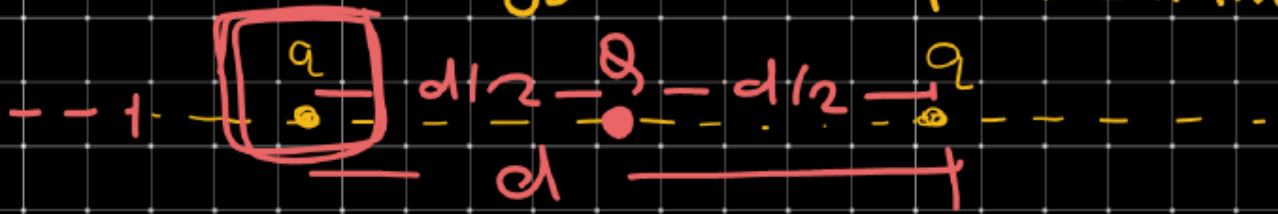
8) find Position of third charge (Q) & value of third charge such that System in equilibrium.



① To find location of the third charge, where Net force on third charge is zero.

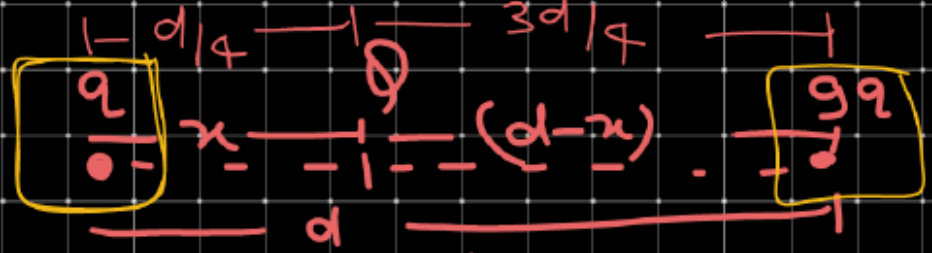
② $F_{qQ} + F_{qq} = 0$

$$\frac{kqQ}{\left(\frac{d}{2}\right)^2} + \frac{kq^2}{(d)^2} = 0$$

$$\frac{4kqQ}{d^2} = -\frac{kq^2}{d^2}$$

$$\boxed{Q = -\frac{q}{4}}$$

Find location & value of third charge Q such that whole System in equilibrium



(1) $\frac{Kqq}{x^2} = \frac{KQ(9q)}{(d-x)^2} \Rightarrow \frac{1}{x^2} = \frac{9}{(d-x)^2} \Rightarrow (d-x)^2 = 9x^2$

$(d-x)^2 = (3x)^2$

$d - x = 3x$

$d = 4x$

$x = \frac{d}{4}$

Step II)

$\frac{Kq^2}{\left(\frac{d}{4}\right)^2} + \frac{KQ(9q)}{d^2} = 0$

$\frac{16Kq^2}{d^2} = -\frac{KQ(9q)}{d^2}$

$Q = -\frac{9q}{16}$

Find location & value of third charge (Q) such that system is in Equilibrium.

Fnet = 0

(1) $\frac{KQq}{x^2} = \frac{KQ(4q)}{(d+x)^2} \Rightarrow \frac{1}{x^2} = \frac{4}{(d+x)^2} \Rightarrow (d+x)^2 = (2x)^2$

$(d+x) = 2x$

$d + x = 2x \Rightarrow \boxed{d = x}$

↳ Location of third charge.

