

HW 2.4, Ex. 12 # 5, 6

12.5)

upper
main

$$V_a = \frac{Q}{A_a} = \frac{500 \text{ L/min} \cdot \frac{1.66 \times 10^{-3} \text{ m}^3/\text{sec}}{1 \text{ L/min}}}{\frac{\pi \cdot (1.0)^2}{4} \cdot 0.00833 \text{ m}^2/\text{sec}} = \frac{8.33 \times 10^{-3} \text{ m}^3/\text{sec}}{0.00833 \text{ m}^2} = 1.061 \text{ m/s}$$

$$N_R = \frac{V_a D_a}{\nu} = \frac{(1.061)(1.0)}{0.000013} = 81800$$

$$R_r = \frac{\Sigma}{D} = \frac{1.5 \times 10^{-6} \text{ m}}{1.00} = 1.5 \times 10^{-5}$$

$$f_a = 0.086, \quad f_r = 0.010$$

lower
branch

$$V_b = \frac{Q}{A_b} = \frac{8.33 \times 10^{-3} \text{ m}^3/\text{sec}}{\frac{\pi \cdot (0.050)^2}{4}} = \frac{8.33 \times 10^{-3}}{1.96 \times 10^{-3} \text{ m}^2} = 4.24 \text{ m/s}$$

$$N_R = \frac{V_b D_b}{\nu} = \frac{(4.24)(0.050)}{1.30 \times 10^{-6}} = 163000$$

$$R_r = \frac{1.5 \times 10^{-6}}{0.050} = 3 \times 10^{-5}$$

$$f_b = 0.016, \quad f_r = 0.010$$

$$\begin{aligned} (h_L)_{\text{upper}} &= h_{frc} + h_{mbc} + \Sigma h_{L} = f_a \left(\frac{L}{D} \right) \frac{V_a^2}{2g} + K \frac{V_a^2}{2g} + \Sigma f_r \left(\frac{L}{D} \right) \frac{V_r^2}{2g} \\ &= 0.086 \left(\frac{30}{1.0} \right) \frac{V_a^2}{2g} + K \frac{V_a^2}{2g} + \Sigma (0.010)(30) \frac{V_r^2}{2g} \\ h_{L_a} &= (6.18 + K) \frac{V_a^2}{2g} \end{aligned}$$

$$\begin{aligned} (h_L)_{\text{lower}} &= h_{frc} + h_{mbc} + \Sigma h_{L} = f_b \left(\frac{L}{D} \right) \frac{V_b^2}{2g} + K \frac{V_b^2}{2g} + \Sigma f_r \left(\frac{L}{D} \right) \frac{V_r^2}{2g} \\ &= f_b \left(\frac{30}{0.050} \right) \frac{V_b^2}{2g} + 2.900 \times (30) \frac{V_r^2}{2g} \\ h_{L_b} &= (10.38) \frac{V_b^2}{2g} \rightarrow V_b^2 = 16V_r^2 \end{aligned}$$

$$\begin{aligned} h_{L_a} &= h_{L_b} \\ 6.18 + K \frac{V_r^2}{2g} &= 10.38 \frac{16V_r^2}{2g} \\ 6.18 + K &= 166.08 \end{aligned}$$

$$K = 160$$

$$12.6) \quad h_{L_a} = 2K_1 \frac{v_a^2}{2g} + K_2 \frac{v_a^2}{2g} = 2(.1) \frac{v_a^2}{2g} + 5 \frac{v_a^2}{2g}$$

$$h_{L_a} = 6.8 \frac{v_a^2}{2g}$$

$$h_{L_b} = 2K \frac{v_b^2}{2g} + K_3 \frac{v_b^2}{2g} = 2(.1) \frac{v_b^2}{2g} + 10 \frac{v_b^2}{2g}$$

$$h_{L_b} = 11.8 \frac{v_b^2}{2g}$$

upper branch

$$\rightarrow Q_{C.15} = 6.8 \frac{v_a^2}{2 \cdot 32.2}$$

$$v_a = 20.9 \text{ ft/s}$$

$$Q_a = A_a v_a = \left(\frac{\pi \left(\frac{2}{12} \right)^2}{4} \right) (20.9) = .456 \text{ ft}^3/\text{s}$$

lower branch

$$46.15 = 11.8 \frac{v_b^2}{2g}$$

$$v_b = 15.67 \text{ ft/s}$$

$$Q_b = A_b v_b = \left(\frac{\pi \left(\frac{4}{12} \right)^2}{4} \right) (15.67) = 1.365 \text{ ft}^3/\text{s}$$

$$Q = Q_a + Q_b = .456 + 1.365$$

$$Q = 1.821 \text{ ft}^3/\text{s}$$

$$b) \quad Q_{b2} = Q_b$$

$$Q_{b2} = 1.365 \text{ ft}^3/\text{s}$$

$$c) \quad Q_{b1} = Q_a$$

$$Q_{b1} = .456 \text{ ft}^3/\text{s}$$