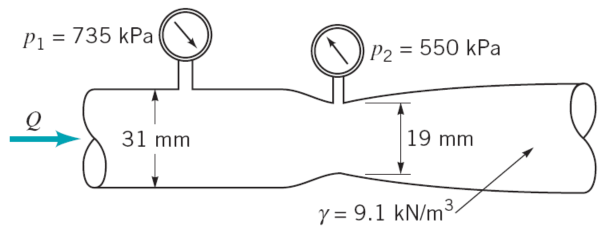
EXAM #3 December 16, 2008

1. Determine the flow rate through the Venturi meter shown below if ideal conditions exist.



2. A prototype water pump has an impeller diameter of 2 ft and is designed to pump 12 ft^3/s at 750 r/min. A 1-ft-diameter model pump is tested in 20°C air at 1800 r/min. According to a dimensional analysis the pump power can be expressed as following when the Reynolds-number effects are negligible:

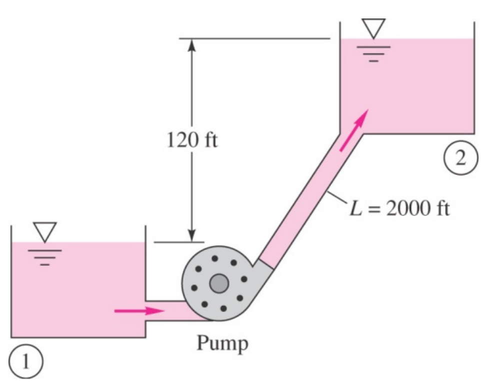
$$\frac{P}{\rho \Omega^3 D^5} = \phi\left(\frac{Q}{\Omega D^3}\right)$$

where, P is the pump power, Q is the volume flow rate, ρ is the density, Ω is the impeller rotation speed, and D is the impeller diameter. For similar conditions, (a) what will be volume flow of the model be in ft^3/s, and (b) what horsepower is required for the prototype if the model pump requires 0.082 hp to drive it?

(For air at 20°C, ρ = 0.00234 slug/ft^3, and for water at 20°C, ρ = 1.94 slug/ft^3)

3. Water at 20°C is to be pumped through 2000 ft of pipe from reservoir 1 to 2 at a rate of 3 ft^3/s as shown below. If the pipe is cast iron of diameter 6 in. and roughness ε = 0.00085 ft, what horsepower pump is needed? Use the equation given below to calculate the friction factor if necessary, and assume that the pump efficiency is 100%.

(ρ = 1.94 slug/ft^3, μ = 2.09 × 10^{-5} slug/ft·s, g = 32.2 ft/s^2, 1 hp = 550 lb·ft/s)



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

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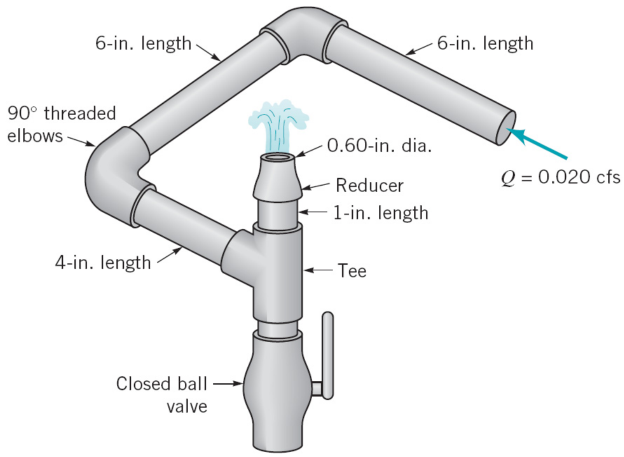
4. Water flows steadily through the 0.75-in. diameter galvanized iron (ε = 0.0005 ft) pipe system shown in Fig. 4 at a rate of 0.020 cfs. What is the ratio between the major and minor losses? Loss coefficients K_L are 1.5, 2.0, and 0.15 for 90° threaded elbows, tee, and reducer, respectively. Use the same equation in problem 3 for a friction factor if necessary.

   ($\nu = 1.21 \times 10^{-5}$ ft^2/s)



Part	K_L
Threaded elblow	1.5
Tee	2.0
Reducer	0.15

5. Consider water flow past a thin flat plate. On both sides of the plate, the boundary layer is tripped at the leading edge. For flow speed 5 m/s, estimate (a) the local wall sear stress at a position 40 cm downstream from the leading edge and (b) the total friction drag if the plate is 2 m long and 1m wide. Transition to turbulent flow occurs at Re = 5×10^5.

   (ρ = 998 Kg/m^3, μ = 0.001 kg/m·s)

6. A 10-cm-diameter ball is supported by an air jet as shown below. Estimate the weight of the ball if the jet velocity is 14.5 m/s. Drag coefficients of a smooth sphere is given below as a function of Reynolds number (solid line). (ρ = 1.225 kg/m^3, $\mu = 1.78 \times 10^{-5}$ kg/m·s)