November 19, 2014

1. Kerosene at 20°C (γ = 50.2 lbf/ft^3) flows through the pump in Fig. 2 at 2.3 ft^3/s. The total head loss between sections 1 and 2 is h_L = 8 ft and the mercury manometer reading is h = 4 ft. Find (a) the velocities V_1 and V_2, (b) the pressure rise $\Delta p = p_2 - p_1$ across the pump and (c) the power $\dot{W}_p$ delivered by the pump. (Note: 1 hp = 550 ft·lbf/s)

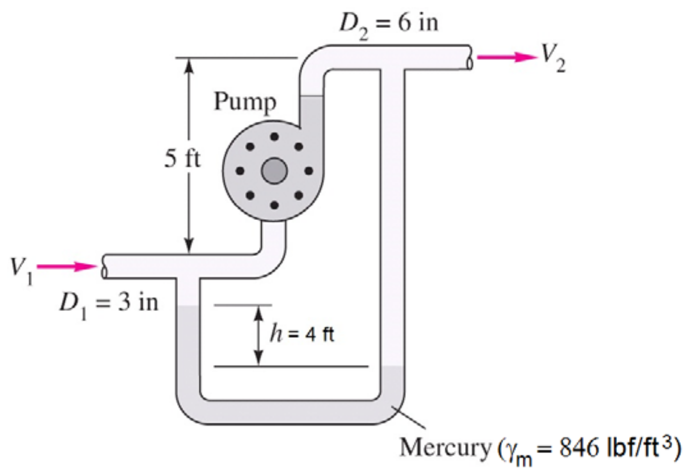

Figure 1

2. Water (γ = 62.4 lb/m^3 and ρ = 1.94 slugs/ft^3) flows steadily in a pipe and exits to the atmosphere as a free jet through a nozzle-end that contains a filter as shown in Fig. 1. If the head loss h_L for the flow through the nozzle-end is 2.5 ft, determine (a) the pressure at the section (1) and (b) the axial component R_y of the anchoring force needed to keep the nozzle stationary. The flow is in a *horizontal* plane such that the sections (1) and (2) are at the same elevation in the vertical plane and the weight of the nozzle and the water in it does *not* contribute to the anchoring force.

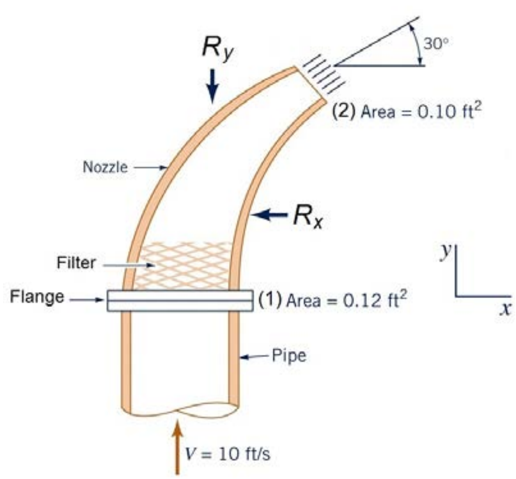

Figure 2

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3. A useful approximation for the x component of velocity in a steady incompressible viscous laminar flow between two stationary parallel flat plates in Fig. 3 is

$$\frac{d^2u}{dy^2} = -\frac{1}{\mu}\left(\frac{\Delta p}{L}\right)$$

where, μ is the fluid viscosity and $\Delta p = p_{out} - p_{in}$ is the pressure drop along the plate length L. (a) By integrating the given equation then applying appropriate boundary conditions, derive an expression for the velocity distribution $u(y)$. (b) If the fluid is SAE 30 oil at 15.6°C ($\mu = 3.8\times10^{-1}$ N·s/m^2), h = 2.5 mm, L = 1.5 m, W = 0.75 m, p_{in} = 101.3 kPa, and p_{out} = 0, estimate the wall shear stress τ_w and the shearing force F_s acting on the *bottom* plate.

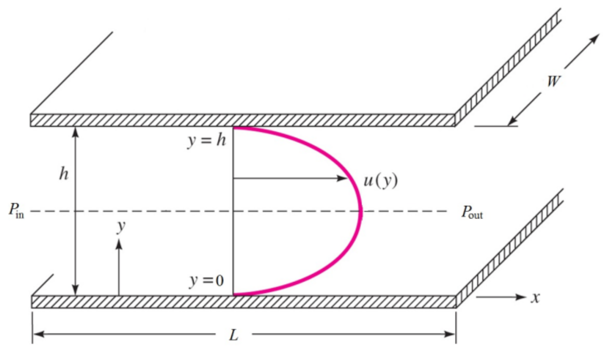

Figure 3

4. Heat exchangers often consist of many triangular passages. Typical is Fig. 4 with length L and side length b. Under laminar conditions, the volume flow Q through the tube is a function of viscosity μ, pressure drop per unit length Δp_L, and b such that $Q = f(\mu, \Delta p_L, b)$. (a) Using the Buckingham pi theorem, find a suitable pi parameter Π for this problem. (b) For one pi parameter the functional relationship must be $\Pi = C$, where C is a constant. Determine by what factor the volume flow will change if the side length b of the tube is doubled.

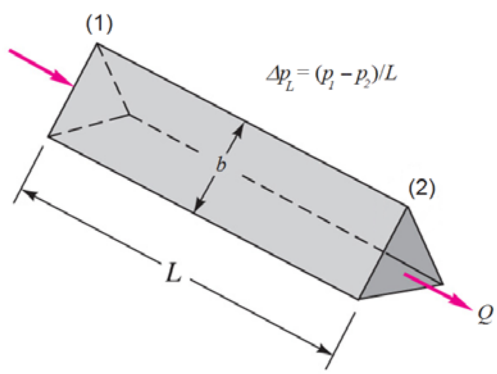

Figure 4