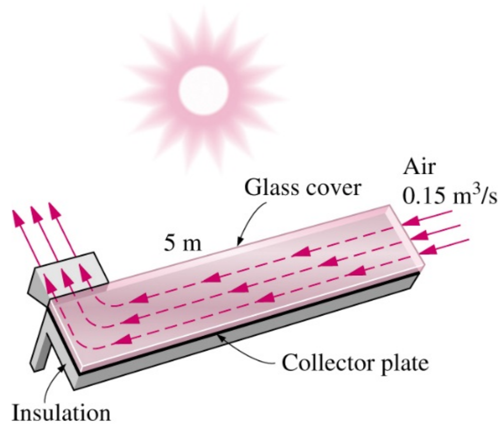
CHEN.3030 Fluid Mechanics

Homework Assignment #10 Spring 2017

Pipe Flow Applications

1. Consider a solar collector that is 1 m wide and 5 m long and has a constant spacing of 3 cm between the glass cover and the collector plate. Air flows within the rectangular channel at an average temperature of 45 C at a rate of 0.15 m^3/s as shown in the sketch.

Disregarding the entrance and roughness effects, estimate the pressure drop in the collector.



2. A positive displacement pump delivers an essentially constant discharge flow rate independent of the discharge pressure. In a particular flow system, with the suction pressure of the pump fixed at 10 psig, the desired water flow rate is 250 gal/min. The water temperature is 60 F and the horizontal Schedule 40 discharge line is 200 ft long. The pipe exit is open to the atmosphere. Assume that the suction line has a relatively short 3½″ Schedule 40 commercial steel pipe ($D_{3.5}$ = 0.2957 ft).

a. Compute the power added by the pump (in hp) if the discharge line is a 2″ Schedule 40 steel pipe (D_2 = 0.1723 ft).

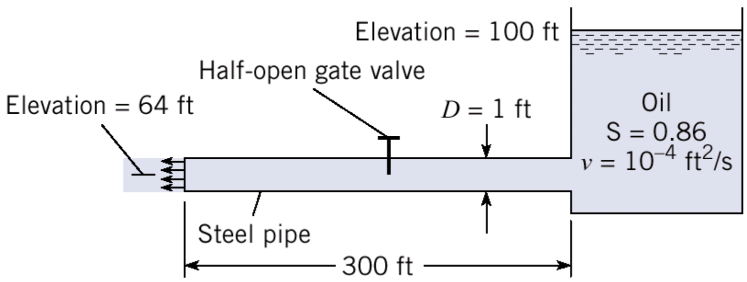
b. Now, redo the calculation from Part a using your favorite computer analysis tool (Excel, Matlab, Mathcad, etc.). Validate the computer calculations using your hand calculations for the 2″ Schedule 40 discharge line as a benchmark case.

Once you get this working, redo the calculations using both 2½″ and 3″ Schedule 40 commercial steel pipes ($D_{2.5}$ = 0.2058 ft^2 and D_3 = 0.2557 ft^2, respectively). With these data, discuss how the power delivered by the pump changes versus discharge line size. How does this tradeoff affect the cost of a given piping system?

3. A vented tanker is to be filled with fuel oil (ρ = 920 kg/m^3 and μ = 0.045 kg/m-s) from a vented underground reservoir using a 20 m long, 5 cm diameter, smooth plastic hose. The connection to the reservoir has a slightly rounded entrance (K = 0.12) and the hose to the tanker has two smooth 90^o bends (K = 0.3 for each bend). The elevation difference between the oil level in the reservoir and the top of the tanker where the hose is connected is 5 m (note that the hose exit is a free jet). A pump in the system between the reservoir and the tanker provides a constant flow rate of 0.01 m^3/s.

Assuming an overall pump efficiency of 82 percent, determine the required power input to the pump to operate this system.

4. Estimate the discharge of oil in gallon/min (gpm) in the configuration shown in the sketch. Assume a sudden contraction at the tank-pipe interface and that the gate valve has a resistance coefficient K = 5.6. Note that this is a Type II problem!



5. Manufacturer data for a small aquarium pump are given below:

Flow Rate (m³/s)	0	1e-6	2e-6	3e-6	4e-6	5e-6
Head (m)	1.10	1.00	0.80	0.60	0.35	0.0

Using this pump, what is the flow rate achieved in the system shown in the diagram? The tubing between the two reservoirs is a smooth plastic material with an inside diameter of 0.5 cm and a total length of 29.8 m. The water is at room temperature. Minor losses can be ignored.