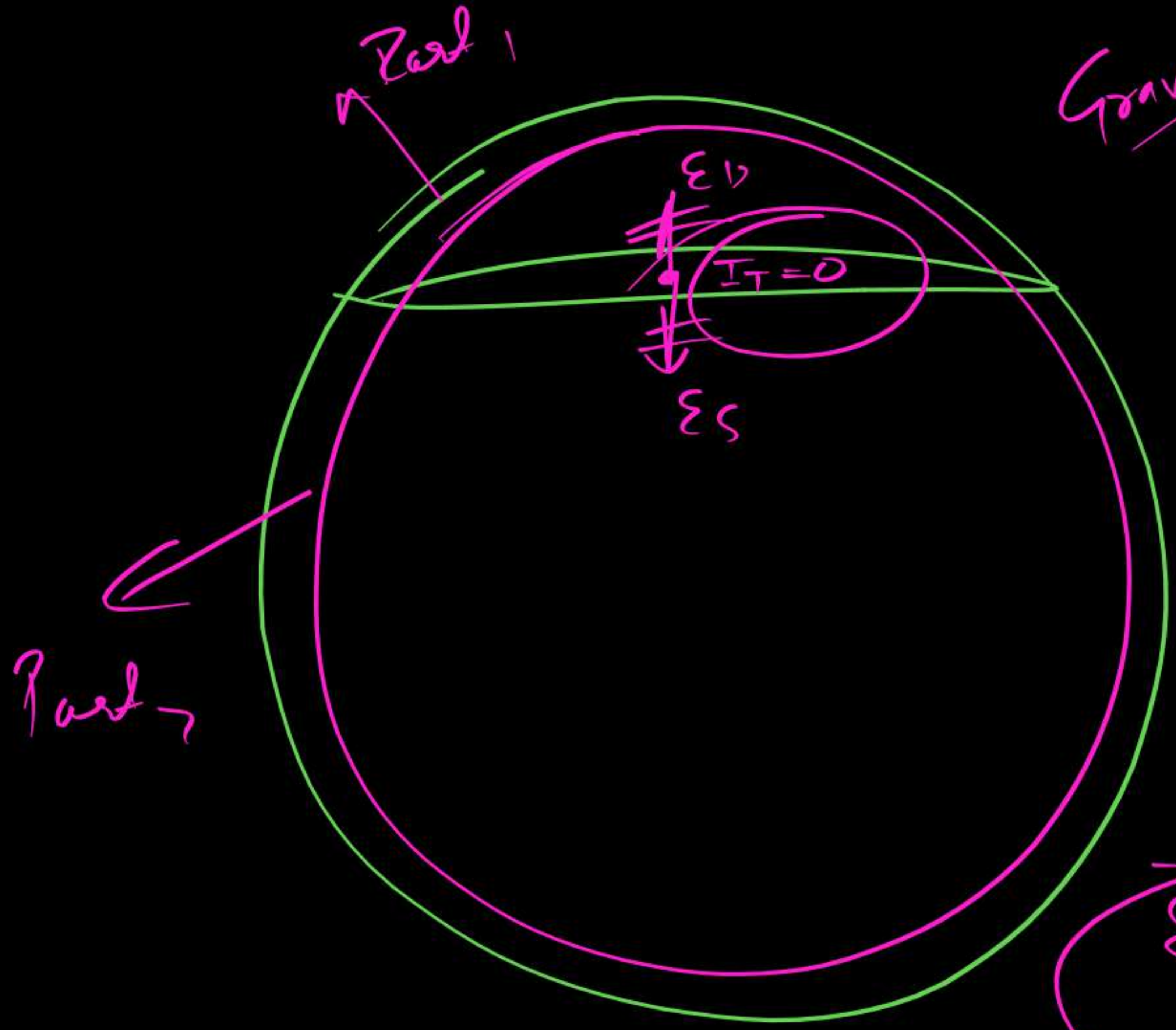
$$|\vec{E}| = |\vec{E}|$$

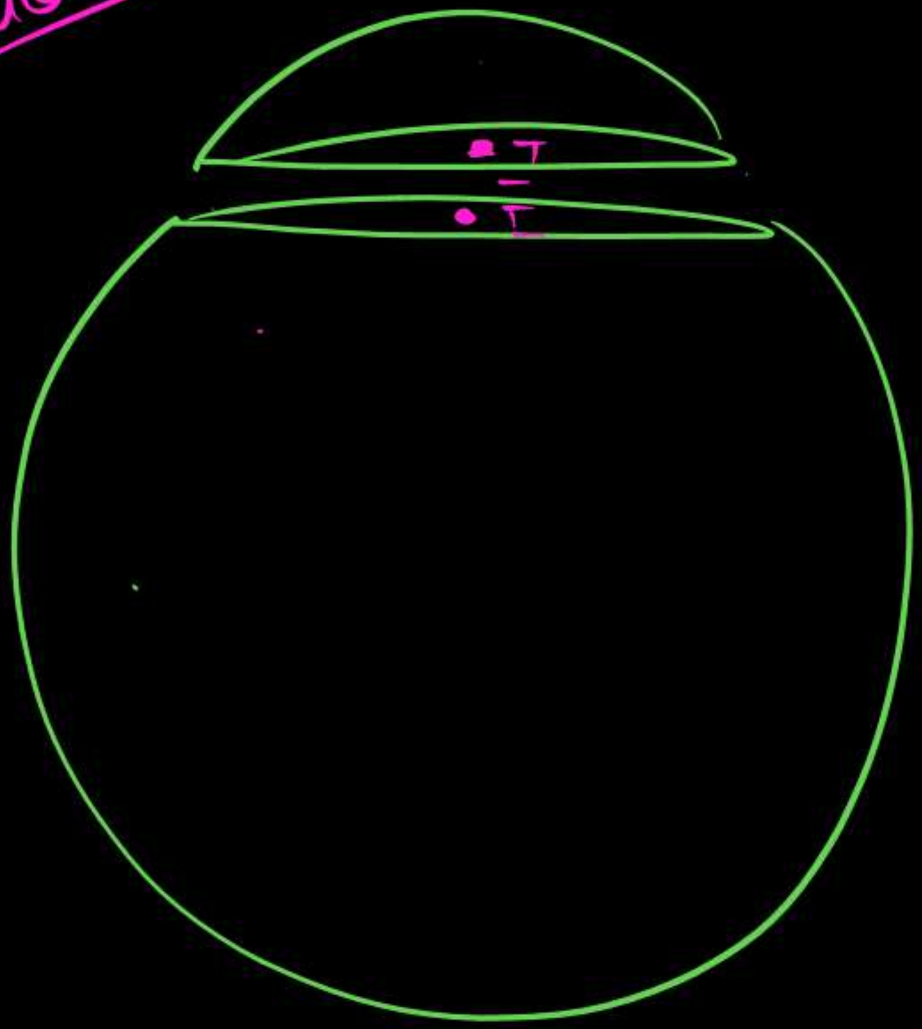
$$E + E = \sigma/\varepsilon_0$$

$$E = \sigma/2\varepsilon_0$$

