November 16, 2015

1. Water flows steadily through the nozzle shown in Fig. 1, discharging to atmosphere. Calculate (a) the jet velocity V_2 at the nozzle end, (b) the pressure p_1 at the flanged joint, and (c) the horizontal component of the anchoring force F_x to keep the nozzle in place. The elevation difference is 12 in. and no loss between the flanged joint and the nozzle end (i.e., between sections 1 and 2). Use ρ = 1.94 slugs/ft^3 and γ = 62.4 lb/ft^3 for water and g = 32.2 ft/s^2.

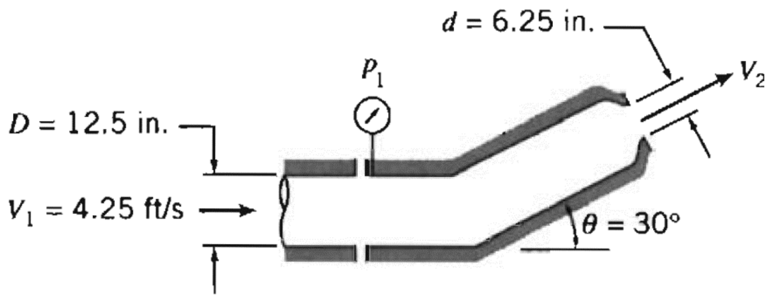

Figure 1

2. A capillary tube of inside diameter d = 6 mm connects tank A and open container B as shown in Fig. 2. The liquid in A, B, and capillary CD is water having a specific weight γ = 9,780 N/m^3 and a viscosity of μ = 0.0008 N·s/m^2. The pressure p_A = 34.5 kPa gage. Neglecting the minor losses at C and D, determine the flow rate Q through the capillary tube. Assume laminar flow from A to B and use $h_f = 32\mu LV/\gamma d^2$ for the friction loss, where V is the water velocity through the capillary tube.

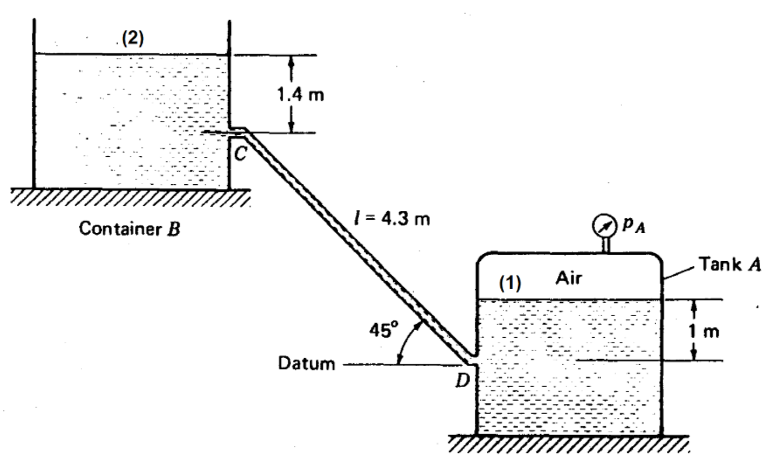

Figure 2

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3. A viscous liquid flows down an inclined plane surface in a steady, fully developed laminar film of thickness *h* and width *b* (out of the paper) as shown in Fig. 3. A useful approximation of the flow is

$$\mu \frac{d^2u}{dy^2} = -\rho g_x$$

where, g_x = g·sinθ is the *x*-component of the gravity acceleration. (a) Derive an expression for the velocity distribution $u(y)$ by integrating the given equation then applying the free-shear (i.e., du/dy = 0) boundary condition at the top and the no-slip boundary condition at the bottom. (b) If the liquid is SAE 30 oil at 15.6°C (ρ = 912 kg/m^3 and μ = 0.38 N·s/m^2) and *h* = 1 mm, *b* = 1 m, and θ = 15°, find the volume flow rate, $Q = \int_0^h u(y)bdy$.

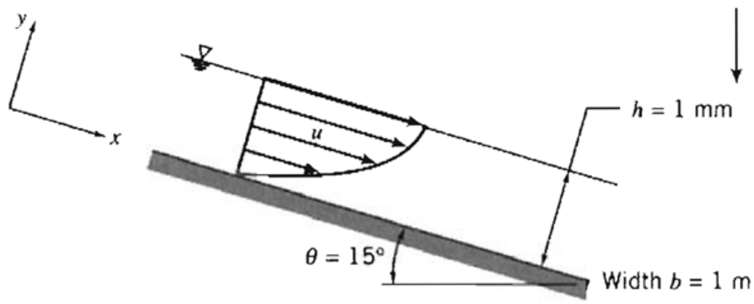

Figure 3

4. In some speed ranges, vortices are shed from the rear of bluff cylinders placed across a flow. The vortices alternately leave the top and bottom of the cylinder, as shown in Fig. 4. The vortex shedding frequency, *f*, is thought to dependent on fluid density, ρ, and viscosity, μ, cylinder diameter, *d*, and free-stream velocity, *V*. (a) Use dimensional analysis to develop a functional relationship for *f*. (b) Vortex shedding occurs in standard air on two cylinders with diameters d_m and d_p, respectively. If the diameter ratio is d_p/d_m = 2, determine the velocity ratio, V_p/V_m, for dynamic similarity, and the ratio of vortex shedding frequencies, f_p/f_m. For part (a), use the *MLT* unit system.

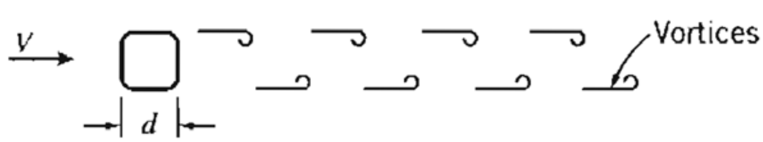

Figure 4