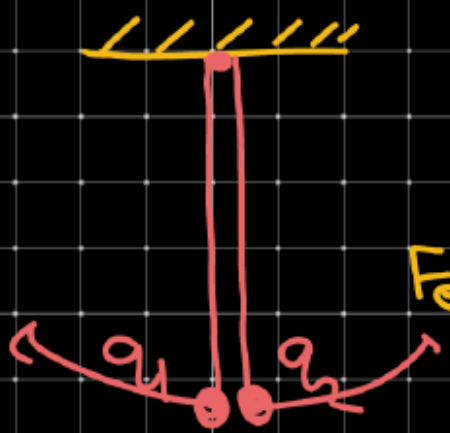
$$\frac{KQ(4q)}{(2d)^2} + \frac{KQ(4q)}{d^2} = 0$$

$$\boxed{x = d}$$

$$\frac{KQ(4q)}{4d^2} = \frac{-Kq(4q)}{d^2}$$

$$\boxed{Q = -4q}$$

String-bob Problem

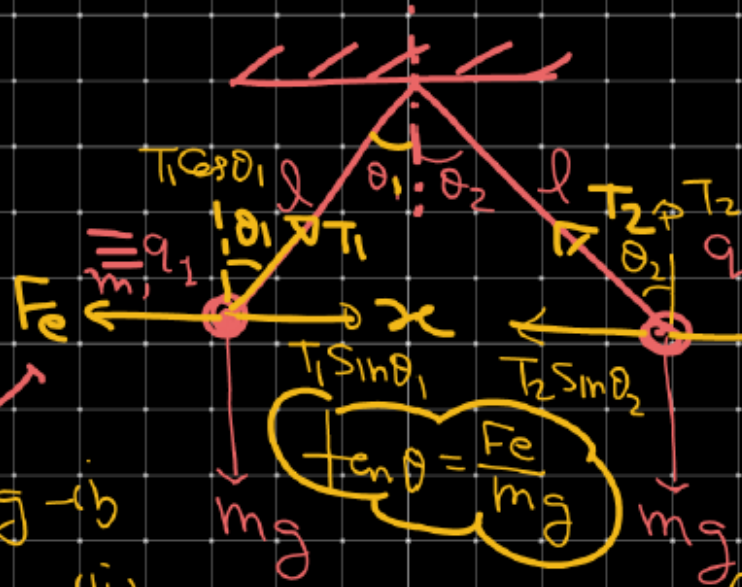


$T_1 \cos\theta_1 = mg$ -(i)

$T_1 \sin\theta_1 = F_e$ -(ii)

(ii)/(i) $\frac{T_1 \sin\theta_1}{T_1 \cos\theta_1} = \frac{F_e}{mg}$

$\tan\theta_1 = \frac{F_e}{mg}$



θ_1 & θ_2 – angle of string with vertical

$T_2 \sin\theta_2 = F_e$ -(iii)

$T_2 \cos\theta_2 = mg$ -(iv)

