

2.145

2.145 When a hydrometer (see Fig. P2.145 and Video V2.8) having a stem diameter of 0.30 in. is placed in water, the stem protrudes 3.15 in. above the water surface. If the water is replaced with a liquid having a specific gravity of 1.10, how much of the stem would protrude above the liquid surface? The hydrometer weighs 0.042 lb.

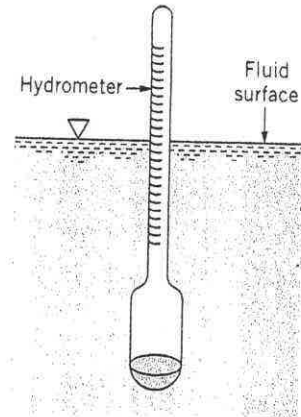


FIGURE P2.145

When the hydrometer is floating its weight,  $W$ , is balanced by the buoyant force,  $F_B$ . For equilibrium,

$$\sum F_{\text{vertical}} = 0$$

Thus, for water

$$F_B = W$$

$$(\gamma_{H_2O}) V_1 = W \quad (1)$$

where  $V_1$  is the submerged volume. With the new liquid

$$(SG)(\gamma_{H_2O}) V_2 = W \quad (2)$$

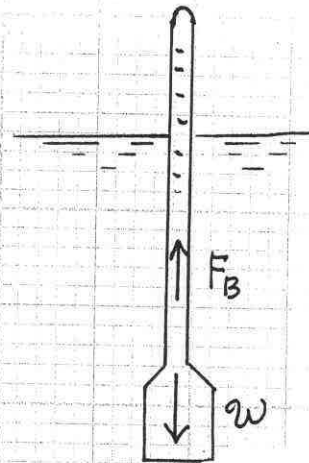
Combining Eqs. (1) and (2) with  $W$  constant

$$(\gamma_{H_2O}) V_1 = (SG)(\gamma_{H_2O}) V_2$$

and

$$V_2 = \frac{V_1}{SG} \quad (3)$$

(cont)



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(Cont)

From Eq. (1)

$$V_1 = \frac{2W}{\gamma_{H_2O}} = \frac{0.042 \text{ lb}}{62.4 \frac{\text{lb}}{\text{ft}^3}} = 6.73 \times 10^{-4} \text{ ft}^3$$

So that from Eq. (3)

$$V_2 = \frac{6.73 \times 10^{-4} \text{ ft}^3}{1.10} = 6.12 \times 10^{-4} \text{ ft}^3$$

$$\text{Thus, } V_1 - V_2 = (6.73 - 6.12) \times 10^{-4} \text{ ft}^3 = 0.61 \times 10^{-4} \text{ ft}^3$$

To obtain this difference the change in length,  $\Delta l$ , is

$$\left(\frac{\pi}{4}\right)(0.30 \text{ in.})^2 \Delta l = (0.61 \times 10^{-4} \text{ ft}^3) \left(1728 \frac{\text{in.}^3}{\text{ft}^3}\right)$$

$$\Delta l = 1.49 \text{ in.}$$

With the new liquid the stem would protrude  
 3.15 in. + 1.49 in. = 4.64 in. above the surface