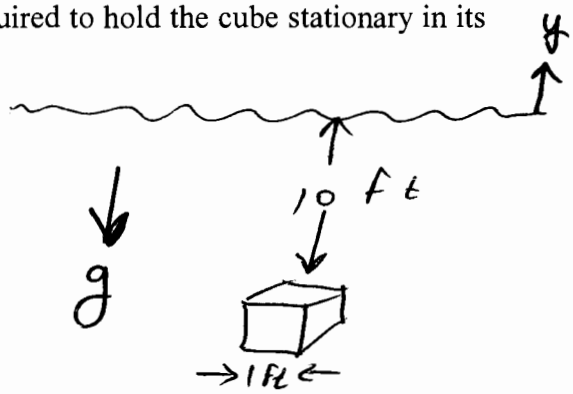
Example:

A cube is measuring 1 ft on a side is submerged 10 ft under water (ρ_w = 62.4 lb_m/ft^3). Determine the magnitude and direction of the force required to hold the cube stationary in its position if the cube is made of:

(a) Cork (ρ_s = 10 lb_m/ft^3)

(b) Steel (ρ_s = 490 lb_m/ft^3)



Ans:

(a) $\vec{F_R} = \vec{F_B} + \vec{F_G}$

$= +\rho_f g V - \rho_s V g$

$= (\rho_f - \rho_s) V g = (62.4 - 10)(32.2)(1)$

$= 1687 \ \frac{lb_m \ ft}{s^2} * \frac{1}{g_c}$

$= 52.4 \ lb_f$ $\quad 32 \ \frac{lb_m \ ft}{s^2 \ lb_f}$

$\Rightarrow$ Required force $-$ 52.4 lb_f

(b) $\vec{F_R} = (62.4 - 490)(32.2)(1) \ \frac{1}{g_c} = -427.1 \ lb_f$

$\Rightarrow$ Required force $+$ 427.1 lb_f

④

14. *Hydrometer—E.* When a hydrometer floats in water, its cylindrical stem is submerged so that a certain point X on the stem is level with the free surface of the water, as shown in Fig. P1.14. When the hydrometer is placed in another liquid L of specific gravity s, the stem *rises* so that point X is now a height z above the free surface of L.

Derive an equation giving s in terms of z. If needed, the cross-sectional area of the stem is A, and when in water a total volume V (stem plus bulb) is submerged.

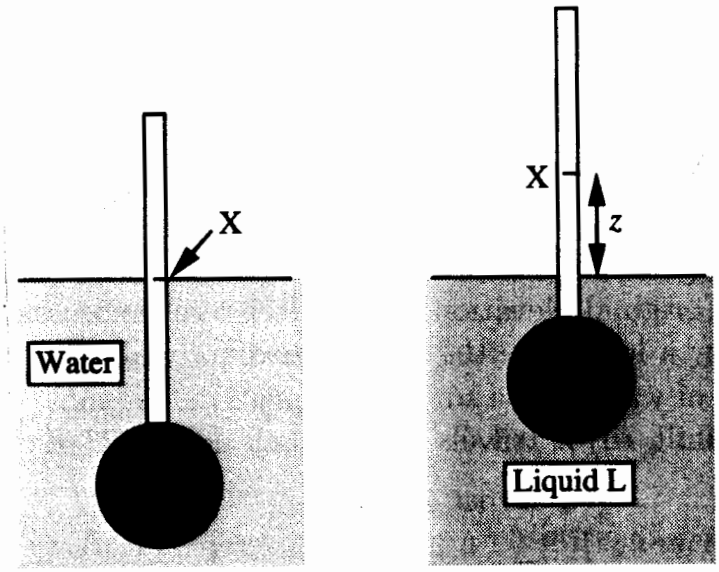


Fig. P1.14 Hydrometer in water and test liquid L.

Mass of Hydrometer $= M_H$

Solution

Case 1. Water $\quad F_R = 0 = \rho_w V g - M_H g$ ①

Case 2. Liquid L $\quad F_R = 0 = \rho_L (V - Az) g - M_H g$ ②

① = ②

$$\Rightarrow \quad \rho_w V g - \cancel{M_H g} = \rho_L (V - Az) g - \cancel{M_H g}$$

$$\boxed{\frac{\rho_L}{\rho_w} = S_L = \frac{V}{V - Az} = \frac{1}{1 - \frac{Az}{V}}}$$