$\frac{T_2 \sin\theta_2}{T_2 \cos\theta_2} = \frac{F_e}{mg}$

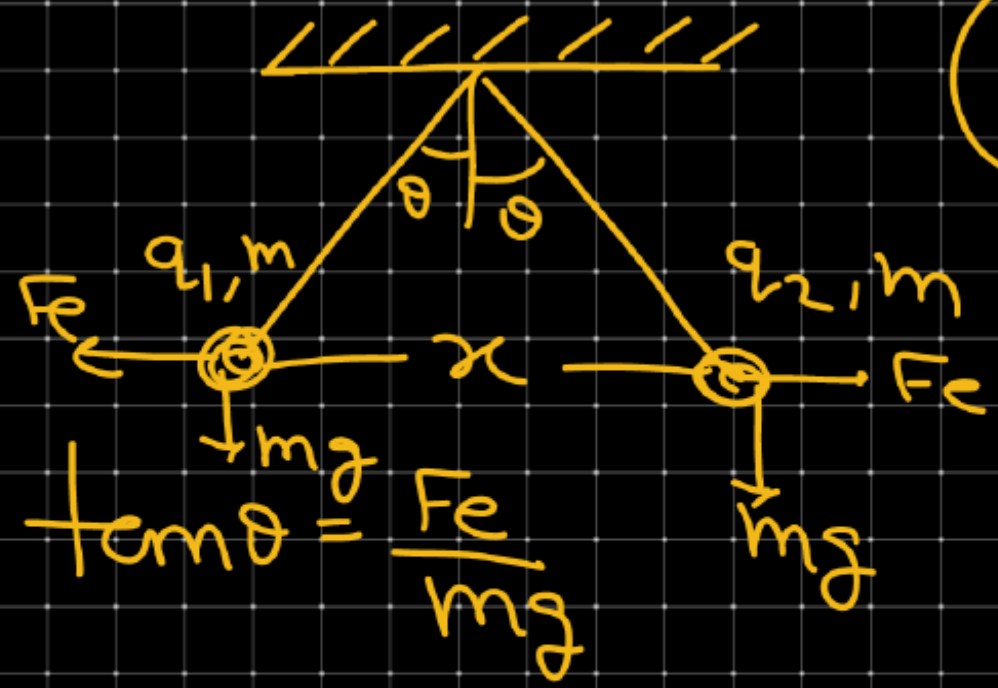
$\tan\theta_2 = \frac{F_e}{mg}$

$\theta_1 = \theta_2$

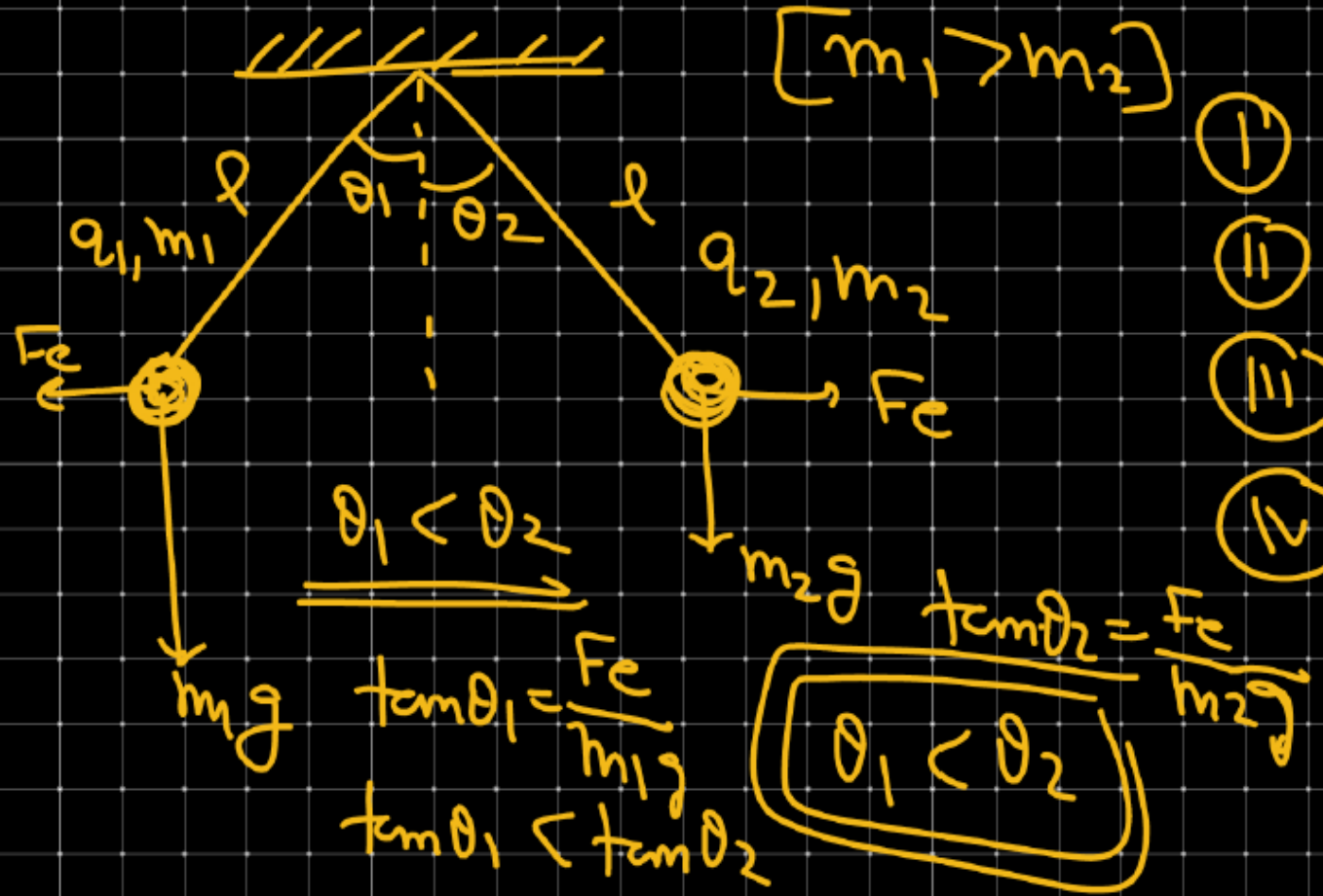
(#) F_e → Electrostatic force → Angle को बढ़ा कर रहा है।

