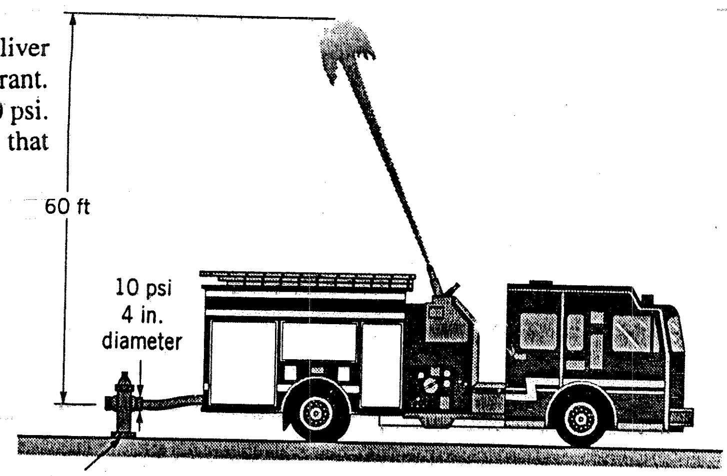
5.107

5.107 The pumper truck shown in Fig. P5.107 is to deliver 1.5 ft³/s to a maximum elevation of 60 ft above the hydrant. The pressure at the 4-in. diameter outlet of the hydrant is 10 psi. If head losses are negligibly small, determine the power that the pump must add to the water.



■ FIGURE P5.107

To solve this problem we first use the energy equation (Eq. 5.84) for flow from the hydrant exit (1) to the maximum desired elevation of 60 ft (2) to get h_s or in this case, the pump head. With the pump head we can get the pump power from Eq. 5.85.

$$\cancelto{0}{\frac{p_2}{\rho}} + \cancelto{0}{\frac{V_2^2}{2g}} + z_2 = \frac{p_1}{\rho} + \frac{V_1^2}{2g} + z_1 + h_s - \cancelto{0}{h_L}$$

$$h_s = z_2 - z_1 - \frac{p_1}{\rho} - \frac{V_1^2}{2g}$$

$$V_1 = \frac{Q}{A_1} = \frac{Q}{\left(\frac{\pi d_1^2}{4}\right)} = \frac{\left(1.5\,\frac{ft^3}{s}\right)(4)}{\pi\left(\frac{4\text{ in.}}{12\,\frac{in.}{ft}}\right)^2} = 17.2\,\frac{ft}{s}$$

$$h_s = 60\text{ ft} - \frac{\left(10\,\frac{lb}{in.^2}\right)\left(144\,\frac{in.^2}{ft^2}\right)}{\left(62.4\,\frac{lb}{ft^3}\right)} - \frac{\left(17.2\,\frac{ft}{s}\right)^2}{2\left(32.2\,\frac{ft}{s^2}\right)}$$

$$h_s = 32.3\text{ ft}$$

$$\dot{W}_{\substack{shaft\\net\ in}} = \gamma Q h_s = \left(62.4\,\frac{lb}{ft^3}\right)\left(1.5\,\frac{ft^3}{s}\right)\frac{(32.2\text{ ft})}{\left(550\,\frac{ft\cdot lb}{s\cdot hp}\right)}$$

$$\dot{W}_{\substack{shaft\\net\ in}} = \underline{\underline{5.48\text{ hp}}}$$