

Name : _____

Quiz: No. 10

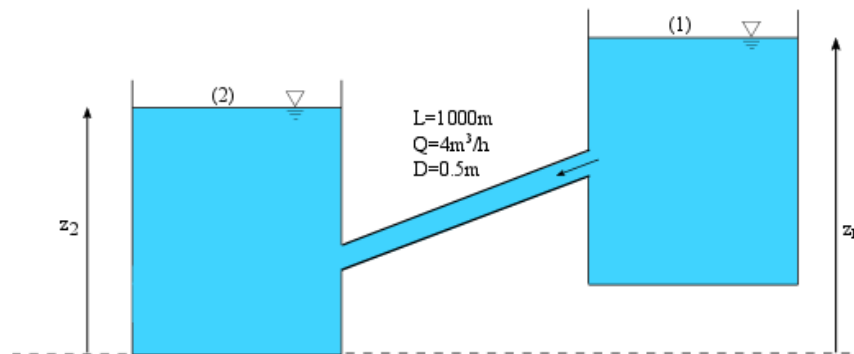
Time: 15 minutes

Student ID# : _____

Course: ME 5160, Fall 2025

The exam is closed book and closed notes.

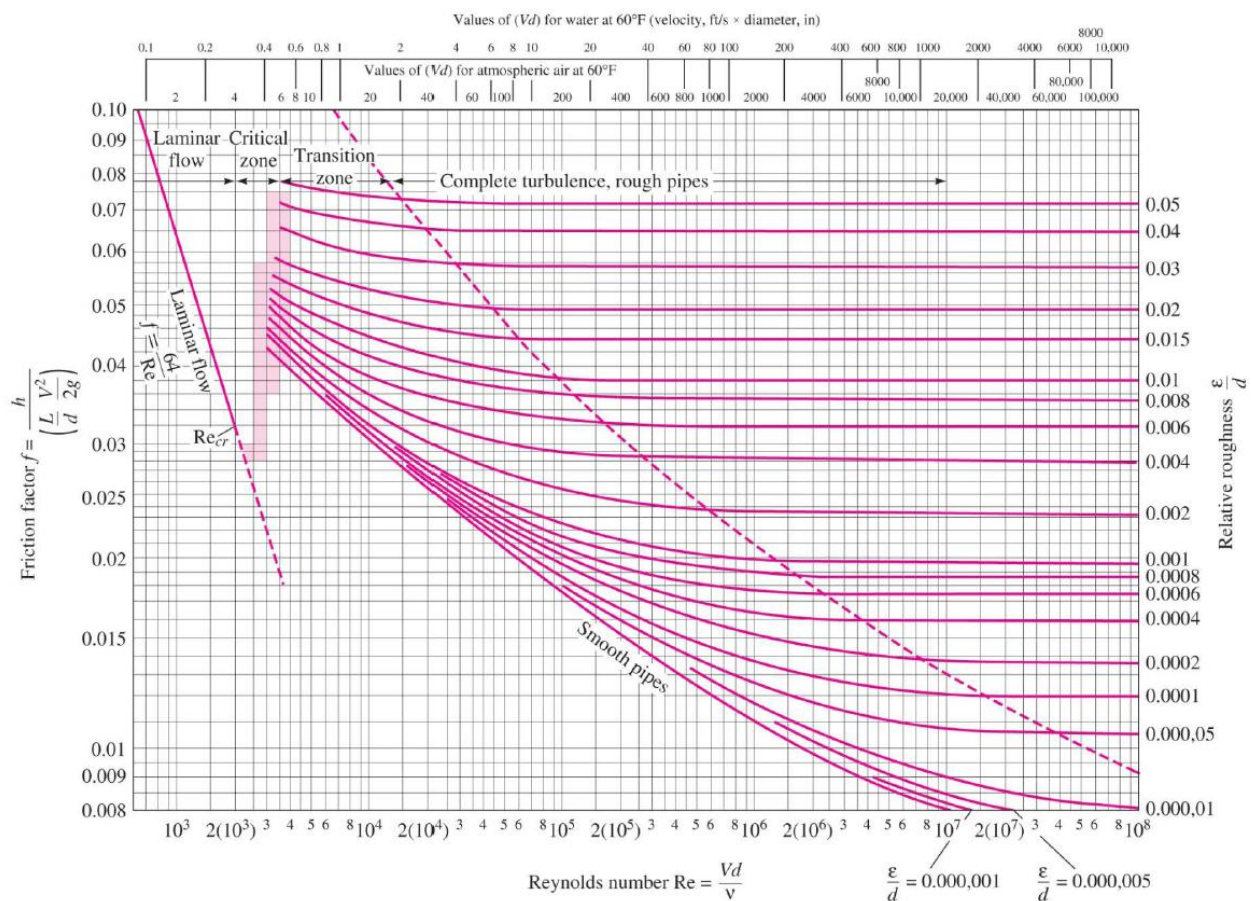
A petrochemical plant transfers water with flowrate $Q = 4\text{ m}^3/\text{s}$ at $T=20^\circ\text{C}$ through a steel pipe section with length $L=1000\text{m}$ and diameter $d = 0.5\text{m}$. The water density and viscosity are $\rho=1000\text{kg/m}^3$ and $\mu=0.001\text{kg/ms}$, respectively. (a) 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:

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

Calculate Reynolds number:

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

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

Write energy equation between Section 1 and 2:

$$\left(\frac{P}{\rho g} + \frac{V^2}{2g} + z \right)_1 = \left(\frac{P}{\rho g} + \frac{V^2}{2g} + z \right)_2 + h_f + h_t$$
$$\Delta z = h_f = \frac{V^2}{2g} f \frac{L}{D} = \frac{20.38^2 \times 0.008 \times 1000}{2 \times 9.81 \times 0.5} = 338.7 \text{ m} \quad (+1)$$

(b)

Calculate ε/d :

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

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

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

Write energy equation between Section 1 and 2:

$$\left(\frac{P}{\rho g} + \frac{V^2}{2g} + z \right)_1 = \left(\frac{P}{\rho g} + \frac{V^2}{2g} + z \right)_2 + h_f + h_t$$
$$\Delta z = h_f = \frac{V^2}{2g} \left(f \frac{L}{D} + K \right) = \frac{20.38^2}{2 \times 9.81} \left(0.014 \frac{1000}{0.5} + 0.5 \right) = 603.3 \text{ m} \quad (+1)$$