3.76

3.76 The specific gravity of the manometer fluid shown in Fig. P3.70 is 1.07. Determine the volume flowrate, Q, if the flow is inviscid and incompressible and the flowing fluid is (a) water, (b) gasoline, or (c) air at standard conditions.

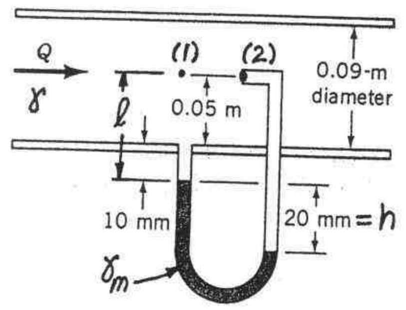

FIGURE P3.70

$$\frac{p_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{p_2}{\gamma} + \frac{V_2^2}{2g} + z_2 \quad \text{where } z_1 = z_2 \text{ and } V_2 = 0$$

Thus,

$$V_1 = \sqrt{2g\,\frac{(p_2 - p_1)}{\gamma}} \qquad (1)$$

But

$$p_1 + \gamma\ell + \gamma_m h = p_2 + \gamma(\ell + h)$$

or

$$p_2 - p_1 = (\gamma_m - \gamma)h \quad \text{so that Eq. (1) becomes}$$

$$V_1 = \sqrt{2g\,\frac{(\gamma_m - \gamma)}{\gamma}h} = \sqrt{2\left(9.81\,\frac{m}{s^2}\right)\left(\frac{1.07\,(9.8\times10^3\,\frac{N}{m^3})}{\gamma} - 1\right)(0.02m)}$$

Thus,

$$Q = A_1V_1 = \frac{\pi}{4}D_1^2V_1 = \frac{\pi}{4}(0.09\,m)^2\sqrt{2(9.81)\left(\frac{10.49\times10^3}{\gamma} - 1\right)(0.02)}$$

or

$$Q = 3.99\times10^{-3}\sqrt{\frac{10.49}{\gamma} - 1}\ \frac{m^3}{s} \quad \text{where } \gamma \sim \frac{kN}{m^3}$$

For the given fluids this gives:

	fluid	$\gamma,\ \frac{kN}{m^3}$	$Q,\ \frac{m^3}{s}$
(a)	water	9.80	1.06×10^{-3}
(b)	gasoline	6.67	3.02×10^{-3}
(c)	air	12×10^{-3}	0.118