3.48 Air is drawn into a wind tunnel used for testing automobiles as shown in Fig. P3.48. (a) Determine the manometer reading, \( h \), when the velocity in the test section is 60 mph. Note that there is a 1-in. column of oil on the water in the manometer. (b) Determine the difference between the stagnation pressure on the front of the automobile and the pressure in the test section.

\[
\frac{p_1}{g} + z_1 + \frac{V_1^2}{2g} = \frac{p_2}{g} + \frac{V_2^2}{2g} + z_2
\]

where
\[z_1 = z_2, \quad \rho_1 = 0, \quad \text{and} \quad V_1 = 0\]

Thus, with \( V_2 = 60 \text{ mph} = 88 \frac{\text{ft}}{\text{s}} \),
\[\frac{p_2}{g} = -\frac{1}{2} \rho \frac{V_2^2}{2g} = -\frac{1}{2} \left( 0.00238 \frac{\text{slugs}}{\text{ft}^2} \right) \left( 88 \frac{\text{ft}}{\text{s}} \right)^2 = -9.22 \frac{\text{lb}}{\text{ft}^2}\]

But \( \rho_2 + \gamma_\text{oil} h - \gamma_\text{oil} (1/2 \text{ ft}) = 0 \) where \( \gamma_\text{oil} = 0.9 \gamma_\text{H}_2\text{O} = 0.9 \left( 62.4 \frac{\text{lb}}{\text{ft}^2} \right) = 56.2 \frac{\text{lb}}{\text{ft}^2}\]

Thus,
\[-9.22 \frac{\text{lb}}{\text{ft}^2} + 62.4 \frac{\text{lb}}{\text{ft}^2} (h \text{ ft}) - 56.2 \frac{\text{lb}}{\text{ft}^2} \left( \frac{1}{2} \text{ ft} \right) = 0, \quad \text{or} \quad h = 0.223 \text{ ft}\]

(b)
\[
\frac{p_2}{g} + z_2 + \frac{V_2^2}{2g} = \frac{p_3}{g} + z_3 + \frac{V_3^2}{2g}
\]

where
\[z_2 = z_3 \quad \text{and} \quad V_3 = 0\]

Thus,
\[\frac{p_2}{g} + \frac{V_2^2}{2g} = \frac{p_3}{g} \quad \text{or}\]
\[p_3 - p_2 = \frac{1}{2} \rho \frac{V_2^2}{2g} = \frac{1}{2} \left( 0.00238 \frac{\text{slugs}}{\text{ft}^2} \right) \left( 88 \frac{\text{ft}}{\text{s}} \right)^2 = 9.22 \frac{\text{lb}}{\text{ft}^2}\]