October 14, 2015

1. A piston is moving through a cylinder at a speed of 19 ft/s, as shown in Fig. 1 (left). The film of oil separating the piston from the cylinder has a viscosity of 0.020 lb·s/ft^2. What is (a) the shear stress τ at the piston surface and (b) the force F_f required to maintain this motion? Assume a cylindrically symmetric, linear velocity profile for the flow of oil in the film as shown in Fig. 1 (right). (Note: 1 ft = 12 in)

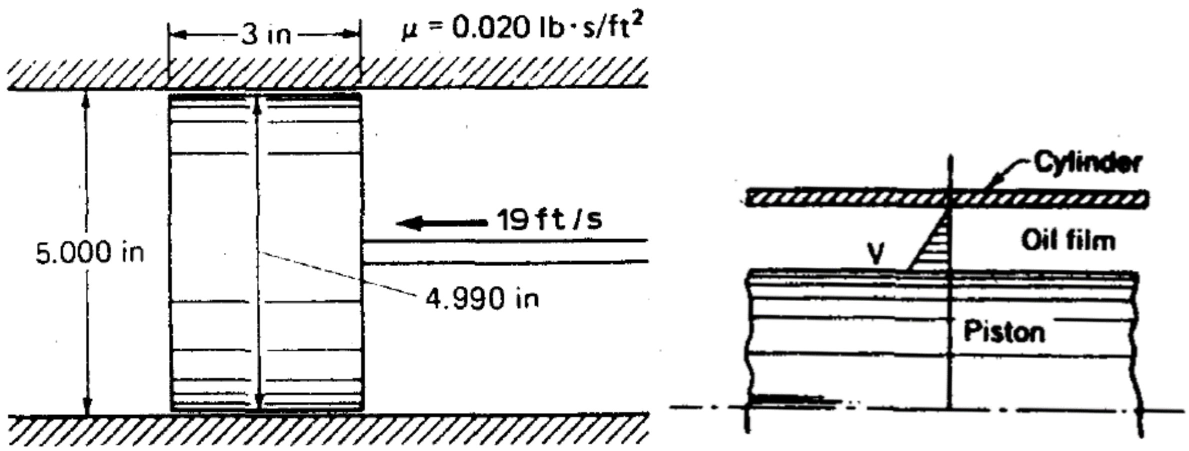

Figure 1

2. The gate shown in Fig. 2 is hinged at *H*. The gate is 3-m wide normal to the plane of the diagram. Calculate (a) the hydrostatic force against the gate, F_R, (b) pressure center, y_R, and (c) the force *F* required at *A* to hold the gate closed. (γ = 9.8 kN/m^3 for water)

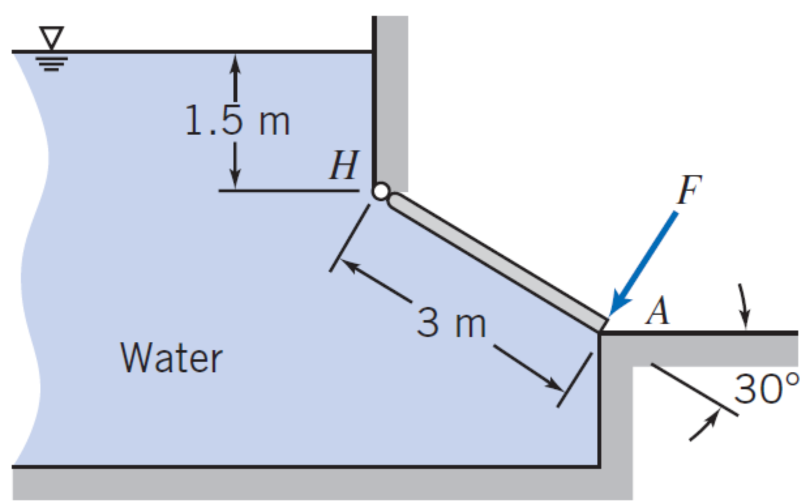

Figure 2

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3. For the Venturi meter shown in Fig. 3, the deflection of mercury in the differential gage is 14.3 in. Determine the (a) pressure drop $\Delta p = p_A - p_B$ between *A* and *B* and (b) flow rate Q of water through the meter. Assume no energy loss between *A* and *B*. (Note: 1 ft = 12 in, γ = 64.2 lb/ft^3 for water, SG = 13.6 for mercury, and g = 32.2 ft/s^2)

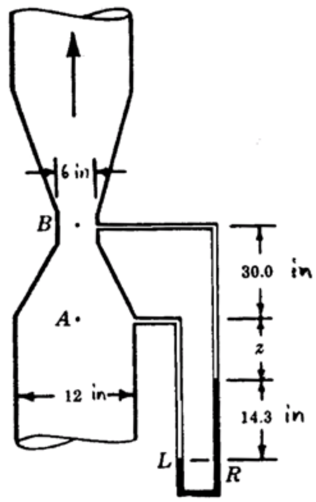

Figure 3

4. The two-dimensional velocity components $u = Kx$ and $v = -Ky$ are used to represent the flow against an infinite plane boundary as illustrated in Fig. 4. The constant *K* has the unit of 1/s, and x and y are in meters. If *K* = 2, find the (a) acceleration components a_x and a_y and (b) pressure gradient $\partial p/\partial y$, at $x = 0$, $y = 1$. For part (b), use the following Navier-Stokes equation,

$$\rho a_y = -\frac{\partial p}{\partial y} + \mu\left(\frac{\partial^2 v}{\partial x^2} + \frac{\partial^2 v}{\partial y^2}\right)$$

where, ρ = 998 Kg/m^3 and $\mu = 1.003 \times 10^{-3}$ N·s/m^2.

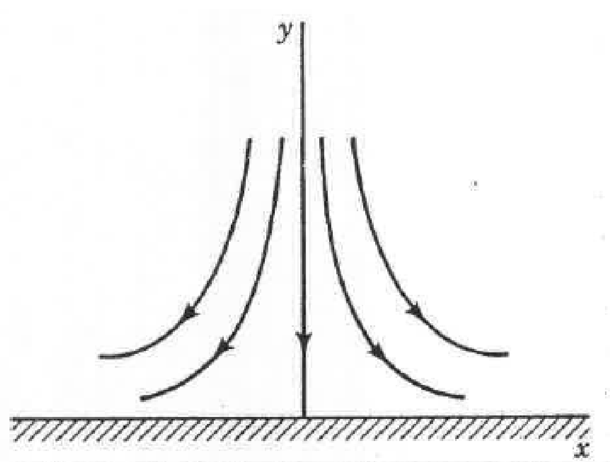

Figure 4