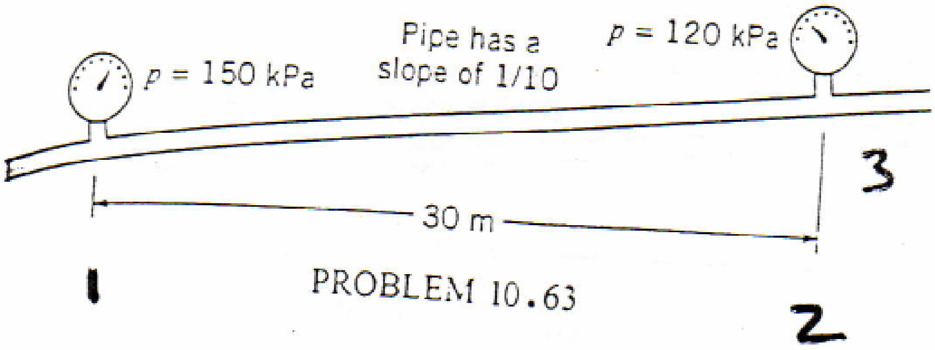
10.63 A fluid with $\nu = 10^{-6}$ m²/s and $\rho = 900$ kg/m³ flows through the 8-cm galvanized-iron pipe. Estimate the flow rate for the conditions shown in the figure.



PROBLEM 10.63

Solution:

$$\frac{\Delta y}{\Delta x} = \frac{1}{10}$$

$$\Delta y = \frac{30}{10} = 3 = \Delta z$$ in energy equation.

$$\frac{p_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{p_2}{\gamma} + \frac{V_2^2}{2g} + z_2 + h_L$$

$$\frac{150,000}{900 \times 9.81} = \frac{120,000}{900 \times 9.81} + 3 + h_L$$

$$h_L = 0.398m$$

$$\text{Re}\, f^{1/2} = \frac{D^{3/2}}{\nu}\left(\frac{2gh_L}{L}\right)^{1/2} \qquad L = \sqrt{30^2 + 3^2} = 30.15$$

$$\text{Re}\, f^{1/2} = \frac{0.08^{3/2}}{10^{-6}}\left(\frac{2 \times 9.8 \times 0.398}{30.15}\right)^{1/2} = 1.15 \times 10^4$$

$$k_s/D = 1.9 \times 10^{-3}$$

$f = 0.026$ from Moody diagram

From $h_L = f\frac{L}{D}\frac{V^2}{2g}$

$$V = \sqrt{\left(\frac{h_L}{f}\right)\left(\frac{D}{L}\right)2g} = 0.895\, m/s$$

$$Q = VA = 4.5\times10^{-3}\, m^3/s$$