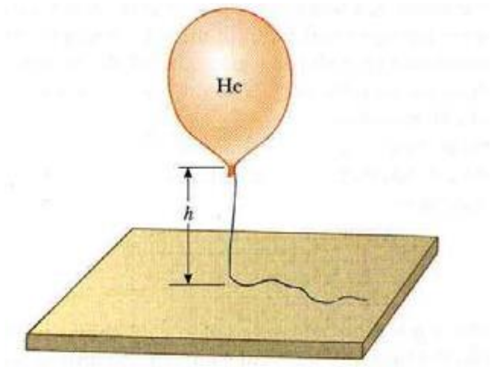
Answer on Question #57294, Physics / Mechanics | Relativity

A helium-filled balloon is tied to a 2.00-m-long, 0.050 0-kg uniform string. The balloon is spherical with a radius of 0.400 m. When released, the balloon lifts a length h of string and then remains in equilibrium. Determine the value of h. The envelope of the balloon has a mass of 0.250 kg.

Solution:

Density of Helium gas $\rho_{He} = 0.179 \text{ kg/m}^3$

Density of air $\rho_{air} = 1.29 \text{ kg/m}^3$



1 force up: buoyant force (due to air) F_b

3 forces down: weights W_{baloon}, W_{He} (helium inside ballon), W_{string} (part of string above the ground)

Newton's Second Law :

$$F_b = W_{balloon} + W_{He} + W_{string}$$

where

$$F_b = \rho_{air} V g = \rho_{air} \frac{4}{3}\pi r^3 g$$

$$W_{balloon} = m_{balloon} g$$

$$W_{He} = \rho_{He} \frac{4}{3}\pi r^3 g$$

$$W_{string} = \frac{h}{L} M g$$

where h is the unknown of this problem.

$$\rho_{air} \frac{4}{3}\pi r^3 = m_{balloon} + \rho_{He} \frac{4}{3}\pi r^3 + \frac{h}{L} M$$

$$h = \frac{L}{M}\left(\rho_{air} \frac{4}{3}\pi r^3 - m_{balloon} - \rho_{He} \frac{4}{3}\pi r^3\right)$$

$$h = \frac{L}{M}\left(\frac{4}{3}\pi r^3(\rho_{air} - \rho_{He}) - m_{balloon}\right)$$

$$h = \frac{2.00}{0.05} \cdot \left(\frac{4}{3} \cdot \pi \cdot 0.4^3 \cdot (1.29 - 0.179) - 0.250\right) = 1.91 \text{ m}$$

Answer: 1.91 m