$$E = \sigma/2\varepsilon_0$$

Gravitation



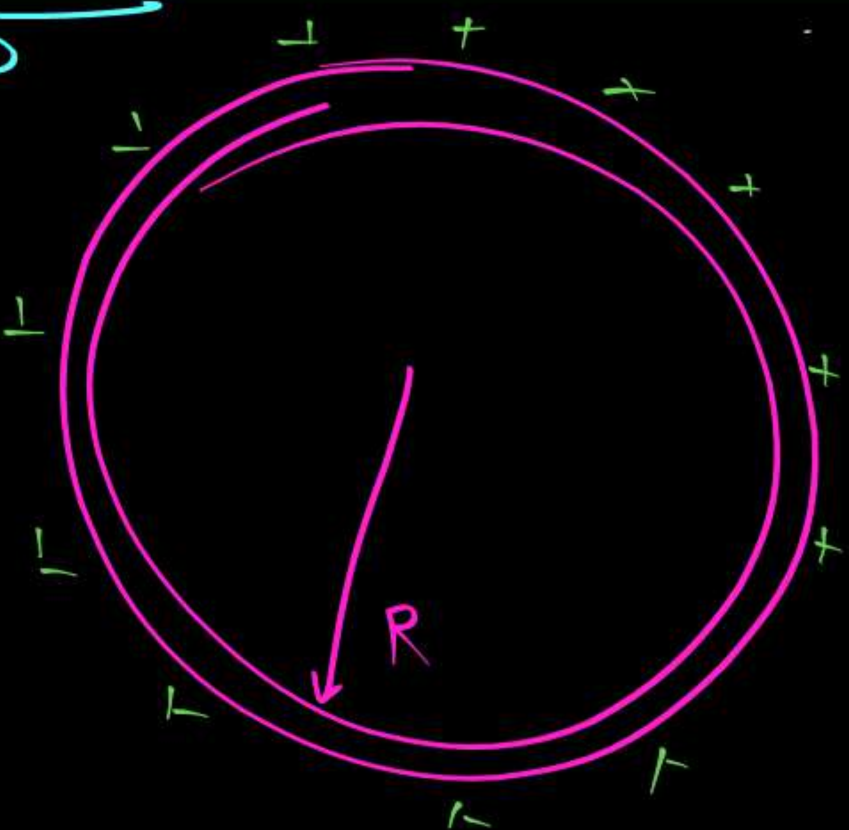


$$\vec{E}_{Part_1} + \vec{E}_{Part_2} = 0$$

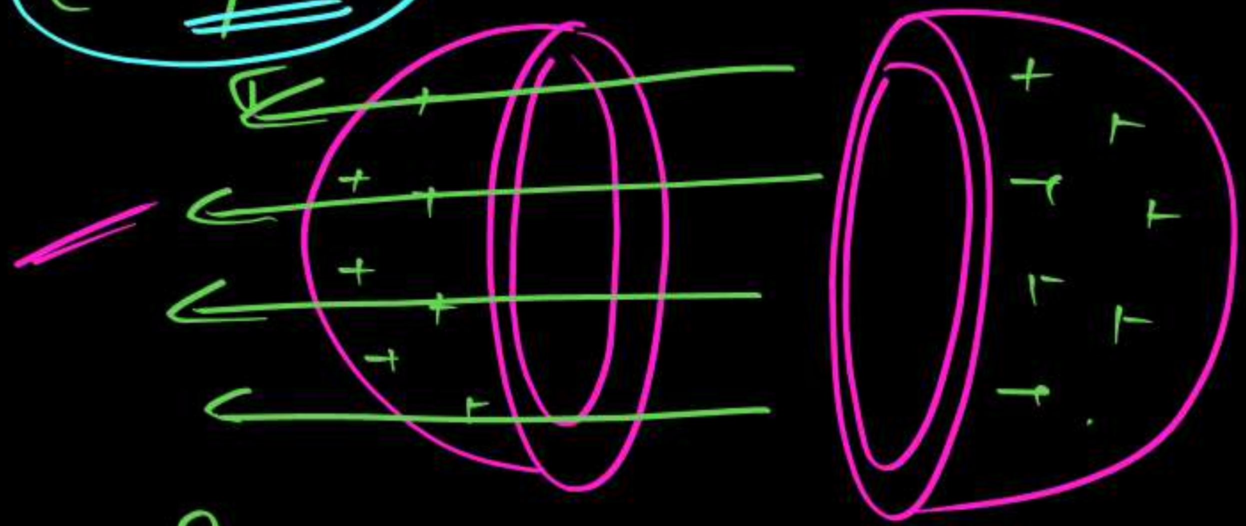
Force between Hemispherical Shells :

A uniformly charged thin spherical shell of radius R and surface charge density σ is cut in two halves. Find the force required to keep the two halves in contact.