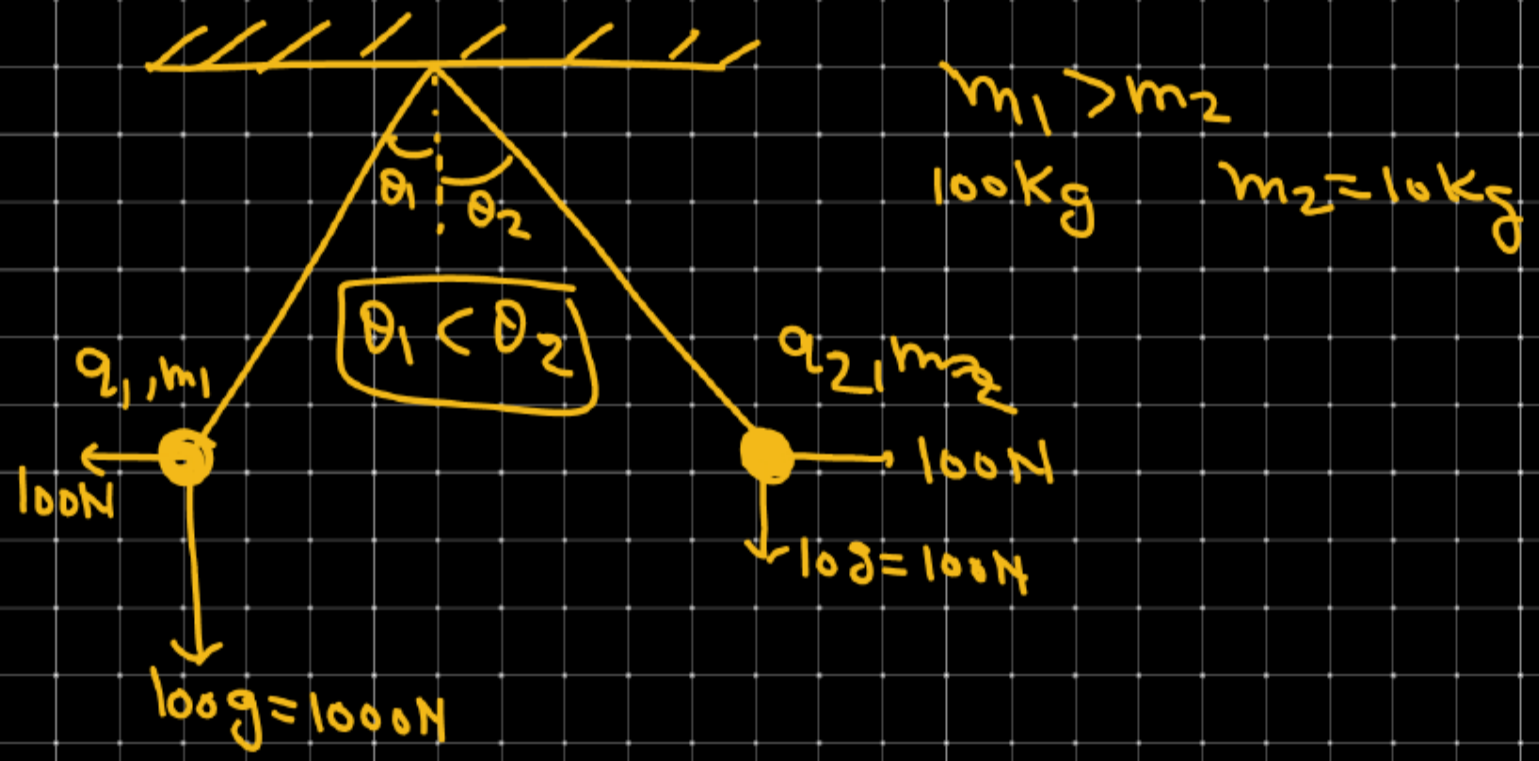
mg → Angle को कम कर रहा है।

$$F_e = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{x^2}$$



$$\tan\theta = \frac{Fe}{mg}$$


$[m_1 > m_2]$
q_1, m_1
ℓ
θ_1
θ_2
ℓ
q_2, m_2
Fe
Fe
$m_1 g$
$m_2 g$
$\theta_1 < \theta_2$
$\tan\theta_1 = \frac{Fe}{m_1 g}$
$\tan\theta_1 < \tan\theta_2$
$\tan\theta_2 = \frac{Fe}{m_2 g}$
$\theta_1 < \theta_2$
(I) $\theta_1 = \theta_2$
(II) $\theta_1 > \theta_2$
(III) $\theta_1 < \theta_2$
(IV) N.O.T.


