**Exercise - 1**

**Q1.** Oil flows through a cast iron pipe at a velocity of 1.0 m/s. The pipe is 45m long and has a diameter of 150mm. Find the head loss due to friction. ($\mu_{\text{oil}} = 0.0814 \, \text{Pa.s}$; $\rho_{\text{oil}} = 869 \, \text{kg/m}^3$)

\[
hL = f \frac{L}{D} \left( \frac{V^2}{2g} \right)
\]

\[
Re = \frac{\rho DV}{\mu} = \frac{869 \times 0.15 \times 1}{0.0814} = 1601
\]

Since $Re < 2000$, the flow is laminar and $f = 64/Re$

\[
f = \frac{64}{Re} = \frac{64}{1601} = 0.04
\]

\[
hL = 0.04 \times \left( \frac{45}{0.15} \right) \times \left( \frac{1^2}{19.62} \right) = 0.611 \, \text{m}
\]
Gasoline is being discharged from a pipe, as shown in figure. The pipe roughness (ε) is 0.500 mm, and the pressure at point 1 is 2500 kPa. Find the pipe diameter needed to discharge gasoline at a rate of 0.10 m³/s. Neglect any minor losses. (SG_{gasoline} = 719 \text{ kg/m}^3, \mu_{gasoline} = 2.92 \times 10^{-4})
Exercise - 2

\[ \frac{P_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + z_2 + h_L \]

Bernoulli Eq.

\[ h_L = f \frac{L V^2}{D 2g} \]

Darcy-Weisbach Head Loss Eq.

\[ h_L = f \frac{965.5}{D} \frac{V^2}{(2 \times 9.81)} = 49.2 f \frac{V_2^2}{D} \]

\[ \frac{2500}{7060} + \frac{V_1^2}{19.62} + 82.65 = 0 + \frac{V_2^2}{19.62} + 66.66 + 49.2 f \frac{V_2^2}{D} \]

\[ Q = V \cdot A \]

\[ Q = V_1 \cdot A_1 = V_2 \cdot A_2 \rightarrow A_1 = A_2 \Rightarrow V_1 = V_2 \]

\[ f \frac{V_2^2}{D} = 0.332 \]
Exercise - 2

\[ f \frac{V_2^2}{D} = 0.332 \]

\[ V_2 = \frac{Q}{A_2} = \frac{0.1}{\pi\left(D^2/4\right)} = 0.1273/D^2 \]

\[ f \frac{(0.1273/D^2)^2}{D} = 0.332 \]

\[ D = (0.04881f)^{1/5} \]

Assume \( f = 0.02 \)

\[ f = 0.02 \rightarrow D = (0.04881 \times 0.02)^{1/5} \cong 0.25 \text{ m} \]

\[ V_2 = 0.1273/0.25^2 = 2.037 \text{ m/s} \]

\[ \text{Re} = \frac{\rho DV}{\mu} = \frac{719 \times 0.25 \times 2.037}{\left(2.92 \times 10^{-4}\right)} = 1.25 \times 10^6 \]
Exercise - 2

\[ \varepsilon = 0.0005 \text{m} \]
\[ \varepsilon / D = 0.0005 / 0.25 = 0.002 \]

From Moody Diagram

\[ f = 0.0235 \]

\[ f = 0.0235 \rightarrow D = (0.04881 \times 0.0235)^{1/5} \approx 0.2582 \text{m} \]

\[ V_2 = 0.1273 / 0.2582^2 = 1.91 \text{m/s} \]

\[ \text{Re} = 1.62 \times 10^6 \rightarrow \varepsilon / D = 0.0019 \rightarrow f \approx 0.0235 \]

OK!