2.89 When a hydrometer (see Fig. P2.89 and Video V2.6) 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 P2.89](image)

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

\[
F_B = W
\]

\[
(\gamma_{H_2O}) \Delta V = W
\]

(1)

where \( \Delta V \) is the submerged volume. With the new liquid

\[
(SG) (\gamma_{H_2O}) \Delta V = W
\]

(2)

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

\[
(\gamma_{H_2O}) \Delta V = (SG) (\gamma_{H_2O}) \Delta V
\]

and

\[
\Delta V = \frac{\Delta V}{SG}
\]

(3)

(con't)
From Eq. (1)
\[
V_1 = \frac{2\Delta l}{\Delta \theta_2} = \frac{0.04216}{62.4 \frac{\text{lb}}{\text{ft}^2}} = 6.73 \times 10^{-4} \text{ ft}^3
\]
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
\[
\left(\frac{11}{4}\right)(0.30 \text{ in.})^3 \Delta l = (0.61 \times 10^{-4} \text{ ft}^3)(1728 \frac{\text{in.}^3}{\text{ft}^3})
\]
\[\Delta l = 1.49 \text{ in.}\]

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