$m_1 > m_2$
100kg
$m_2 = 10kg$
θ_1
θ_2
$\theta_1 < \theta_2$
q_1, m_1
q_2, m_2
100N
100N
$10g = 100N$
$100g = 1000N$

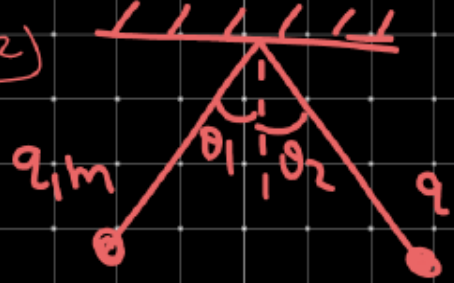
⑨ $q_1 < q_2$

① $\theta_1 = \theta_2$
② $\theta_1 > \theta_2$
③ $\theta_1 < \theta_2$
④ N·O·T.

$\tan\theta_1 = \frac{Fe}{mg}$ $\theta_1 = \theta_2$

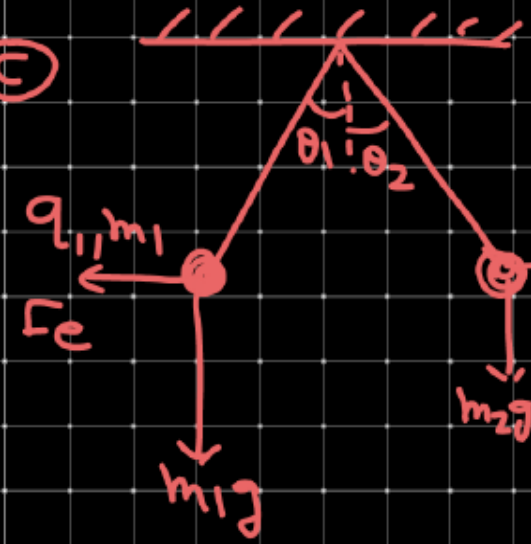
$\tan\theta_2 = \frac{Fe}{mg}$

θ2



① $\theta_1 = \theta_2$ ✓
② $\theta_1 > \theta_2$
③ $\theta_1 < \theta_2$
④ N·O·T.