qE, σ — Surface Charge density



$E = \sigma / 2\varepsilon_0$

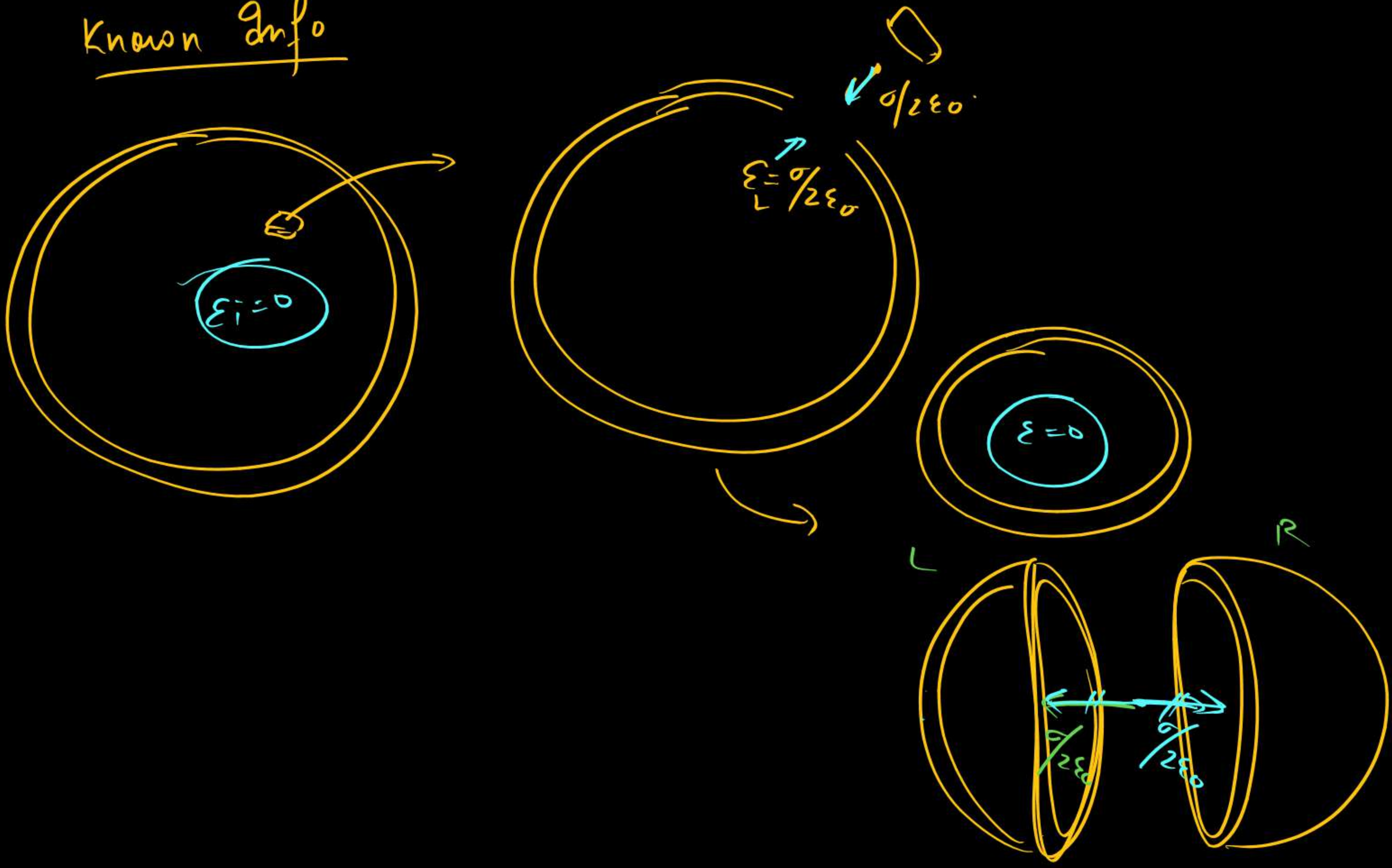


E Field due to left sphere

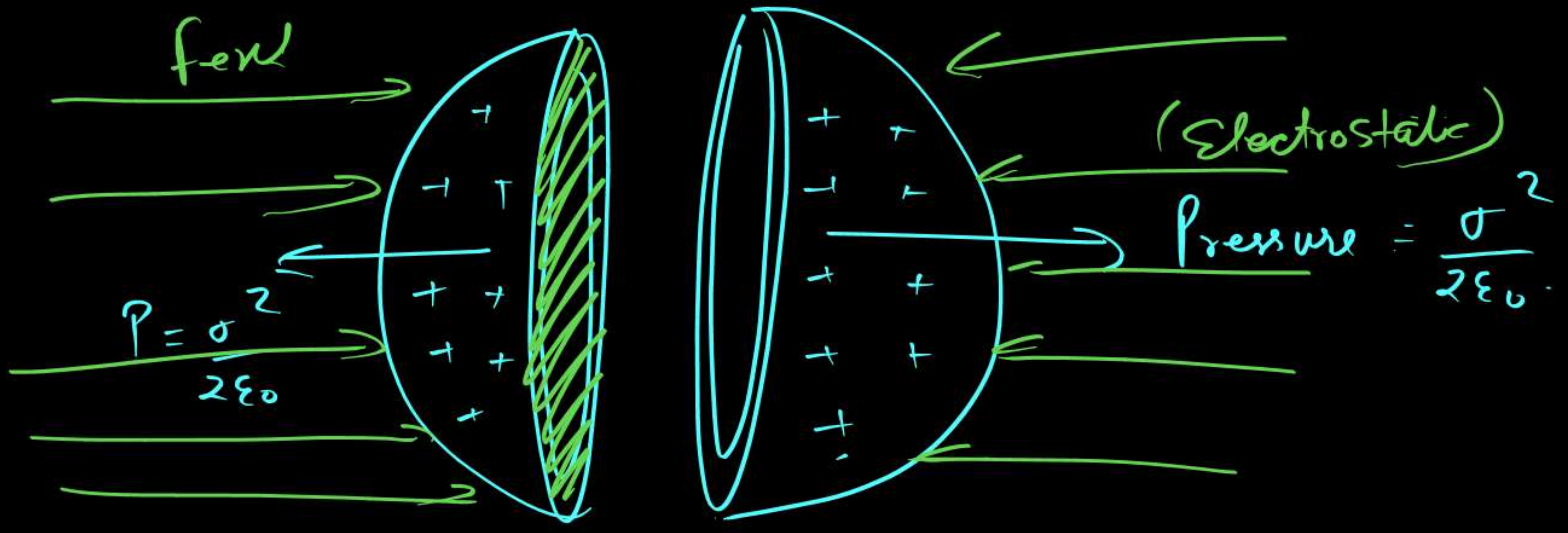
Electrostatic Pressure $= \dfrac{\sigma^2}{2\varepsilon_0}$

$$\text{Pressure} = \frac{F}{\text{Area}} = \frac{(\text{charge on left shell})\ \sigma/2\varepsilon_0}{(\text{Area})} = \frac{\sigma^2}{2\varepsilon_0}$$

Known info



$\varepsilon_i = 0$
$\sigma/2\varepsilon_0$
$\varepsilon_L = \sigma/2\varepsilon_0$
$\varepsilon = 0$
L
R
$\sigma/2\varepsilon_0$
$\sigma/2\varepsilon_0$



