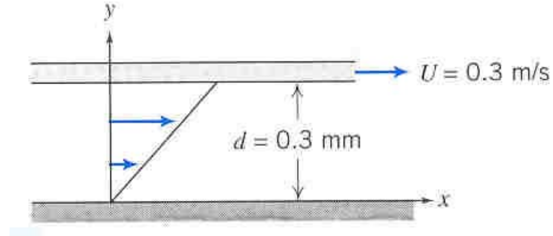
HW #2 (Spring 2007) MAE 2314

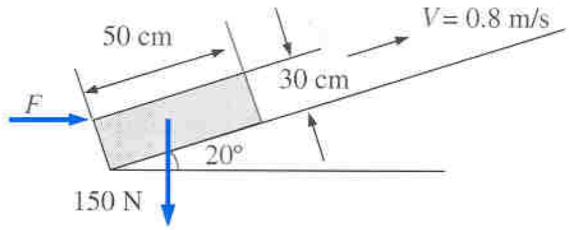
#1.

An infinite plate is moved over a second plate on a layer of liquid. For small gap width, *d*, we assume a linear velocity distribution in the liquid. The liquid viscosity μ is 1.36×10^{-5} lbf·s/ft^2 and its specific gravity is 0.88. Determine *(a)* Kinematic viscosity ν in SI units. *(b)* Shear stress on the upper plate in lbf/ft^2 . *(c)* Shear stress on the lower plate in Pa. *(d)* The direction of each shear stress calculated in parts *(b)* and *(c)*.

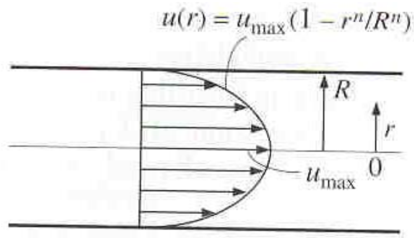


#2.

A 50-cm × 30-cm × 20-cm block weighing 150N is to be moved at a constant velocity of 0.8 m/s on an inclined surface with a friction coefficient of 0.27. *(a)* Determine the force F that needs to be applied in horizontal direction. *(b)* If a 0.4-mm-thick oil film with a dynamic viscosity of 0.012 Pa·s is applied between the block and the inclined surface, determine the percent reduction in the required force.

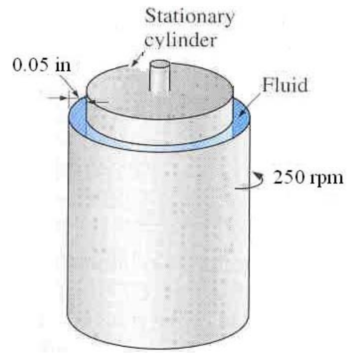


#3.
Consider the flow of a fluid with viscosity μ through a circular pipe. The velocity profile in the pipe is given as $u(r) = u_{max}(1 - r^n/R^n)$, where u_{max} is the maximum flow velocity, which occurs at the centerline; r is the radial distance from the centerline; and $u(r)$ is the flow velocity at the position r. Develop a relation for the drag force exerted on the pipe wall by the fluid in the flow direction per unit length of the pipe.



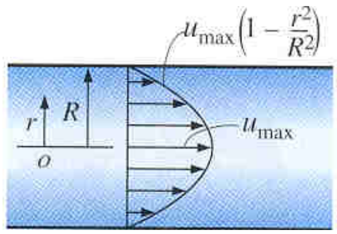
#4.

The viscosity of a fluid is to be measured by a viscometer constructed of two 3-ft-long concentric cylinders. The inner diameter of the outer cylinder is 6 in, and the gap between the two cylinders is 0.05 in. The outer cylinder is rotated at 250 rpm, and the torque is measured to be 1.2 lbf·ft. Determine the viscosity of the fluid.



#5.

In regions far from the entrance, fluid flow through a circular pipe is one-dimensional, and the velocity profile for the laminar flow is given by $u(r) = u_{max}(1 - r^2/R^2)$, where R is the radius of the pipe, r is the radial distance from the center of the pipe, and u_{max} is the maximum flow velocity, which occurs at the center. Obtain *(a)* a relation for the drag force applied by the fluid on a section of the pipe of length L and *(b)* The value of the drag force for water flow with R = 0.08 m, L = 15 m, u_{max} = 5 m/s and μ = 0.0010 kg/m·s.



#6.

The velocity distribution for the laminar flow between parallel plates is given by

$$\frac{u}{u_{\max}} = 1 - \left(\frac{2y}{h}\right)^2$$

Where h is the distance separating the plates and the origin is placed midway between the plates. Consider the flow of water with u_{max} = 0.10 m/s and h = 0.25 mm. Calculate the shear stress on the upper plate and give its direction. (μ of water is 1.14×10^{-3} N·s/m^2)

#7.

The velocity distribution for the laminar flow between parallel plates is given by

$$\frac{u}{u_{\max}} = 1 - \left(\frac{2y}{h}\right)^2$$

Where *h* is the distance separating the plates and the origin is placed midway between the plates. Consider the flow of water with the maximum speed of 0.05 m/s and $h = 1$ mm. Calculate the force on a 1 m^2 section of the lower plate and give its direction.

#8.

Crude oil, with specific gravity SG = 0.85 and the viscosity $\mu = 2.15 \times 10^{-3}$ lbf·s/ft^2, flows steadily down a surface inclined $\theta = 30°$ below the horizontal in a film of thickness $h = 0.125$ in. The velocity profile is given by

$$u = \frac{\rho g}{\mu}\left(hy - \frac{y^2}{2}\right)\sin\theta$$

(Coordinate x is along the surface and y is normal to the surface.) Plot the velocity profile. Determine the magnitude and direction of the shear stress τ that acts on the surface.