ⓒ $m_1 > m_2$



① $\theta_1 = \theta_2$
② $\theta_1 < \theta_2$
③ $\theta_1 > \theta_2$
④ N·O·T.

Relative permittivity

K - dielectric constant of medium

$$\varepsilon_r = \frac{\varepsilon}{\varepsilon_0}$$

$$\varepsilon_r = K = \frac{\text{Permittivity of medium}}{\text{Permittivity of free space}}$$

Q1) Relative permitivity of a medium is 100. Find Permitivity of medium.

$\varepsilon_r = 100$

$\varepsilon = ?$

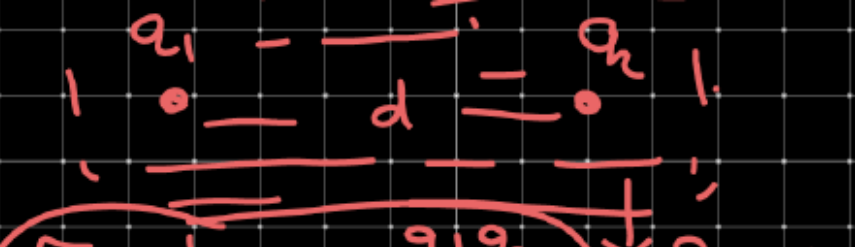
$$\varepsilon = \varepsilon_r \cdot \varepsilon_0$$

$$= 100 \times 8.85 \times 10^{-12} \ \frac{C^2}{N\text{-}m^2}$$

$$\boxed{\varepsilon = 8.85 \times 10^{-10} \ \frac{C^2}{N\text{-}m^2}}$$

#

$$F_{air} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{d^2}$$



$$F_m = \frac{1}{4\pi\varepsilon_0\varepsilon_r}\frac{q_1 q_2}{d^2}$$

$$F_m = \frac{F_{air}}{\varepsilon_r}$$

$$F_{med} = \frac{F_{air}}{81}$$

ε_r water $= 81$

$$F_m = \frac{1}{4\pi\varepsilon}\frac{q_1 q_2}{d^2}$$

$$F_m = \frac{F_{air}}{\varepsilon_r}$$

$$F_{air} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{d^2}$$

$$F_m = \frac{1}{4\pi\varepsilon_0\varepsilon_r}\frac{q_1 q_2}{r^2}$$

$$F_m = \frac{1}{4\pi\varepsilon_0 K}\frac{q_1 q_2}{r^2}$$

↳ find new distance b/w two charges placed in medium such that, Force b/w them is same as in air at distance d.

$$\frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{d^2} = \frac{1}{4\pi\varepsilon_0 K}\frac{q_1 q_2}{r^2}$$

