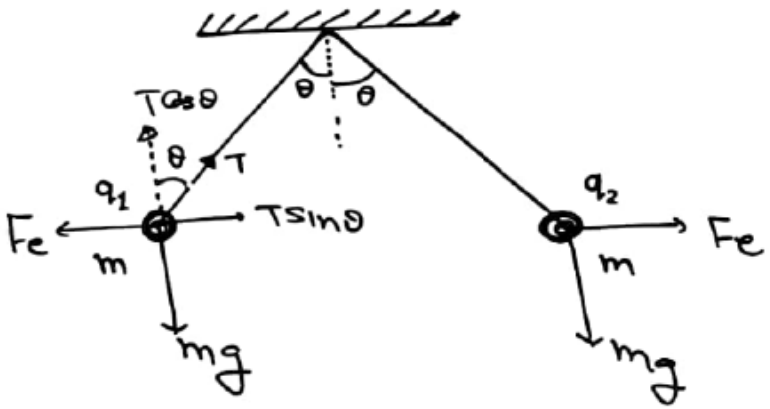
String & bob problem

Angle of string with vertical.



At Equilibrium

$T\cos\theta = mg$ —(i)

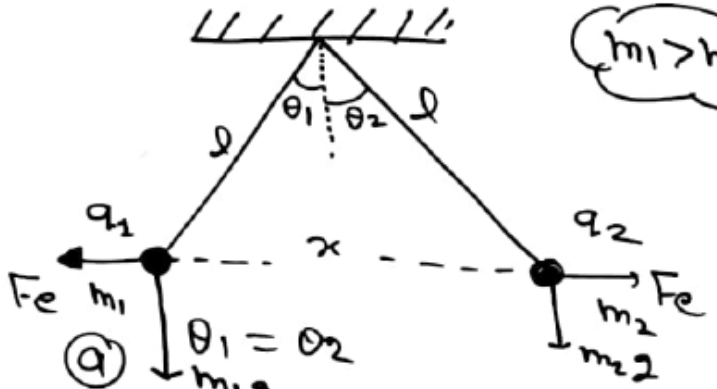
$T\sin\theta = Fe$ —(ii)

(ii)/(i) $\frac{T\sin\theta}{T\cos\theta} = \frac{Fe}{mg}$

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

$$\theta = \tan^{-1}\left(\frac{Fe}{mg}\right)$$

String & bob problem



(a) $\theta_1 = \theta_2$

(b) $\theta_1 > \theta_2$

(c) $\theta_1 < \theta_2$

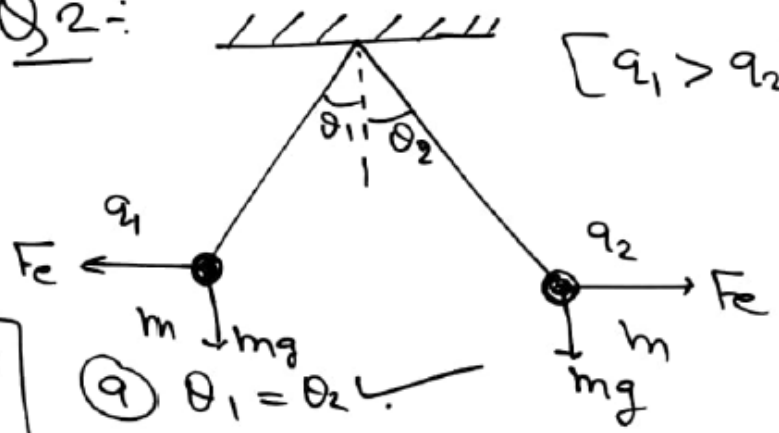
(d) Can't Say.

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

$m_1 > m_2$

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

θ_2 :-



$[q_1 > q_2]$

(a) $\theta_1 = \theta_2$

(b) $\theta_1 > \theta_2$.

(c) $\theta_1 < \theta_2$.

(d) Can't Say.

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

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

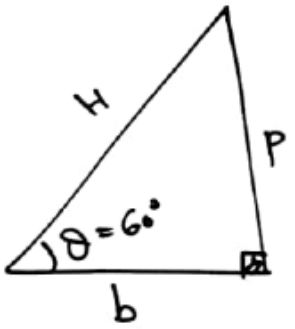
$\theta_1 = \theta_2$

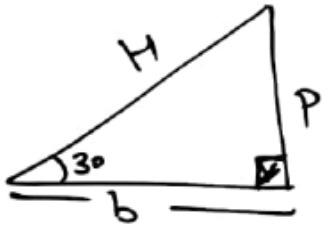
String & bob problem

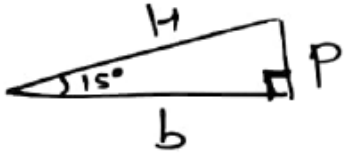
⇒ Right angle triangle

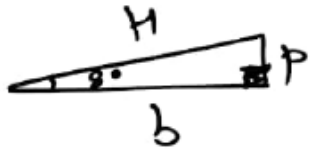
When θ is small

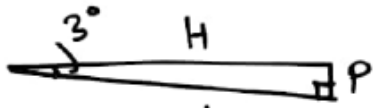
then $\tan\theta = \sin\theta \simeq \theta$