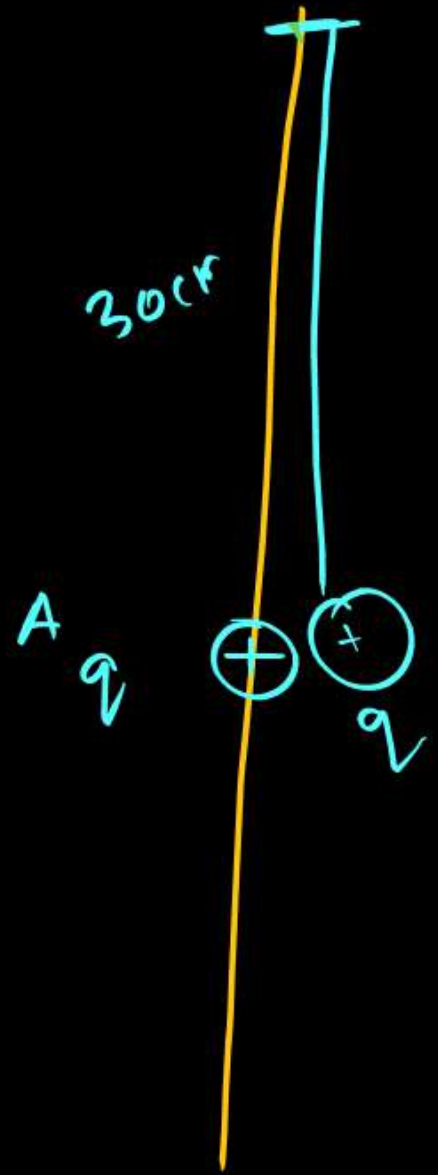
$$P_{external} = P_{internal}$$

$$\frac{f_{ext}}{\pi R^2} = \frac{\sigma^2}{2\varepsilon_0}$$

$$f_{ext} = \frac{\sigma^2 \pi R^2}{2\varepsilon_0}$$

#

10. *A particle A having a charge of* $5{\cdot}0 \times 10^{-7}$ C *is fixed in a vertical wall. A second particle B of mass* 100 g *and having equal charge is suspended by a silk thread of length* 30 cm *from the wall. The point of suspension is* 30 cm *above the particle A. Find the angle of the thread with the vertical when it stays in equilibrium.*

