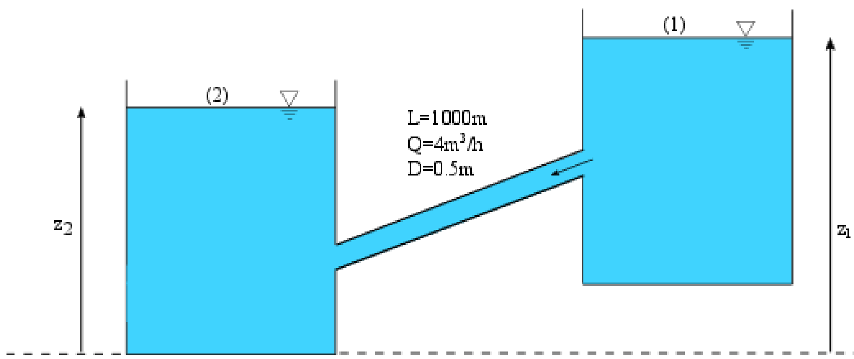
Name :__________________ **Quiz: No. 10** **Time: 15 minutes**

Student ID# : _____________ **Course: ME 5160, Fall 2023**

The exam is closed book and closed notes.

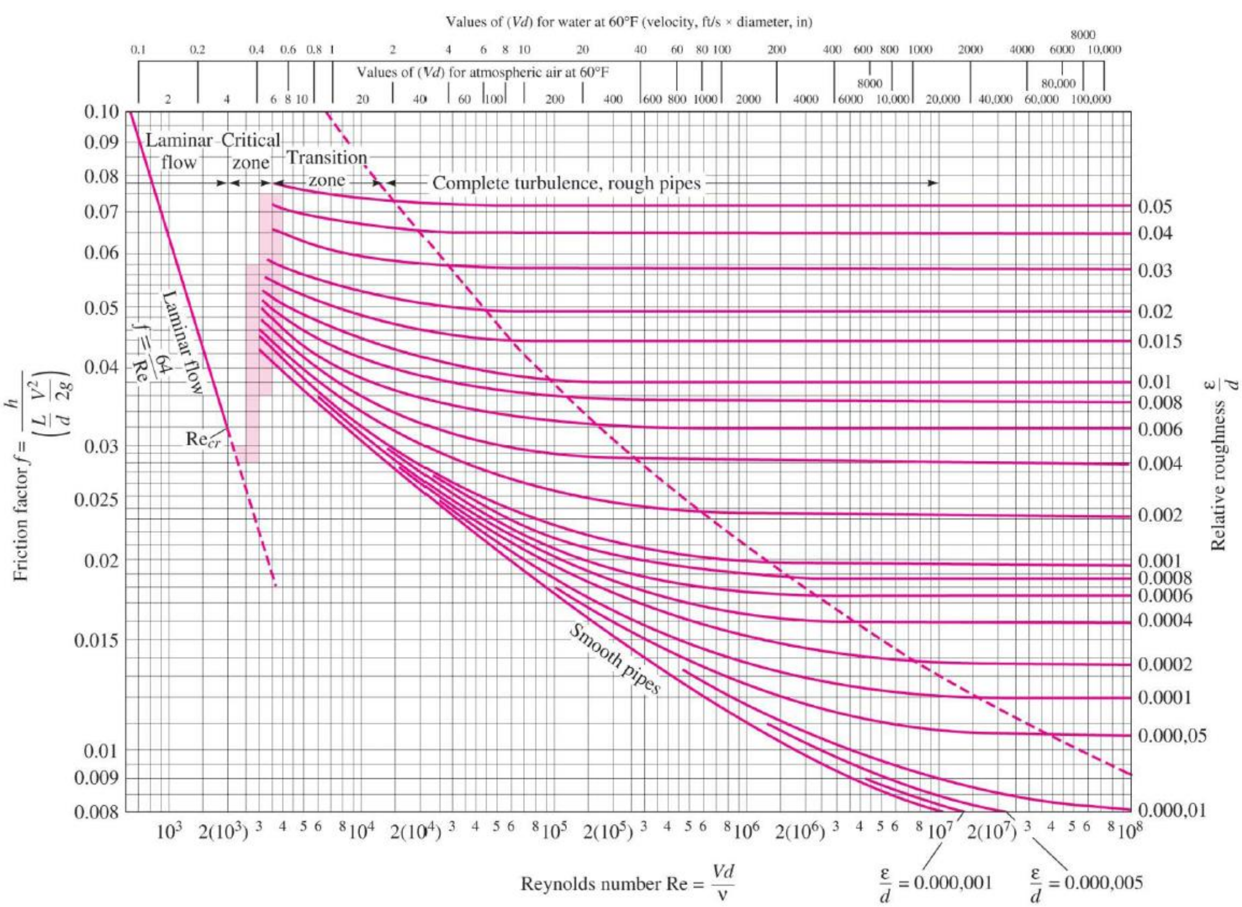
A petrochemical plant transfers water with flowrate $Q = 4m^3/s$ at T=20 °C through a steel pipe section with length L=1000m and diameter $d = 0.5m$. The water density and viscosity are ρ=1000kg/m^3 and μ=0.001kg/ms, respectively. (a) Determine the height difference between Sections 1 and 2 for a smooth pipe neglecting minor losses. (b) Determine the height difference if the pipe has an absolute roughness ε of 0.1 mm and minor losses for the sharp entrance are included ($K = 0.5$).



