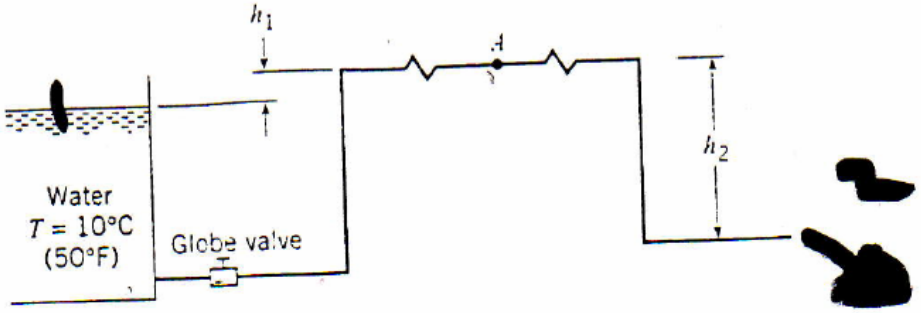
10.81 The 10-cm galvanized-steel pipe is 1000 m long and discharges water into the atmosphere. The pipeline has an open globe valve and four threaded elbows; $h_1 = 3$ m and $h_2 = 15$ m. What is the discharge, and what is the pressure at A, the midpoint of the line?



Solution:

Reservoir to exit ($z = 0$ exit)

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

$$z_1 - z_2 = \frac{V_2^2}{2g}\left(1 + K_e + K_V + 4K_b + f\frac{L}{D}\right)$$

Fully rough. Guess $k_s/D = 0.0005$ and $f = 0.025$

$$12 = \frac{V_2^2}{2g}\left(1 + 0.5 + 10 + 4\times 0.9 + 0.025\times\frac{1000}{0.1}\right)$$

$$V = 0.942\, m/s$$

$$Q = VA = 0.942\times\frac{\pi}{4}\times 0.1^2 = 0.0074\, m^3/s$$

$$\mathrm{Re} = \frac{VD}{\nu} = 7\times 10^4 \Rightarrow f = 0.025\text{, OK}$$

$$\frac{p_A}{\gamma}+\frac{V_A^2}{2g}+z_A=\frac{p_2}{\gamma}+\frac{V_2^2}{2g}+z_2+h_f+\sum h_m$$

$$\frac{p_A}{\gamma}+z_A=\frac{V_2^2}{2g}\left(2K_b+f\frac{L}{D}\right)$$

$$\frac{p_A}{\gamma}+15=\frac{0.942^2}{2\times 9.81}\left(2\times 0.9+0.025\times\frac{500}{0.1}\right)=6.21$$

$$\frac{p_A}{9810}=-8.8$$

$p_A=-86.3kPa$ near cavitation level