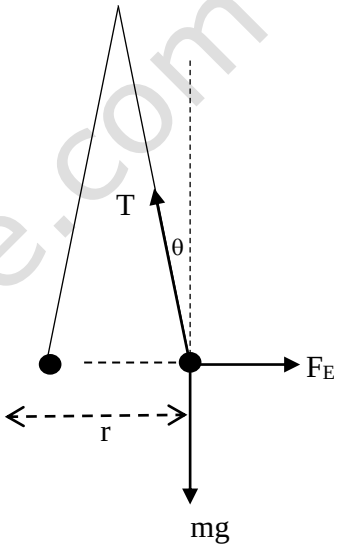
Q- Two equally charged point masss of mass m each are suspended from a point by massless threads of length L. In equilibrium positon each thread makes and angle θ with vertical.

(a) Find the ratio of magnitudes of horizontal electric force and vertical gravitational force on a the masses.

(b) What is the ratio if the angle θ = 15^0 ?

(C) If each mass is 0.15 gm and the length L =14 inch, what is the magnitude of excess charge on each mass?

(a) In equilibrium condition the forces acting on each mass are



1 Its weight F_G = mg vertically down

2 The electrostatic force of repulsion between the two charges is given by Coulomb's law as $F_E = \frac{q^2}{4\pi\epsilon_0 r^2}$ Horizontally

Where $\epsilon_0$the permittivity of free space and the value is given by

$$\frac{1}{4\pi\epsilon_0} = 9 * 10^9 \text{ Nm}^2/\text{C}^2$$

And

3 The tension in the string T, along the string.

Resolving the tension T in horizontal and vertical directions we get

Horizontal component T_x = T sin θ and

Vertical component T_y = T cos θ

Now for equilibrium the horizontal and vertical forces must be zero and hence we get

$$F_E - T_x = 0$$

Gives $F_E = T_x = T \sin\theta$ ---------- (1)

And $T_y - F_G = 0$

Gives $F_G = T_y = T \cos\theta$ ---------- (2)

Thus, from equations 1 and 2 we get

$$\frac{F_E}{F_G} = \frac{T \sin\theta}{T \cos\theta} = \tan\theta$$ ---------- (A)

(b) Substituting the values of θ in equation A we get

$$\frac{F_E}{F_G} = \tan 15^0 = 0.268$$

Hence the value of the ratio will be **0.27**

(C) Now using the value of F_E as given by Coulomb's law and the weight mg, the ratio of the magnitudes of the Electrostatic force and the weight of each strip is given by

$$\frac{F_E}{F_G} = \frac{q^2}{4\pi\epsilon_0 r^2 * mg}$$

Now the distance between the two charges r can be given by using right angle triangle properties as

r = 2* L sin θ

Thus, the ratio is given by

$$\frac{F_E}{F_G} = \frac{q^2}{4\pi\epsilon_0(2L\sin\theta)^2 * mg}$$

Or $$\frac{F_E}{F_G} = \frac{q^2}{4*4\pi\epsilon_0 L^2 \sin^2\theta * mg}$$ ---------- (B)

Now here the mass m = 0.15 gm = $1.5*10^{-4}$ kg

g = 9.8 m/s^2

L = 14″ = 14*0.0254 = 0.3556 m

And $\theta = 15^0$

Substituting the numerical values in equation B we get

$$0.268 = \frac{9*10^9\, q^2}{4*0.3556^2 \sin^2 15^0 * 1.5*10^{-4}*9.8}$$

Or $$q^2 = \frac{0.268*4*0.3556^2*0.067*1.5*10^{-4}*9.8}{9*10^9} = 1.48 * 10^{-15}$$

Or q = $3.85*10^{-8}$ C