When a hydrometer (see Fig. P2.105 and Video V2.9) 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.

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,

\[
F_B = W
\]

\[
(\delta_{H_2O}) \frac{V}{V_1} = W
\]

where \( V_1 \) is the submerged volume. With the new liquid,

\[
(\text{SG}) (\delta_{H_2O}) \frac{V_2}{V_1} = W
\]

Combining Eqs. (1) and (2) with \( W \) constant,

\[
(\delta_{H_2O}) \frac{V_1}{V_2} = (\text{SG})(\delta_{H_2O}) \frac{V_1}{V_2}
\]

and

\[
V_2 = \frac{V_1}{\text{SG}}
\]

(con't)
From Eq. (1)

\[ V_1 = \frac{2V}{\pi} = \frac{0.042 \text{ in.}^3}{62.4 \text{ in.}^3} = 6.73 \times 10^{-4} \text{ ft}^3 \]

so that from Eq. (3)

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

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

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

\[ \Delta l = 1.49 \text{ in.} \]

With the new liquid the stem would protrude

3.15 in. + 1.49 in. = 4.64 in. above the surface