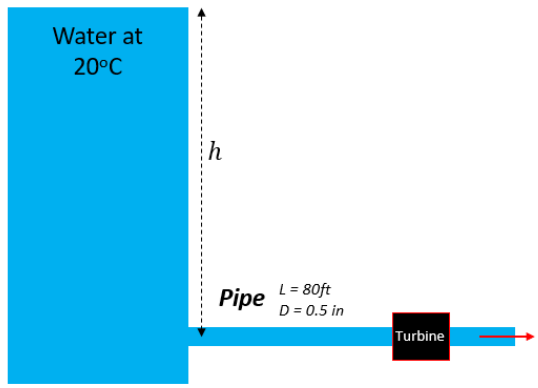
Name :____________________ **Quiz: No. 10** **Time: 15 minutes**

Course: ME 5160, Fall 2024

The exam is closed book and closed notes.

A turbine is powered using water from a reservoir. Water reaches the turbine through an exhaust pipe with a flowrate Q=0.015 ft^3/s. The pipe is 80 ft long, made with commercial-steel, and its diameter is 0.5 in. When active, the turbine is providing h_t= 10 ft. Consider the minor losses at the sharp entrance (K= 0.5) of the pipe and calculate h such that the pipe flow rate is equal to 0.015 ft^3/s.

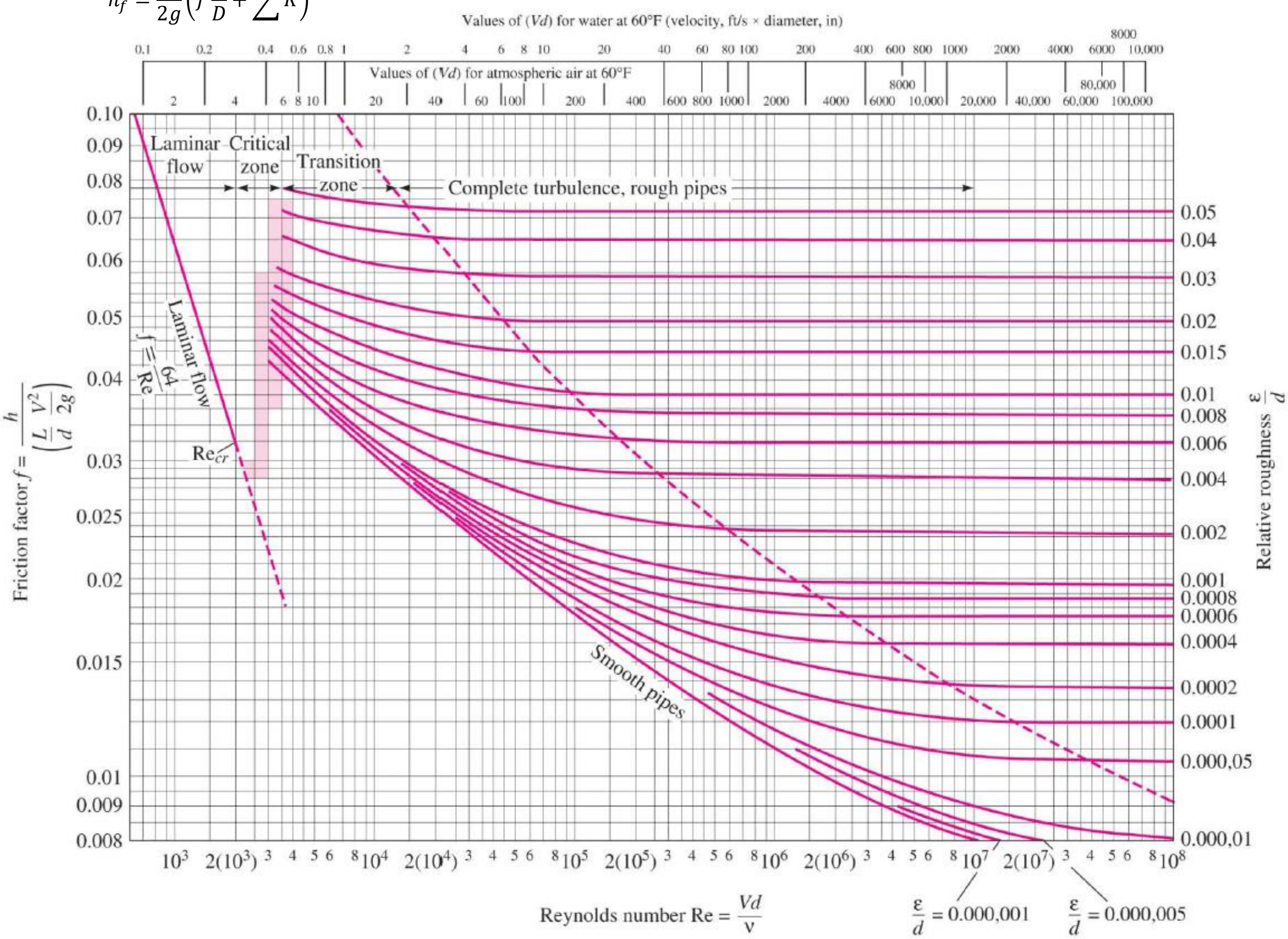
$\rho = 1.94\, slug\,/\,ft^3$
$\mu = 2.09 \times 10^{-5} slug/ft \cdot s$
g(gravity) = 32.2 ft/s^2
Commercial steel $\varepsilon = 0.00015ft$



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

Calculate Velocity:

$$V = \frac{Q}{A} = \frac{0.015}{\frac{\pi}{4}\left(\frac{0.5}{12}\right)^2} = 11\ ft/s$$ **(+2)**

Calculate ε/d:

$$\frac{\varepsilon}{d} = \frac{0.00015}{\frac{0.5}{12}} = 0.0036$$ **(+1)**

Calculate Reynolds number:

$$Re_d = \frac{\rho V d}{\mu} = \frac{1.94 \times 11 \times \frac{0.5}{12}}{2.09 \times 10^{-5}} \approx 42543$$

$$\frac{\varepsilon}{d} = 0.0036$$
$$Re_d = 42543$$
$$\therefore f_{Moody} \approx 0.0301$$ **(+3)**

Energy equation:

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

$$z_1 - z_2 = \frac{V^2}{2g} + \frac{V^2}{2g}\left(f\frac{L}{D} + K\right) + h_t = \frac{V^2}{2g}\left(1 + f\frac{L}{D} + K\right) + h_t$$ **(+2)**

$$\therefore h = z_1 - z_2 = \frac{11^2}{2 \times 32.2}\left(1 + 0.0301\frac{80}{\frac{0.5}{12}} + 0.5\right) + 10 = 121.4ft$$ **(+2)**