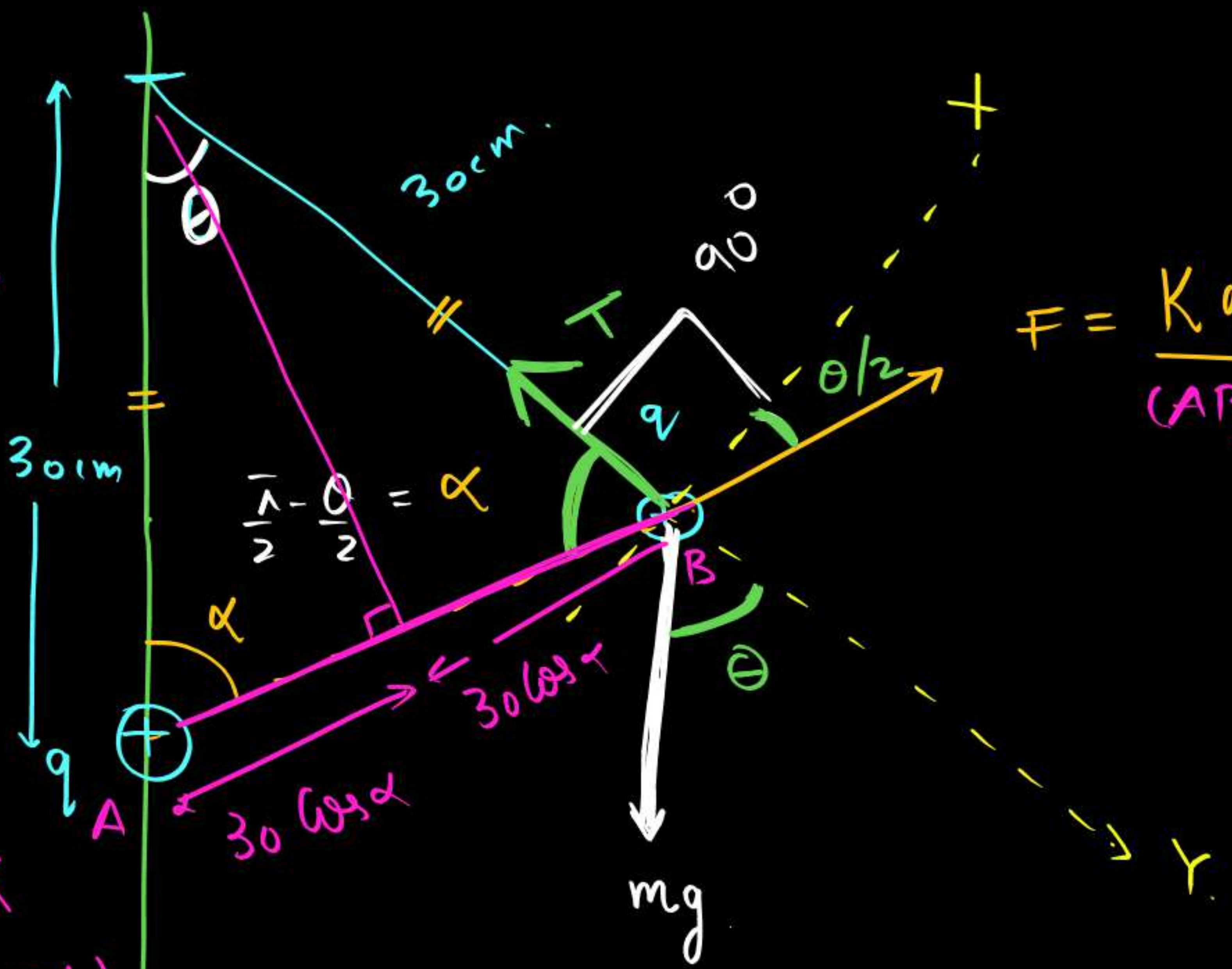


q. m = 100g.

