8.31 Water at 20°C flows at 3 m/s in a 20-cm smooth pipe. What must be the velocity of air (standard atmospheric pressure) at 30°C in a 10-cm smooth pipe for the two flows to be dynamically similar? If the pressure change for the water flow was measured as 2.0 kPa over a given length of pipe, what pressure change should you get for the air flow with the same length of pipe?

8.31 Water 20°C $V_w = 3$ m/s $D_w = 20\text{cm} = .2\text{m}$

Air 30°C, patm $D_a = 10\text{cm} = .1\text{m}$

V_a for dynamic similarity

Similarity: ① $Re_a = Re_w$

$$\frac{V_a D_a}{\nu_a} = \frac{V_w D_w}{\nu_w}$$

$$V_a = V_w D_w \nu_a / D_a \nu_w$$

$$= 3 \times \left(\frac{.2}{.1}\right) \times \left(\frac{1.6\times10^{-5}}{1\times10^{-6}}\right)$$

$$= 96 \text{ m/s}$$

② $$\frac{\Delta P_a}{\frac{1}{2}\rho_a V_a^2} = \frac{\Delta p_w}{\frac{1}{2}\rho_w V_w^2}$$

$$\Delta p_a = \Delta p_w \cdot \frac{\frac{1}{2}\rho_a V_a^2}{\frac{1}{2}\rho_w V_w^2} = 2 \times \frac{1.17}{998} \times \frac{96^2}{3^2}$$

$$= 2.4 \text{ kPa}$$