$$\frac{1}{d^2} = \frac{1}{Kr^2} \quad r^2 = \frac{d^2}{K}$$

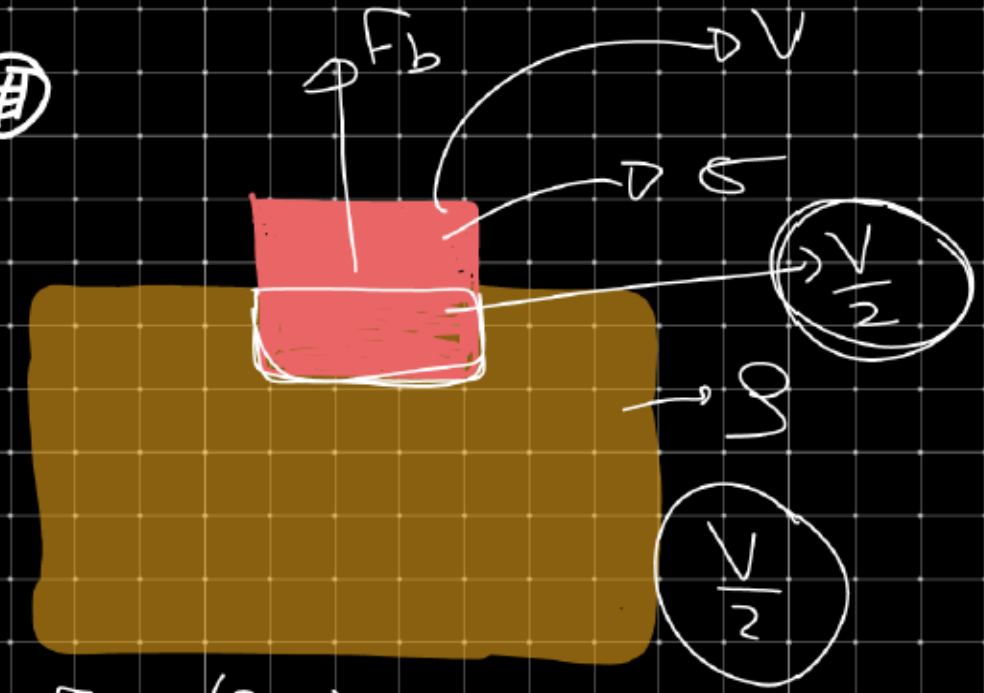
$$\boxed{r = \frac{d}{\sqrt{K}}}$$

q_1 and q_2 are in air

Same force

$$r = \frac{d}{\sqrt{K}} = \frac{d}{\sqrt{\varepsilon_r}}$$

$$r = \frac{9}{\sqrt{9}} = \frac{9}{3} = 3m$$



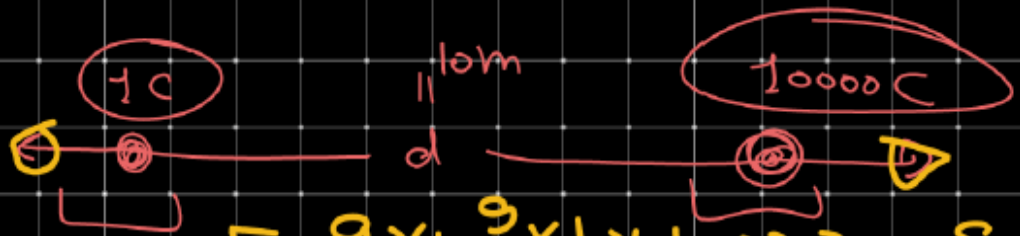
F_b = Weight of liquid displace.

mg

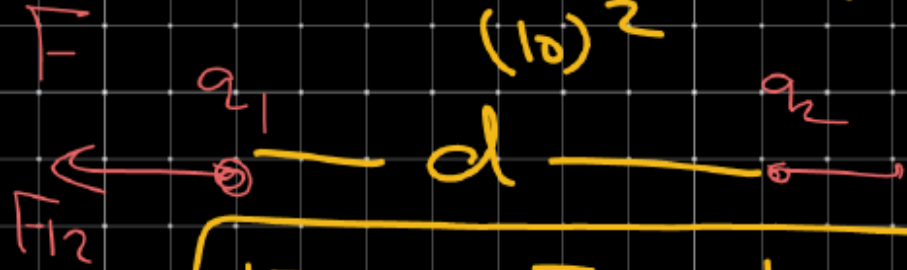
$F_b = \left(\rho \frac{V}{2}\right) g$

$m = \frac{V}{2} \times \rho$

$$F_b = \frac{\rho V g}{2}$$



$$F = \frac{9\times10^9\times1\times10000}{(10)^2} = \frac{9\times10^9\times10000}{100} = 9\times10^9\times10^2 = 9\times10^{11}\ N$$



$$|\vec{F}_{12}| = |\vec{F}_{21}| = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{d^2}$$

$$\vec{F}_{12} = -\vec{F}_{21}$$