9.88

9.88 A 2-in.-diameter sphere weighing 0.14 lb is suspended by the jet of air shown in Fig. P9.84 and Video V3.2. The drag coefficient for the sphere is 0.5. Determine the reading on the pressure gage if friction and gravity effects can be neglected for the flow between the pressure gage and the nozzle exit.

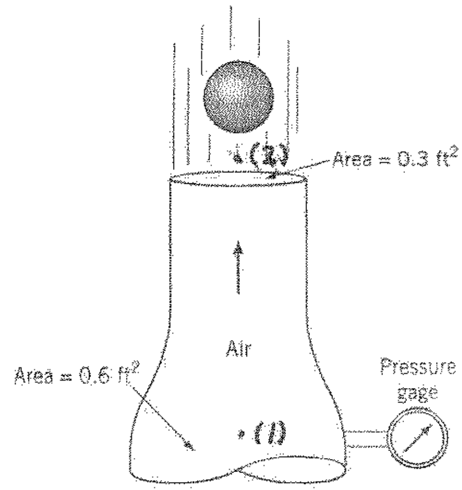
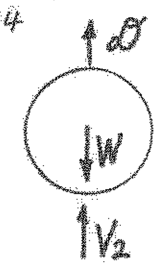


FIGURE P9.84



For equilibrium, $\mathscr{D} = W$ or

$$C_D \tfrac{1}{2}\rho V_2^2 A = W, \text{ where } A = \tfrac{\pi}{4}D^2$$

Thus,

$$V_2 = \left[\frac{2W}{C_D \rho \pi D^2/4}\right]^{1/2}$$

$$= \left[\frac{8\,(0.14\,lb)}{0.5\left(0.00238\,\frac{slugs}{ft^3}\right)\pi\left(\frac{2}{12}\,ft\right)^2}\right]^{1/2} = 104\,\frac{ft}{s}$$

Also,

$$V_1 A_1 = V_2 A_2 \quad \text{or} \quad V_1 = V_2 \frac{A_2}{A_1} = \left(104\,\frac{ft}{s}\right)\frac{0.3\,ft^2}{0.6\,ft^2} = 52.0\,\frac{ft}{s}$$

and

$$p_1 + \tfrac{1}{2}\rho V_1^2 = p_2 + \tfrac{1}{2}\rho V_2^2 \quad \text{where } p_2 = 0$$

Thus,

$$p_1 = \tfrac{1}{2}\rho\left[V_2^2 - V_1^2\right] = \tfrac{1}{2}\left(0.00238\,\frac{slugs}{ft^3}\right)\left[\left(104\,\frac{ft}{s}\right)^2 - \left(52.0\,\frac{ft}{s}\right)^2\right]$$

$$= \underline{\underline{9.65\,\frac{lb}{ft^2}}}$$