3.48

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.

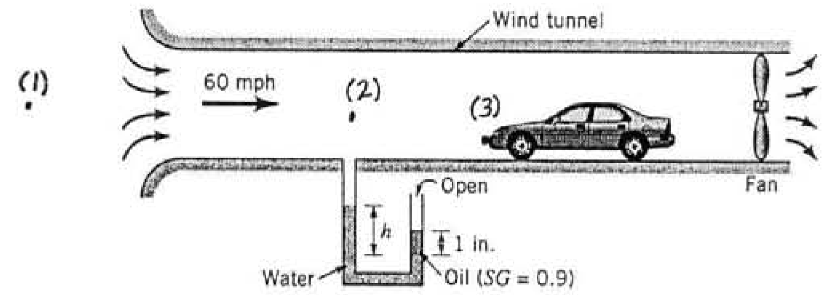

FIGURE P3.48

(a) $\frac{p_1}{\gamma} + z_1 + \frac{V_1^2}{2g} = \frac{p_2}{\gamma} + \frac{V_2^2}{2g} + z_2$

where

$z_1 = z_2$, $p_1 = 0$, and $V_1 \approx 0$

Thus, with $V_2 = 60\ mph = 88\ \frac{ft}{s}$,

$\frac{p_2}{\gamma} = -\frac{V_2^2}{2g}$ or

$p_2 = -\frac{1}{2}\rho V_2^2 = -\frac{1}{2}(0.00238\ \frac{slugs}{ft^3})(88\ \frac{ft}{s})^2 = -9.22\ \frac{lb}{ft^2}$

But $p_2 + \gamma_{H_2O}\, h - \gamma_{oil}\left(\frac{1}{12} ft\right) = 0$ where $\gamma_{oil} = 0.9\,\gamma_{H_2O} = 0.9(62.4\ \frac{lb}{ft^3})$
$= 56.2\ \frac{lb}{ft^3}$

Thus,

$-9.22\ \frac{lb}{ft^2} + 62.4\ \frac{lb}{ft^3}(h\ ft) - 56.2\ \frac{lb}{ft^3}\left(\frac{1}{12} ft\right) = 0$, or $h = \underline{\underline{0.223\ ft}}$

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

where

$z_2 = z_3$ and $V_3 = 0$

Thus,

$\frac{p_2}{\gamma} + \frac{V_2^2}{2g} = \frac{p_3}{\gamma}$ or

$p_3 - p_2 = \frac{1}{2}\rho V_2^2 = \frac{1}{2}(0.00238\ \frac{slugs}{ft^3})(88\ \frac{ft}{s})^2 = \underline{\underline{9.22\ \frac{lb}{ft^2}}}$