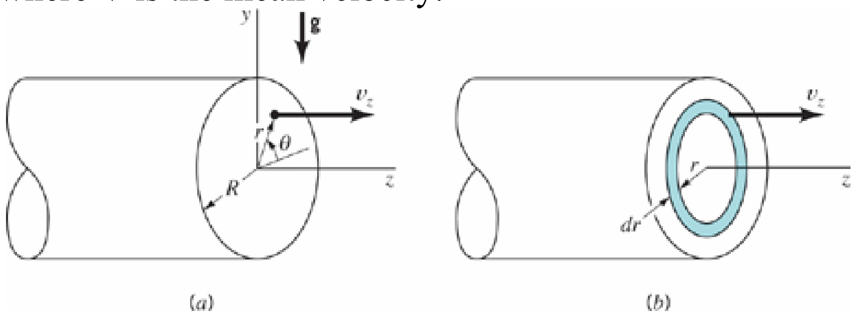
057:20 **Quiz # 07** **10/27/2006**

It is known that the velocity distribution for steady, laminar flow in circular tubes is parabolic. The flow remains laminar for Reynolds numbers, $Re = \rho V(2R)/\mu$, below 2100, where V is the mean velocity.



Consider a 10-mm-diameter horizontal tube through which ethyl alcohol is flowing with a steady mean velocity 0.15 m/s as is shown in the above figure. The velocity distribution is

$$v_z = \frac{1}{4\mu}\left(\frac{\partial p}{\partial z}\right)\left(r^2 - R^2\right)$$

and the mean velocity is

$$V = \frac{R^2}{8\mu}\left(-\frac{\partial p}{\partial z}\right) = \frac{R^2}{8\mu}\left(\frac{\Delta p}{l}\right)$$

(a) Would you expect the velocity distribution to be parabolic in this case? Explain.

(b) What is the pressure drop per unit length ($\frac{\Delta p}{l}$)along the tube?

(c) The maximum velocity occurs at the center of the tube. Determine the maximum velocity.

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(a) Check Reynolds number to determine if flow is laminar:

$$Re = \frac{\rho V (2R)}{\mu} = \frac{(789 \frac{kg}{m^3})(0.15 \frac{m}{s})(0.010 m)}{1.19 \times 10^{-3} \frac{N \cdot s}{m^2}} = 995 < 2100$$

Thus, The flow is laminar and velocity distribution would be parabolic. Yes.

(b) Since the flow is laminar

$$V = \frac{R^2}{8\mu} \frac{\Delta p}{\ell} \qquad (Eq.\ 6.152)$$

so that

$$\frac{\Delta p}{\ell} = \frac{8\mu V}{R^2} = \frac{8 (1.19 \times 10^{-3} \frac{N \cdot s}{m^2})(0.15 \frac{m}{s})}{(\frac{0.010 m}{2})^2}$$

$$= 57.1 \frac{N}{m^2} \text{ per } m$$

(C) $v_z = \frac{1}{4\mu}\left(\frac{\partial p}{\partial z}\right)\left(r^2 - R^2\right)$

When r = 0

$$v_{z\max} = \frac{R^2}{4\mu}\left(-\frac{\partial p}{\partial z}\right) = \frac{R^2}{4\mu}\left(\frac{\Delta p}{l}\right) = 0.30\, m/s$$