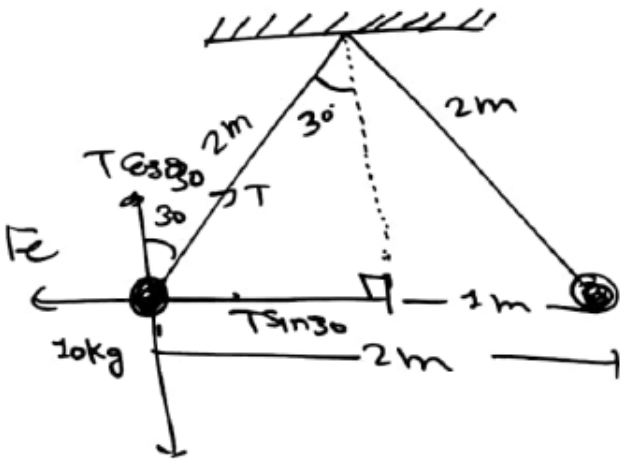


θ is very small

$\sin\theta = \frac{P}{H}$ ⇒ $b \simeq H$

$\tan\theta = \frac{P}{b} = \frac{P}{H}$ $\tan\theta = \sin\theta$

Question based on String-bob problem :



Find charge on bob, If charge on both bob is equal.

$mg = 10 \times 10 = 100\,N$

$T\cos 30 = mg$

$T\sin 30 = Fe$

$\sin 30° = \frac{P}{2}$

$\frac{1}{2} = \frac{P}{2} \Rightarrow P = 1m$

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

$Fe = \frac{9\times10^9 \times q\times q}{4}$

$\frac{1}{\sqrt{3}} \times 100 = \frac{9\times10^9 \times q^2}{4}$

$q^2 = \frac{10^2 \times 4}{\sqrt{3}\ 9\times10^9}$

$q^2 = \frac{4}{9\sqrt{3}} \times 10^{-7}$

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

$\tan 30° = \frac{Fe}{mg}$

JEE Mains 2013

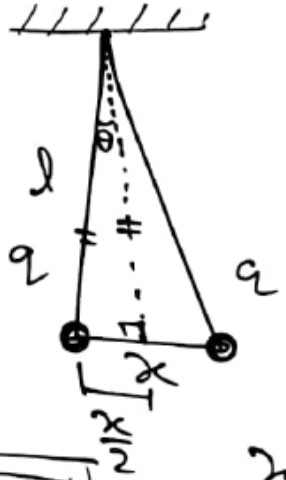
two balls of same mass & carrying equal charge are hung from a fixed support of length l. At electrostatic equilibrium, assuming angles made by each thread is small, the seperation x between the ball is proportional to.

(a) l

(b) l^2

(c) $l^{2/3}$

(d) ~~$l^{1/3}$~~



$\tan\theta = \frac{x}{2b}$

$\tan\theta = \frac{x}{2l}$

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

$\frac{x}{2l} \times mg = \frac{1}{4\pi\varepsilon_0} \frac{q \times q}{x^2}$

$x^3 \propto l$

$x^n \propto l$

$x \propto l^{1/n}$

$x \propto l^{1/3}$

NEET-2016 AIEEE-2011

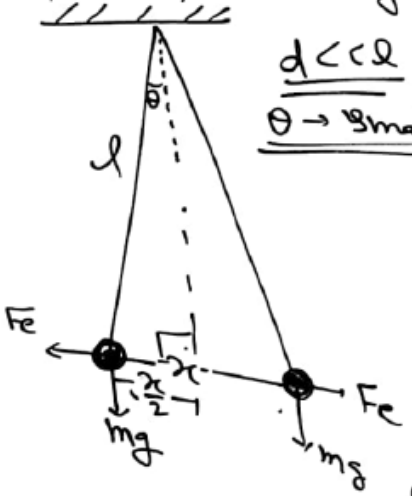
Q) Two identical charged sphere suspended from a common point by two massless string of length l, are initially at a distance ($d << l$) apart because of their mutual repulsion. The charge begin to leak from both the sphere at constant Rate. As a result, the sphere approch each other with velocity v. v varies as a function of the distance x b/w the sphere. as

(a) $v \propto x^{-1/2}$

(b) $v \propto x$

(c) $v \propto x^{+1/2}$

(d) $v \propto x^{-1}$.



