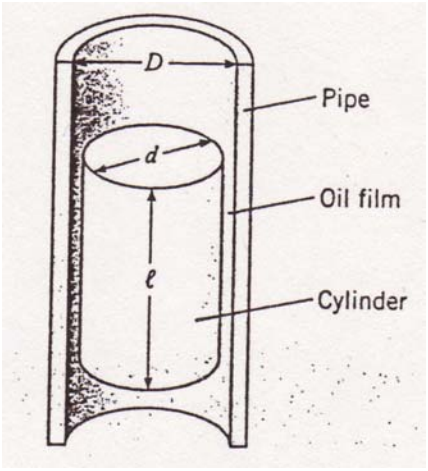
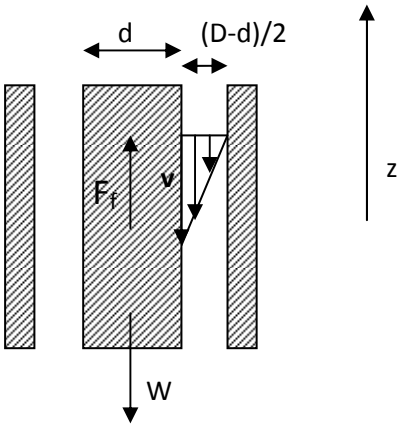
ID:----------	**Quiz: Chapter 1**	**Time: 15 minutes**
Name: ----------	**Course: 58:160, Fall 2009**	

A solid circular cylinder of diameter *d* and length *l* slides inside a vertical smooth pipe that has an inside diameter *D*. The small space between cylinder and the pipe is lubricated with an oil film has a viscosity μ. Derive formula for the rate of descent of the cylinder (cylinder velocity) in the vertical pipe. Assume that the cylinder has a weight W and is concentric with the pipe as it falls. Use the formula to find the rate of descent of a cylinder 100 mm in diameter that slides inside a 100.5 mm pipe. The cylinder is 200 mm long and weighs 20 N. The lubricant is SAE 30W oil at 20C (ρ=891 kg/m^3; μ=0.29 kg/m.s).



Solutions:

(a)



$$\sum F_z = 0$$
$$F_f - W = 0 \quad \textit{(2 point)}$$

$$F_f = \tau \times A = \mu \frac{du}{dy} \times \pi dl = \mu \frac{\Delta u}{\Delta y} \times \pi dl = \mu \frac{V-0}{(D-d)/2} \times \pi dl = \frac{2\mu\pi dlV}{D-d} \quad \textit{(6 point)}$$

$$F_f - W = 0 \Rightarrow \frac{2\mu\pi dVl}{D-d} - W = 0 \Rightarrow V = \frac{(D-d)W}{2\mu\pi dl} \quad \textit{(1 point)}$$

For l=200 mm, D=100.5 mm, d=100mm, W=20 N, and SAE 30 W oil (μ=0.29 kg/m.s):

$$V = \frac{(D-d)W}{2\mu\pi dl} = \frac{(0.1005-0.1)20}{2\times 0.29\times \pi \times 0.1\times 0.2} = 0.2744\ m/s \quad \textit{(1 point)}$$