$\theta + 2\alpha = \pi$

$2\alpha = \pi - \theta$

$\alpha = \frac{\pi}{2} - \frac{\theta}{2}$



$F = \frac{Kqq}{(AB)^2}$

$AB = 2 \times 30 \cos\alpha$

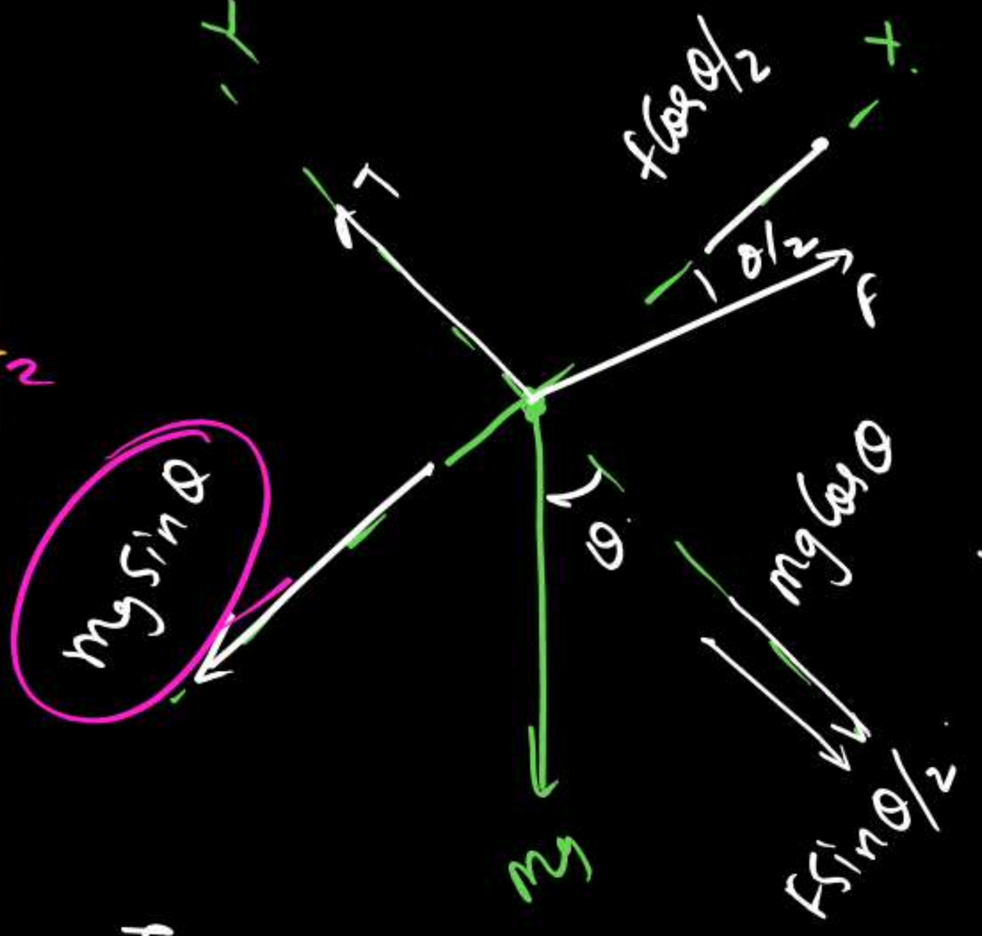
$= 60 \cos\left(\frac{\pi}{2} - \theta/2\right)$

$= 60 \sin \theta/2$

Line AB $\alpha + \pi/2 + (\ ) = \pi$

$\pi/2 - \theta/2 + \pi/2 + (\ ) = \pi$

$(\ ) = \theta/2$



$T = mg\cos\theta + F\sin\theta/2$

$mg\sin\theta = F\cos\theta/2$

$2mg\sin\theta/2 \cos\theta/2 = F\cos\theta/2$

$2mg\sin\theta/2 = F$

Thank You Lakshyians