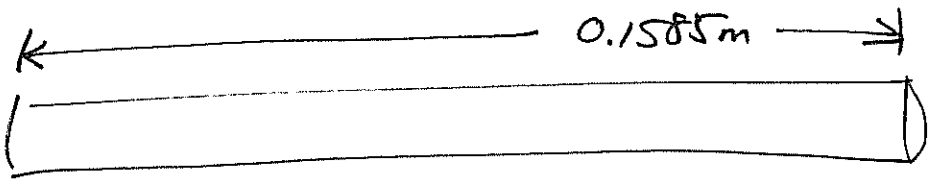
Geankoplis 3rd edition 2.10-1. Viscosity may be determined for a liquid by subjecting it to Poiseuille flow in a tube. In a horizontal tube of length 0.1585m and of diameter 2.222mm a fluid is made to flow under a pressure drop of 131 mm water. The flow rate under these conditions at steady state is 5.33 X 10^{-7} m^3/s. The density of the fluid is 912 kg/m^3 and the density of water is 996 kg/m^3. Calculate the viscosity of the fluid; give your answer in Pa s.



$D = 2.222 mm$

$\Delta P = 131 mm H_2O$

$Q = 5.33 \times 10^{-7} m^3/s$

$\rho_f = 912 kg/m^3$

$\rho_{H_2O} = 996 kg/m^3$

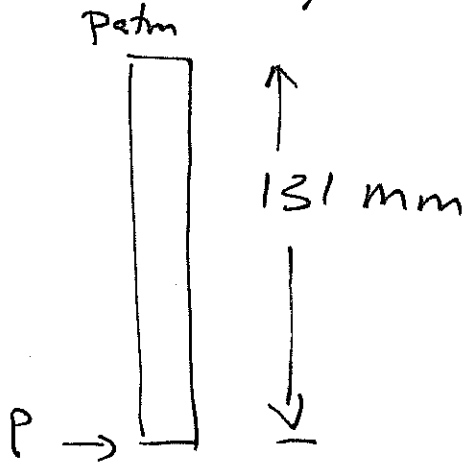
$$Re = \frac{\rho \langle v \rangle D}{\mu}$$ ← if LAMINAR $Re < 2100$ + we can use Hagen–Poiseuille eqn

$$\Delta P = \frac{32 \mu \langle v \rangle L}{D^2}$$

$$\mu = \frac{\Delta P D^2}{32 \langle v \rangle L}$$

Convert pressure:

131 mm H_2O = what pressure?



$$P = P_{atm} + \rho g h$$

$$P - P_{atm} = P_{gauge} = \rho g h$$

$$= 996 \frac{kg}{m^3} \; 9.806 \frac{m}{s^2} \; 0.131 m$$

$$= 1279.526 \frac{\cancel{kg}}{\cancel{m} s^2} \frac{\cancel{N} s^2}{\cancel{kg} \cancel{m}} \frac{Pa}{\cancel{N}/\cancel{m^2}}$$

$$\boxed{P = 1279.526 \; Pa}$$

gauge pressure

$$\mu = \frac{\left(1279.526 \frac{kg}{m s^2}\right)\left(2.222\times10^{-3} m\right)^2 \; Pa\, s^2 m^2 / kg\, m}{32\left(\frac{5.33\times10^{-7} m^3/s}{\pi\left(1.111\times10^{-3} m\right)^2}\right) 0.1585\, m}$$

$$\boxed{\mu = 9.0617\times10^{-3}\ Pa\, s}$$

Check Re:

$$Re = \frac{\left(912 \frac{kg}{m^3}\right)\left(\frac{5.33\times10^{-7} \frac{m^3}{s}}{\pi\left(1.111\times10^{-3} m\right)^2}\right)\left(2.222\times10^{-3} m\right)}{9.0617\times10^{-3} \frac{kg}{m\, s}}$$

$$\boxed{Re = 30.7}$$ OK!

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