Energy equation

$$\left(\frac{P}{\rho g}+\frac{V^2}{2g}+z\right)_1=\left(\frac{P}{\rho g}+\frac{V^2}{2g}+z\right)_2+h_f+h_t$$

$$h_f=\frac{V^2}{2g}\left(f\frac{L}{D}+\sum K\right)$$



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Solution

(a)
Calculate Velocity:

$$V = \frac{Q}{A} = \frac{4}{\frac{\pi}{4}(0.5)^2} = 20.38\, m/s \qquad \textbf{(+2)}$$

Calculate Reynolds number:

$$Re_d = \frac{\rho V d}{\mu} = \frac{1000 \times 20.38 \times 0.5}{0.001} = 10{,}190{,}000 \approx 1 \times 10^7 \qquad \textbf{(+1)}$$

Assume smooth pipe and enter Moody diagram: $f_{smooth} = 0.008$ **(+1)**

Write energy equation between Section 1 and 2:

$$\left(\frac{P}{\rho g} + \frac{V^2}{2g} + z\right)_1 = \left(\frac{P}{\rho g} + \frac{V^2}{2g} + z\right)_2 + h_f + h_t$$

$$\Delta z = h_f = \frac{V^2}{2g} f \frac{L}{D} = \frac{20.38^2 \times 0.008 \times 1000}{2 \times 9.81 \times 0.5} = 338.7m \qquad \textbf{(+1)}$$

(b)
Calculate ε/d:

$$\frac{\varepsilon}{d} = \frac{0.1 \times 10^{-3}}{0.5} = 0.0002 \qquad \textbf{(+1)}$$

$$Re_d \approx 1 \times 10^7$$

Enter Moody diagram: $f \approx 0.014$ **(+1)**

Write energy equation between Section 1 and 2:

$$\left(\frac{P}{\rho g} + \frac{V^2}{2g} + z\right)_1 = \left(\frac{P}{\rho g} + \frac{V^2}{2g} + z\right)_2 + h_f + h_t$$

$$\Delta z = h_f = \frac{V^2}{2g}\left(f \frac{L}{D} + K\right) = \frac{20.38^2}{2 \times 9.81}\left(0.014 \frac{1000}{0.5} + 0.5\right) = 603.3m \qquad \textbf{(+1)}$$