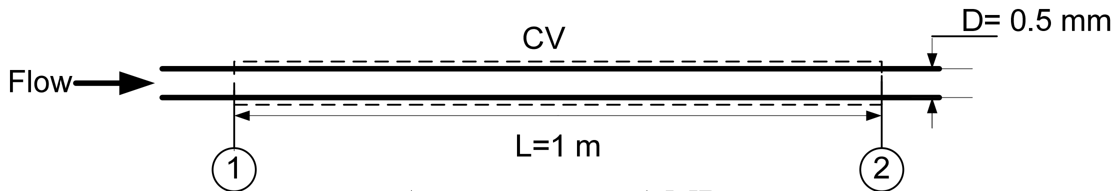
ENSC 283 Week # 11, Tutorial # 7 – Capillary Viscometer

Problem: A simple and accurate viscometer can be made from a length of capillary tubing. If the flow rate and pressure drop are measured, and the tube geometry is known, the viscosity of a Newtonian liquid can be computed from $Q = \pi \Delta p D^4/(128\, \mu L)$. A test of a certain liquid in a capillary viscometer gave the following data:

Flow rate: 880 mm^3/s	Tube length: 1 m
Tube diameter: 0.5 mm	Pressure drop: 1 MPa

Determine the viscosity of the liquid.



$$\Delta p = p_1 - p_2 = 1\, MPa$$

Solution

Step 1: Write out what you are required to solve for (this is so you don't forget to answer everything the question is asking for)

Find:

– μ, the viscosity of the liquid

Step 2: State your assumptions (you may have to add to your list of assumptions as you proceed in the problem)

Assumptions:

1) Laminar flow
2) Steady state
3) Incompressible flow
4) Fully developed flow
5) Horizontal tube

Step 3: Calculations

Using the given equation, the viscosity can be found.

$$\mu = \frac{\pi \Delta p D^4}{128\, LQ} = \frac{\pi \left(10^6 \frac{N}{m^2}\right)(0.5\, mm)^4}{128(1\, m)(880\, mm^3/s)} \left(\frac{1\, m}{10^3 mm}\right) \quad \text{(Eq1)}$$
$$= \mathbf{1.74 \times 10^{-3}\ N \cdot s/m^2}$$

Check the Reynolds number. Assume the fluid density is similar to that of water, $999 kg/m^3$. Then

$$\bar{V} = \frac{Q}{A} = \frac{4Q}{\pi D^2} = \frac{4\,(880\, mm^3/s)}{\pi\,(0.5\, mm)^2} \left(\frac{1\, m}{10^3 mm}\right) = 4.48\, m/s \quad \text{(Eq2)}$$

and

$$Re = \frac{\rho \bar{V} D}{\mu} = \frac{(999 kg/m^3)(4.48\, m/s)(0.5\, mm)}{1.74 \times 10^{-3}\ N \cdot s/m^2} \left(\frac{1\, m}{10^3 mm}\right)\left(\frac{N \cdot s}{kg \cdot m}\right) \quad \text{(Eq3)}$$
$$= \mathbf{1290}$$

Consequently, since $Re < 2300$, the flow is laminar.