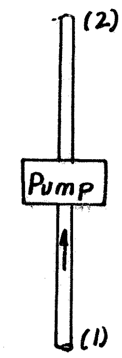
8.61

8.61 What horsepower is added to water to pump it vertically through a 200-ft-long, 1.0-in.-diameter drawn tubing at a rate of 0.060 ft³/s if the pressures at the inlet and outlet are the same?



$$\frac{p_1}{\gamma}+\frac{V_1^2}{2g}+z_1+h_p=\frac{p_2}{\gamma}+\frac{V_2^2}{2g}+z_2+f\frac{\ell}{D}\frac{V^2}{2g}, \text{ where } p_1=p_2$$

and $V_1=V_2$. Thus,

$$h_p=z_2-z_1+f\frac{\ell}{D}\frac{V^2}{2g}, \text{ where } z_2-z_1=\ell=200\text{ ft and} \qquad (1)$$

$$V=\frac{Q}{A}=\frac{0.06\frac{ft^3}{s}}{\frac{\pi}{4}(\frac{1}{12}ft)^2}=11.0\frac{ft}{s}$$

Also, $\frac{\varepsilon}{D}=\frac{5\times10^{-6}\text{ ft}}{(1/12\text{ ft})}=6\times10^{-5}$ (Table 8.1)

and $Re=\frac{VD}{\nu}=\frac{(11.0\frac{ft}{s})(\frac{1}{12}ft)}{1.21\times10^{-5}\frac{ft^2}{s}}=7.58\times10^4$ we obtain from Fig. 8.20

$f=0.019$

From Eq. (1)

$$h_p=200\text{ ft}+(0.019)\left(\frac{200\text{ ft}}{\frac{1}{12}\text{ ft}}\right)\frac{(11.0\frac{ft}{s})^2}{2(32.2\frac{ft}{s^2})}=286\text{ ft}$$

Thus,

$$\mathcal{P}=\gamma Q h_p=(62.4\tfrac{lb}{ft^3})(0.06\tfrac{ft^3}{s})(286\text{ft})=1071\ \tfrac{ft\cdot lb}{s}\left(\frac{1\text{ hp}}{550\frac{ft\cdot lb}{s}}\right)=\underline{\underline{1.95\text{ hp}}}$$

8.62

8.62 Water flows from a lake as is shown in Fig. P8.62 at a rate of 4.0 cfs. Is the device inside the building a pump or a turbine? Explain and determine the horsepower of the device. Neglect all minor losses and assume the friction factor is 0.025.

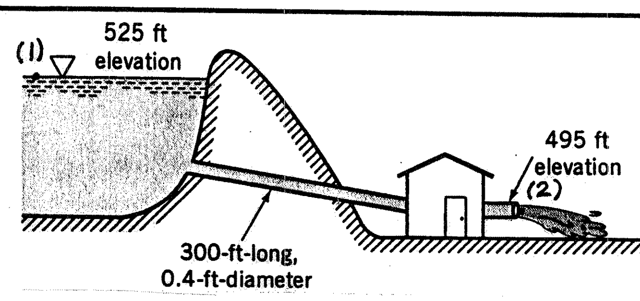


FIGURE P8.62

$$\frac{p_1}{\gamma}+\frac{V_1^2}{2g}+z_1+h_p=\frac{p_2}{\gamma}+\frac{V_2^2}{2g}+z_2+h_t+f\frac{\ell}{D}\frac{V^2}{2g}, \text{ where } p_1=p_2=0,\ V_1=0$$

Assume the device is a pump ($h_t=0$).

and $V_2=V=\frac{Q}{\frac{\pi}{4}D^2}=\frac{4\frac{ft^3}{s}}{\frac{\pi}{4}(0.4ft)^2}=31.8\frac{ft}{s}$

Thus, $z_1+h_p=\frac{V^2}{2g}(1+f\frac{\ell}{D})+z_2$, or

$$h_p=495\text{ ft}-525\text{ ft}+\frac{(31.8\frac{ft}{s})^2}{2(32.2\frac{ft}{s^2})}\left(1+0.025\left(\frac{300\text{ ft}}{0.4\text{ ft}}\right)\right)=280\text{ ft}$$

Note: Since $h_p>0$ <u>the device is a pump</u>.

Also, $\mathcal{P}=g\dot{m}h_p=\gamma Q h_p=(62.4\frac{lb}{ft^3})(4\frac{ft^3}{s})(280\text{ft})=69{,}900\ \frac{ft\cdot lb}{s}\left(\frac{1\text{ hp}}{550\frac{ft\cdot lb}{s}}\right)$

or

$$\mathcal{P}=\underline{\underline{127\text{ hp}}}$$