

Water flows through a pipe where the diameter is 1 m and the length of 10 m. The flow rate is $7 \text{ m}^3/\text{s}$. Determine the change in pressure across the pipe.

Example 1

$$Q = 7 \text{ m}^3/\text{s} \quad D = 1 \text{ m} \quad L = 10 \text{ m} \quad \Delta P = ? \quad \rho = 997 \text{ kg/m}^3$$

$$U = \frac{4Q}{\pi D^2} = \frac{4(7 \text{ m}^3/\text{s})}{\pi (1 \text{ m})^2} = 8.91 \text{ m/s} \quad \mu = 1 \times 10^{-3} \text{ kg/m}\cdot\text{s}$$

$$Re = \frac{\rho U D}{\mu} = \frac{(997 \text{ kg/m}^3)(8.91 \text{ m/s})(1 \text{ m})}{1 \times 10^{-3} \text{ kg/m}\cdot\text{s}} = 8.89 \times 10^6 \quad \rightarrow \text{turbulent}$$

$$f = [3.6 \log(\frac{Re}{6.9})]^{-2} = [3.6 \log(\frac{8.89 \times 10^6}{6.9})]^{-2} = .0021$$

$$\Delta P = -\frac{2\rho U^2 L f}{D} = -\frac{2(997 \text{ kg/m}^3)(8.91 \text{ m/s})^2(10 \text{ m})(.0021)}{1 \text{ m}} = -3324.3 \text{ Pa}$$

pressure drop of $3324.3 \text{ Pa} = \Delta P$

Calculate the drag force of a particle ($D = .5 \text{ m}$) moving through water at 2 m/s .

Example 2

$$D = .5 \text{ m} \quad U = 2 \text{ m/s} \quad \mu = 1 \times 10^{-3} \text{ kg/m}\cdot\text{s} \quad \rho = 997 \text{ kg/m}^3$$

$$Re = \frac{\rho U D}{\mu} = \frac{(997 \text{ kg/m}^3)(2 \text{ m/s})(.5 \text{ m})}{1 \times 10^{-3} \text{ kg/m}\cdot\text{s}} = 997 \quad \rightarrow \text{laminar}$$

from equation sheet $C_D = .445$

$$F_D = \frac{1}{2} \rho U^2 A C_D \quad A = \pi D^2 / 4 = \pi (.5 \text{ m})^2 / 4 = .196 \text{ m}^2$$

$$= \frac{1}{2} (997 \text{ kg/m}^3)(2 \text{ m/s})^2 (.196 \text{ m}^2)(.445) = 174.2 \text{ N}$$

$$F_D = 174.2 \text{ N}$$