5.111

5.111 Gasoline ($SG = 0.68$) flows through a pump at $0.12\ m^3/s$ as indicated in Fig. P5.111. The loss between sections (1) and (2) is loss $= h_L g = 0.3\ V_1^2/2$. What will the difference in pressures between sections (1) and (2) be if 20 kW is delivered by the pump to the fluid?

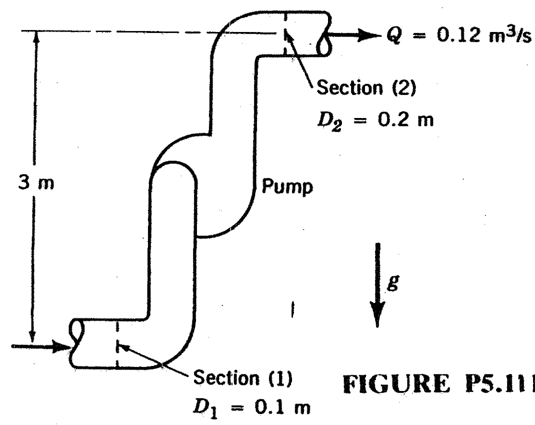

FIGURE P5.111

From Eq. 5.82 we get for the flow from section (1) to section (2)

$$p_1 - p_2 = \rho\left[\frac{V_2^2 - V_1^2}{2} + g(z_2 - z_1) - w_{\substack{shaft\\net\ in}} + \text{loss}\right] \qquad (1)$$

From the volume flowrate we obtain

$$V_2 = \frac{Q}{A_2} = \frac{Q}{\frac{\pi D_2^2}{4}} = \frac{\left(0.12\ \frac{m^3}{s}\right)^2}{\frac{\pi\ (0.2\ m)^2}{4}} = 3.82\ \frac{m}{s}$$

and from conservation of mass (Eq. 5.13) it follows that

$$V_1 = V_2\frac{A_2}{A_1} = V_2\frac{D_2^2}{D_1^2} = \left(3.82\ \frac{m}{s}\right)\frac{(0.2\ m)^2}{(0.1\ m)^2} = 15.28\ \frac{m}{s}$$

Also

$$w_{\substack{shaft\\net\ in}} = \frac{\dot{W}_{\substack{shaft\\net\ in}}}{\rho Q} = \frac{\left(20{,}000\ \frac{N\cdot m}{s}\right)}{(0.68)\left(999\ \frac{kg}{m^3}\right)\left(0.12\ \frac{m^3}{s}\right)} = 245.3\ \frac{N\cdot m}{kg}$$

and

$$\text{loss} = 0.3\frac{V_1^2}{2} = \frac{(0.3)\left(15.28\ \frac{m}{s}\right)^2}{2}\left(\frac{1\ N}{kg\cdot\frac{m}{s^2}}\right) = 35.02\ \frac{N\cdot m}{kg}$$

From Eq. 1 then

$$p_1 - p_2 = (0.68)\left(999\ \frac{kg}{m^3}\right)\left\{\left[\frac{\left(3.82\ \frac{m}{s}\right)^2 - \left(15.28\ \frac{m}{s}\right)^2}{2} + \left(9.81\ \frac{m}{s^2}\right)(3\ m)\right]\left(\frac{1\ N}{kg\cdot\frac{m}{s^2}}\right) - 245.3\ \frac{N\cdot m}{kg} + 35.02\ \frac{N\cdot m}{kg}\right\}$$

or

$$\underline{\underline{p_1 - p_2 = -197{,}000\ \frac{N}{m^2}}} = \underline{\underline{-197\ kPa}}$$