66 In Fig. 21-43, two tiny conducting balls of identical mass m and identical charge q hang from nonconducting threads of length L. Assume that θ is so small that $\tan\theta$ can be replaced by its approximate equal, $\sin\theta$. (a) Show that

$$x = \left(\frac{q^2 L}{2\pi\varepsilon_0 m g}\right)^{1/3}$$

gives the equilibrium separation x of the balls. (b) If $L = 120$ cm, $m = 10$ g, and $x = 5.0$ cm, what is $|q|$?

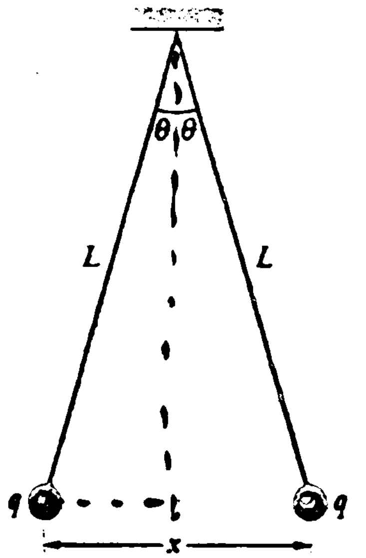
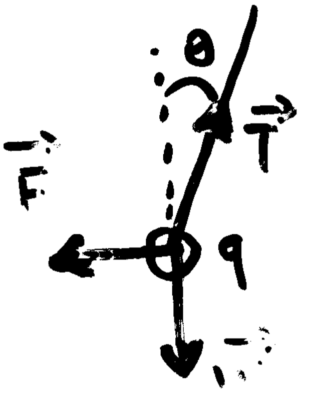


Fig. 21-43 Problems 66 and 67.

$$\sin\theta = \frac{x/2}{L}$$

$$\left.\begin{aligned}\sum F_x &= 0\\ \sum F_y &= 0\end{aligned}\right\}\ \text{equilibrium}$$



$$\sum F_x = T\sin\theta - k\frac{q^2}{x^2} = 0$$

$$\sum F_y = T\cos\theta - mg = 0 \Rightarrow T = \frac{mg}{\cos\theta}$$

$$mg\tan\theta = k\frac{q^2}{x^2} = \frac{1}{4\pi\varepsilon_0}\frac{q^2}{x^2}$$

θ small $\tan\theta \simeq \sin\theta = \dfrac{x}{2L}$

$$mg\frac{x}{2L} = \frac{1}{4\pi\varepsilon_0}\frac{q^2}{x^2} \Rightarrow x^3 = \frac{q^2 L}{2\pi\varepsilon_0 mg}$$

$$\Rightarrow x = \left(\frac{q^2 L}{2\pi\varepsilon_0 mg}\right)^{1/3}$$

(b) $L = 1.2\,m$ $\quad m = 0.01\,Kg$ $\quad x = 0.05\,m$

$$q^2 = \frac{2\pi\varepsilon_0 m g x^3}{L}$$

$$q = \pm\sqrt{\frac{2\pi\varepsilon_0 m g x^3}{L}} = \pm 2.4\times10^{-8}\,C$$

<u>extra</u>

\# of electrons ?

$$q = n e$$

$$2.4\times10^{-8} = n\ 1.6\times10^{-19}$$

$n = 1.5\times10^{11}$ electrons

$n = 150000{,}000000$ electrons.