$d << l$

$\theta \rightarrow$ small

At any time

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

$\frac{x}{2xl} = \frac{1}{4\pi\varepsilon} \times \frac{q^2}{x^2} \times \frac{1}{mg}$

$\frac{mg(2x)}{2l} \times 4\pi\varepsilon(x^2) = q^2$ Const

$\frac{dq}{dt} = \frac{3}{2} x^{3/2-1} \times \frac{dx}{dt}$

$\frac{dq}{dt} = \text{Const}$

$C \propto \frac{3}{2} x^{1/2} \cdot v$

$q^2 \propto x^3$

$\frac{C}{x^{1/2}} \propto v$

$q \propto x^{3/2}$

$v \propto x^{-1/2}$

diff w.r.t t

$\frac{dq}{dt} \propto \frac{d}{dt}(x^{3/2})$

String - bob Problem

find angle with vertical If it placed in liquid :-

σ = density of bob

V = Volume of bob

ρ = density of liquid.

F_m = Force in medium b/w two charges

$T\sin\theta = F_m$ —(i)

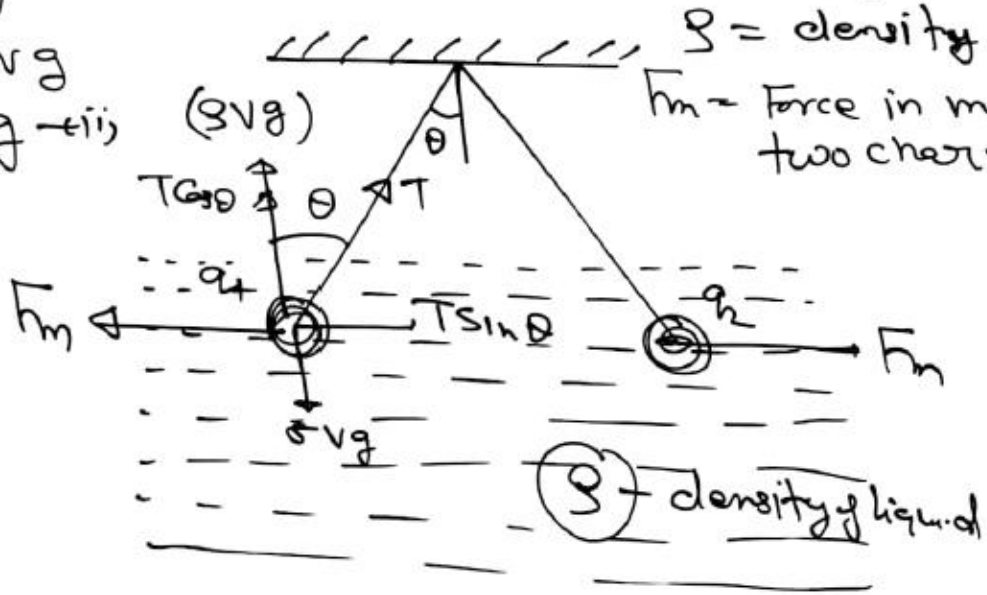
$T\cos\theta + \rho V g = \sigma V g$

$T\cos\theta = \sigma V g - \rho V g$

$T\cos\theta = (\sigma - \rho) V g$ —(ii)

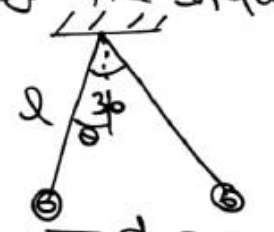
$$\frac{T\sin\theta}{T\cos\theta} = \frac{F_m}{(\sigma-\rho)Vg}$$

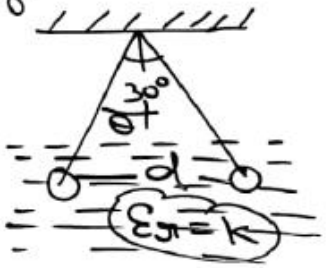
$$\tan\theta = \frac{F_m}{(\sigma-\rho)Vg}$$



Q] Two identical charged sphere are suspended by string of equal lengths. The string make an angle of 30° with each other. When suspended in liquid of density 0.8 g/cm³ the angle remains the same. If the density of material of the sphere is 1.6 g/cm³, the dielectric constant of the liquid is

(a) 4
(b) 2
(c) 3
(d) 1





$$\tan\theta = \frac{F_e}{\sigma V g}$$

$$\tan\theta = \frac{\frac{1}{4\pi\varepsilon_0}\frac{q^2}{d^2}}{\sigma V g}$$

$$\tan\theta = \frac{q^2}{4\pi\varepsilon_0 d^2 \sigma V g}$$

$$\tan\theta = \frac{F_m}{(\rho_{bod} - \rho_{Liquid})Vg}$$

$$\tan\theta = \frac{\frac{1}{4\pi\varepsilon_0 K}\frac{q^2}{d^2}}{(1.6-0.8)Vg}$$

$$\tan\theta = \frac{q^2}{4\pi\varepsilon_0 K d^2 (0.8) Vg}$$

$$\frac{q^2}{4\pi\varepsilon_0 d^2 (1.6) Vg} = \frac{q^2}{4\pi\varepsilon_0 K d^2 \times 0.8 Vg}$$

$$\frac{1}{2} = \frac{1}{K} \Rightarrow K = 2$$