

84.

Problem 18.39 (RHK)

Liquid mercury (viscosity, $\eta = 1.55 \times 10^{-3} \text{ N s m}^{-2}$) flows through a horizontal pipe of internal radius 1.88 cm and length 1.26 m. The volume flux is $5.35 \times 10^{-2} \text{ L min}^{-1}$. We have to show (a) that the flow is laminar; (b) calculate the pressure between the two ends of the pipe.



Solution:

(a)

In order to find whether the flow is laminar we will calculate the Reynolds number

$$R = \frac{\rho D v}{\eta}.$$

Internal radius of the pipe is 1.88 cm and the volume flux is

$$\begin{aligned} 5.35 \times 10^{-2} \text{ L min}^{-1} &= \frac{5.35 \times 10^{-2} \times 10^{-3}}{60} \text{ m}^3 \text{ s}^{-1} \\ &= 8.92 \times 10^{-7} \text{ m}^3 \text{ s}^{-1}. \end{aligned}$$

Speed of flow of mercury in the pipe

$$v = \frac{8.92 \times 10^{-7}}{\pi \times (1.88 \times 10^{-2})^2} \text{ m s}^{-1} = 8.03 \times 10^{-4} \text{ m s}^{-1}.$$

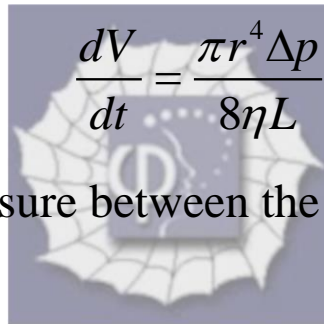
Reynolds number for this speed of flow is

$$R = \frac{13.6 \times 10^3 \times 3.76 \times 10^{-2} \times 8.03 \times 10^{-4}}{1.55 \times 10^{-3}} = 264.9.$$

As this is less than 2000, flow is laminar.

(b)

Volume flux through a pipe of length L and radius r is



$$\frac{dV}{dt} = \frac{\pi r^4 \Delta p}{8 \eta L}.$$

Difference in pressure between the two ends of the pipe is

$$\begin{aligned} \Delta p &= \frac{8 \eta L}{\pi r^4} \frac{dV}{dt} = \frac{8 \times 1.55 \times 10^{-3} \times 1.26 \times 8.92 \times 10^{-7}}{\pi (1.88 \times 10^{-2})^4} \\ &= 35.5 \text{ mPa.} \end{aligned}$$