November 18, 2013

1. A 180° elbow is used to direct water (ρ=1000 kg/m^3) flow at a constant rate of 25 kg/s in a horizontal pipe to make a U-turn. The diameter of the entire elbow is 10 cm. The elbow discharges water into the atmosphere, and thus the pressure at the exit is the local atmospheric pressure. The elevation difference between the centers of the exit and the inlet of the elbow is 70 cm. The Weight of the elbow and the water in it and all friction are considered to be negligible. Determine (a) the inlet and outlet velocities, (b) the gage pressure at the center of the inlet of the elbow and (c) the anchoring force needed to hold the elbow in place.

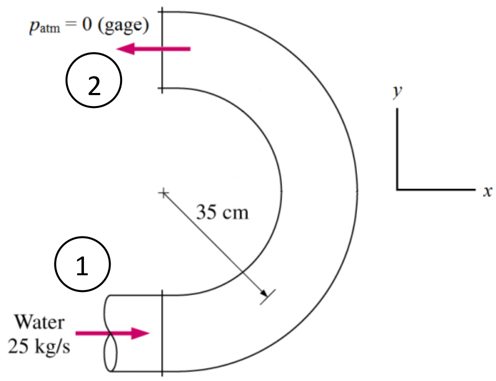

Fig. 1

2. Fuel oil (γ = 48.0 lb/ft^3, μ = 2.0×10^{-5} lb·s/ft^2) is pumped through the piping system shown in Fig. 2 with a velocity of 4.6 ft/s. The pressure is 5 psi upstream of the pump. The head loss associated with the 2-in diameter pipe flow is $h_L = 41.3\,\bar{V}^2/2g$, where $\bar{V}$ is the average velocity in the pipe. Assume kinetic energy correction factor α is 1.What horse-power is needed to drive it? (1 hp = 550 ft·lbf/s)

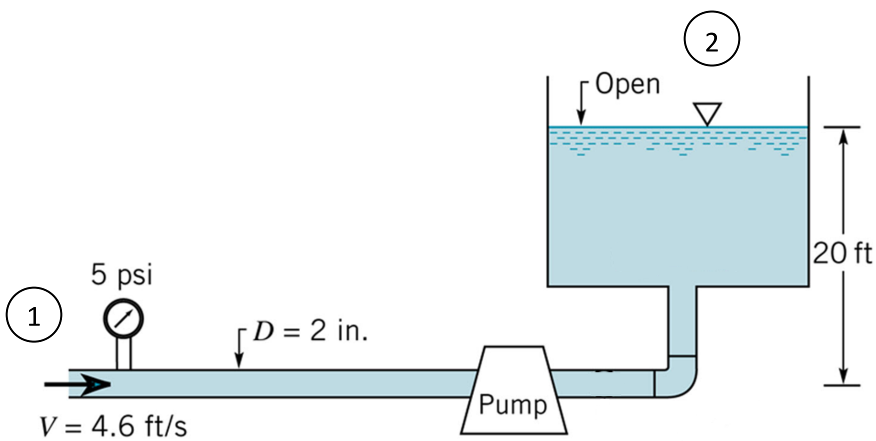

Fig. 2

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3. A layer of viscous liquid of constant thickness (no velocity perpendicular to plate) flows steadily down an infinite, inclined plane. (a) Solve the Navier-Stokes equations and show the velocity profile is

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

(b) If the liquid is SAE 30W oil (ρ = 891 kg/m^3 and μ = 0.28 kg/m·s), h = 10 mm, and θ = 30°, determine the flow rate per unit width (into the paper). The flow is laminar and fully developed, and the shearing stress at the free surface is zero.

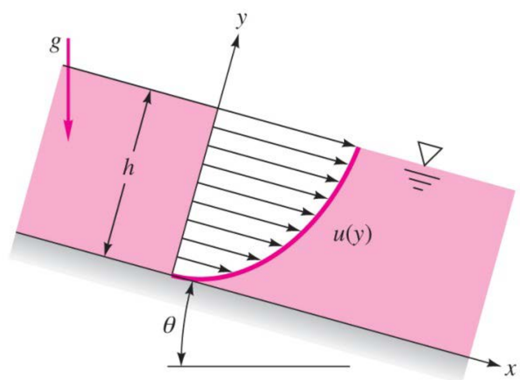

Fig.3

4. A thin plate having a diameter of 0.3 ft is towed through a tank of oil (γ_{oil} = 53 lb/ft^3) at a velocity of 5 ft/s. The plane of the plate is perpendicular to the direction of motion, and the plate is submerged so that wave action is negligible. Under these conditions the drag on the plate is 1.4 lb. If viscous effects are neglected, (a) by using the pi theorem find a dimensionless relationship between the drag D and the plate diameter d, fluid density ρ and the velocity V and (b) predict the drag on a geometrically similar, 2-ft-diameter plate that is towed with a velocity of 3 ft/s through water (γ_{water} = 1.94 slugs/ft^3) at 60 °F under conditions similar to those for the smaller plate.