5.116

5.116 Water flows by gravity from one lake to another as sketched in Fig. P5.116 at the steady rate of 80 gpm. What is the loss in available energy associated with this flow? If this same amount of loss is associated with pumping the fluid from the lower lake to the higher one at the same flowrate, estimate the amount of pumping power required.

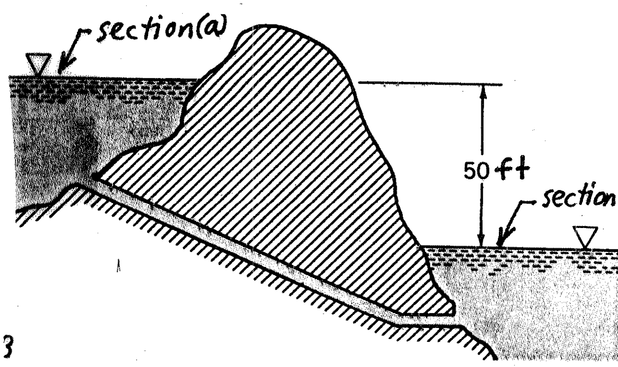

FIGURE P5.116

$$Q = \frac{80 \frac{gal}{min}}{\left(60 \frac{s}{min}\right)\left(7.48 \frac{gal}{ft^3}\right)} = 0.178 \frac{ft^3}{s}$$

For the flow from section (a) to section (b) Eq. 5.82 leads to

$$loss = g(z_a - z_b) = \left(32.2 \frac{ft}{s^2}\right)(50 ft)\left(\frac{1\ lb}{slug \cdot \frac{ft}{s^2}}\right) = \underline{\underline{1610}}\ \frac{ft\,lb}{slug}$$

For pumped flow from section b to section a Eq. 5.82 yields

$$\dot{W}_{\substack{shaft\\net\ in}} = \rho Q\left[g(z_a - z_b) + loss\right] = \left(1.94 \frac{slugs}{ft^3}\right)\left(0.178 \frac{ft^3}{s}\right)\left[\left(32.2 \frac{ft}{s^2}\right)(50 ft)\left(\frac{1\ lb}{slug \cdot \frac{ft}{s^2}}\right) + 1610 \frac{ft \cdot lb}{slug}\right]$$

or

$$\dot{W}_{\substack{shaft\\net\ in}} = \underline{\underline{1110}}\ \frac{ft \cdot lb}{s} = \underline{\underline{2.02\ hp}}$$

5.117

5.117 A $\frac{3}{4}$-hp motor is required by an air ventilating fan to produce a 24-in.-diameter stream of air having a uniform speed of 40 ft/s. Determine the aerodynamic efficiency of the fan.

The aerodynamic efficiency of the fan, η, is

$$\eta = \frac{\text{ideal power required}}{\text{actual power required}}$$

The actual shaft power required, $\dot{W}_{actual}$, is 0.75 hp.

The ideal shaft power required, $\dot{W}_{ideal}$, is obtained from Eq. 5.82 for flow without loss across the fan. Thus

$$\dot{W}_{ideal} = \dot{m}\frac{V_{out}^2}{2} = \rho A_{out} V_{out} \frac{V_{out}^2}{2} = \rho \frac{\pi D_{out}^2}{4} \frac{V_{out}^3}{2} = \left(2.38 \times 10^{-3} \frac{slug}{ft^3}\right)\frac{\pi (2 ft)^2}{4} \times \frac{\left(40 \frac{ft}{s}\right)^3}{2}\left(\frac{1\ lb}{slug \cdot \frac{ft}{s^2}}\right)\left(\frac{1}{550 \frac{ft \cdot lb}{s \cdot hp}}\right)$$

or $\dot{W}_{ideal} = 0.435\ hp$

Then

$$\eta = \frac{0.435\ hp}{0.75\ hp} = \underline{\underline{0.58}}$$