

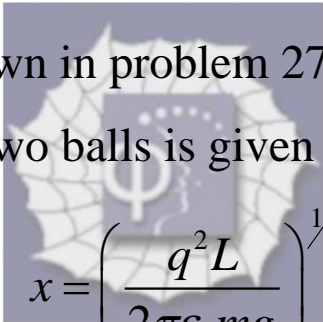
278.

Problem 27.18 (RHK)

Assume that each conducting ball in problem 277 is losing charge at the rate of 1.20 nC s^{-1} . We have to calculate the instantaneous relative speed with which the two balls approach each other initially.

Solution:

We have shown in problem 277 that the equilibrium separation of the two balls is given by the relation


$$x = \left(\frac{q^2 L}{2\pi\epsilon_0 mg} \right)^{1/3} .$$

Therefore,

$$\begin{aligned} \frac{dx}{dt} &= \left(\frac{L}{2\pi\epsilon_0 mg} \right)^{1/3} \times \left(\frac{2}{3} \times q^{-1/3} \times \frac{dq}{dt} \right) = \left(\frac{Lq^2}{2\pi\epsilon_0 mg} \right)^{1/3} \times \left(\frac{2}{3q} \frac{dq}{dt} \right) \\ &= \frac{2x}{3q} \frac{dq}{dt} . \end{aligned}$$

We use the data that initially

$x = 4.70 \text{ cm}$, $q = 22.8 \times 10^{-9} \text{ C}$, and

$$\frac{dq}{dt} = 1.20 \times 10^{-9} \text{ C s}^{-1}.$$

Therefore, initially the two balls will approach other with relative speed

$$\left(\frac{dx}{dt} \right)_{initial} = \frac{2 \times 4.70 \times 1.20 \times 10^{-9}}{3 \times 22.8 \times 10^{-9}} \text{ cm s}^{-1} = 1.65 \text{ mm s}^{-1}.$$

