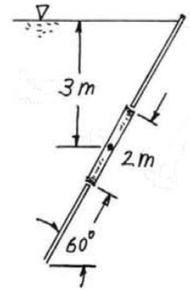
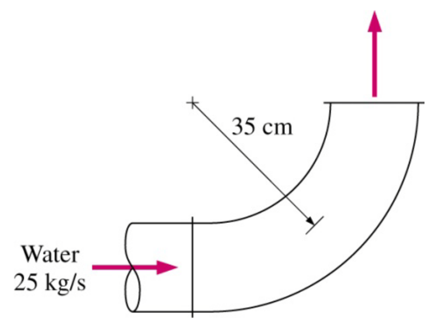
Exam 3, December 14, 2010

1. A circular 2-m-diameter gate is located on the sloping side of a swimming pool. The side of the pool is oriented 60° relative to the horizontal bottom, and the center of the gate is located 3 m below the water surface. Determine the magnitude of the water force F_R acting on the gate and the point through which it acts (or the center of pressure y_R). Note that $\gamma = 9.8$ kN/m^3 for water and $I_{xc} = \pi R^4/4$ for a circle of radius R.

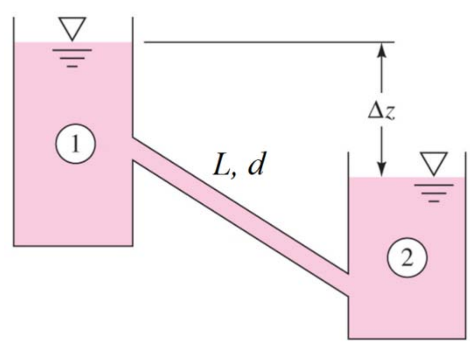


2. A 90° elbow is used to direct water ($\rho = 1000$ kg/m^3) flow at a rate of 25 kg/s in a horizontal pipe upward. The diameter of the entire elbow is 10 cm. The elbow discharges water into the atmosphere, and thus the pressure at the exit is the local atmospheric pressure. The elevation difference between the centers of the exit and the inlet of the elbow is 35 cm. The weight of the elbow and the water in it is considered to be negligible. Determine (a) the water velocity at inlet and outlet, (b) the gage pressure at the inlet of the elbow and (c) the anchoring force needed to hold the elbow in place. Assume the flow is steady, frictionless, and irrotational.



3. The reservoirs contain water at 20°C ($\rho = 998$ kg/m^3 and $\mu = 0.001$ N·s/m^2). If the pipe is smooth with length $L = 4500$ m and diameter $d = 4$ cm, what will the flow rate be for $\Delta z = 100$ m? First assume a friction factor $f = 0.0224$ and start iteration process if necessary. You may use the following formula to find the friction factor for turbulent flow in smooth pipes:

$$f = \frac{0.316}{Re^{1/4}}$$



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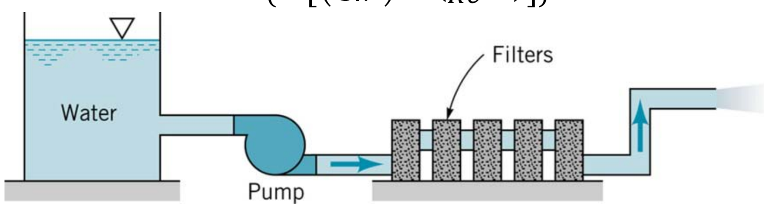
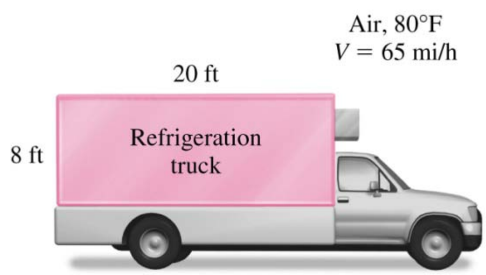
4. Water (ρ = 1.94 slug/ft^3 and $\mu = 2.34 \times 10^{-5}$ slug/ft·s) flows through the pipe at a rate of 0.30 ft^3/s. The pipe diameter is 2 in. and its roughness is 0.002 in. The loss coefficient for each of the five filters is 6.0, and all other minor losses are negligible. Deterine the power added to the water by the pump if the pressure immediately before the pump is to be the same as that immediately after the last filter. The length of the pipe between these two locations is 80 ft. Aassume the elevation difference between the two locations is negligible. Note that g = 32.2 ft/s^2 and 1 hp = 550 ft·lb/s. You may use the following equation to calculate the friction factor:

$$f = \frac{1.325}{\left\{\ln\left[\left(\frac{\varepsilon/D}{3.7}\right) + \left(\frac{5.74}{Re^{0.9}}\right)\right]\right\}^2}$$



5. Consider a refrigeration truck traveling at 65 mi/h (95.34 ft/s) at a location where the air temperature is 80°F and pressure 1 atm (ρ = 0.07350 lbm/ft^3 and $\nu = 1.697 \times 10^{-4}$ ft^2/s). The refrigerated compartment of the truck can be considered to be a 9-ft-wide, 8-ft-high, and 20-ft-long rectangular box. Assuming the airflow over the entire outer surface to be turbulent and attached (no flow separation), determine (a) the boundary layer thickness at the trailing edge of the top surface and (b) the drag force acting on the top and side surfaces. Note that 1 lbf = 32.2 lbm·ft/s^2.



6. A sphere weights 250 g and is 7.35 cm in diameter. It is dropped from the surface of a 100-m-depth lake. Assuming a laminar-flow drag coefficient C_D = 0.5, estimate (a) its falling (or terminal) velocity and (b) the time to reach to the lake bottom. Neglect the initial transient state and assume that the sphere falls at constant velocity from the beginning. (ρ = 1000 kg/m^3 and $\nu = 1.12 \times 10^{-6}$ m^2/s for water; $\forall = 4\pi R^3/3$ for a sphere of radius R)