CASE WESTERN RESERVE UNIVERSITY
Case School of Engineering

ECHE 225: Fall 2024
Homework #9: Internal flow
Due: November 7

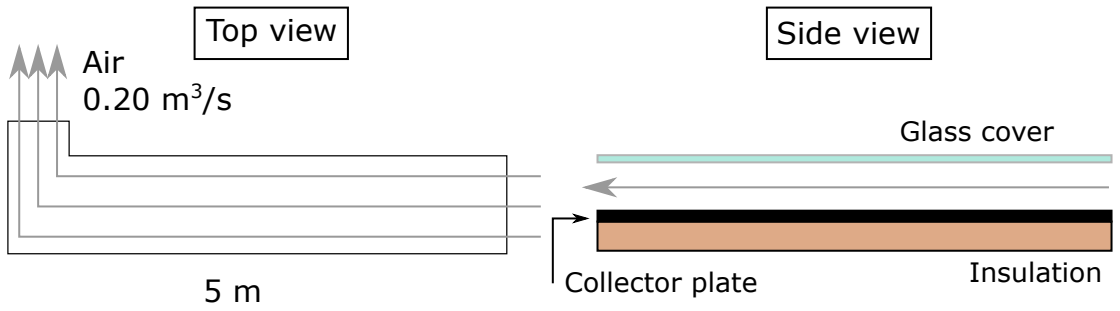
1. [Chapter 14] Water at 10°C ($\rho = 999.7$ kg/m^3, $\mu = 1.307 \times 10^{-3}$ kg/m·s) is flowing steadily in a 0.15-cm-diameter, 15-m-long pipe at an average velocity of 1.1 m/s. Determine:

   (a) pressure drop

   (b) head loss

   (c) pumping power required to overcome this pressure drop.

2. [Chapter 14] Consider an air 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 at an average temperature of 45°C at a rate of 0.20 m^3/s through the 1-m-wide edge of the collector along the 5-m-long passageway. Disregarding the entrance and roughness effects and the 90° bend, determine the pressure drop in the collector.



3. [Chapter 14] A 4-m high cylindrical tank having a cross-sectional area $A_T = 1.5$ m^2 is filled with equal volumes of water and oil. The specific gravity of the oil is 0.75. A 1 cm-diameter hole at the bottom of the tank is opened and water starts to flow out. If the discharge coefficient of the hole is $C_d = 0.82$, determine how long it will take for the water in the tank to completely drain. Assume that the tank is open to the atmoshere. The discharge coefficient represents a fraction of the expected volumetric flow rate through the opening: $\dot{V} = C_d V A$.

4. [Chapter 14] A certain part of the cast iron piping of a water distribution system involves a parallel section. Both parallel pipes have a diameter of 30 cm and the flow is fully turbulent. One of the branches (pipe A) is 1800 m long while the other branch (pipe B) is 2300 m long. If the flow rate through pipe A is 0.6 m^3/s, determine the flow rate through pipe B. Disregard minor loss and assume the water temperature to be 15°C. Show that the flow is fully rough, and thus the friction factor is independent of Reynolds number.

5. [Chapter 14] Water is to be withdrawn from a 10-m-high reservoir by drilling a 2.5-cm-diameter hole at the bottom surface. Disregarding the effect of the kinetic energy correction factor, determine the flow rate of water through the hole if (a) the entrance of the hole is well-rounded and (b) the entrance is sharp-edged.

Answers

1. (a) 306.7 kPa, (b) 31.3 m, (c) 0.596 W
2. 53.1 Pa
3. 1.89 hrs
4. 0.531 m^3/s
5. (a) 6.77×10^{-3} m^3/s, (b) 5.61×10^{-3} m^3/s