MEEN 461-501 Heat Transfer Fall 2016

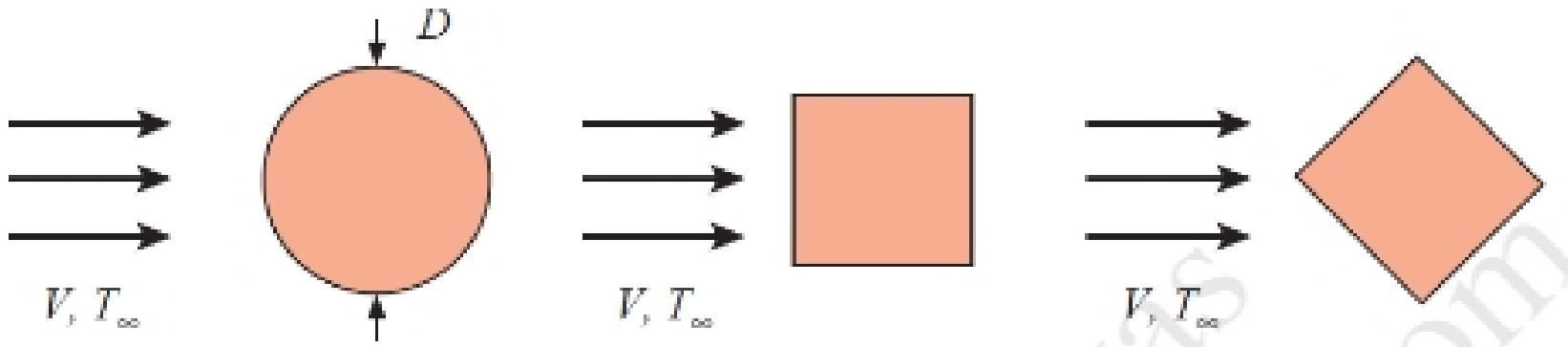
Homework 7

Due at the beginning of the class on Tuesday, October 25, 2016

7.46 Consider the following fluids, each with a velocity of $V = 5$ m/s and a temperature of $T_\infty = 20°C$, in cross flow over a 10-mm-diameter cylinder maintained at 50°C: atmospheric air, saturated water, and engine oil.

(a) Calculate the rate of heat transfer per unit length, q', using the Churchill–Bernstein correlation.

7.51 Pin fins are to be specified for use in an industrial cooling application. The fins will be subjected to a gas in cross flow at $V = 10\,\text{m/s}$. The cylindrical fin has a diameter of $D = 15\,\text{mm}$, and the cross-sectional area is the same for each configuration shown in the sketch.



Configuration A Configuration B Configuration C

Cross sections of cylindrical and square fins in cross flow

For fins of equal length and therefore equal mass, which fin has the largest heat transfer rate? Assume the gas properties are those of air at $T = 350\,\text{K}$. *Hint*: Assume the fins can be treated as infinitely long and apply the Hilpert correlation to the fin of circular cross section.

7.90 A preheater involves the use of condensing steam at 100°C on the inside of a bank of tubes to heat air that enters at 1 atm and 25°C. The air moves at 5 m/s in cross flow over the tubes. Each tube is 1 m long and has an outside diameter of 10 mm. The bank consists of 196 tubes in a square, aligned array for which $S_T = S_L = 15\,\text{mm}$. What is the total rate of heat transfer to the air? What is the pressure drop associated with the airflow?

8.6 Consider pressurized water, engine oil (unused), and NaK (22%/78%) flowing in a 20-mm-diameter tube.

(a) Determine the mean velocity, the hydrodynamic entry length, and the thermal entry length for each of the fluids when the fluid temperature is 366 K and the flow rate is 0.01 kg/s.

(b) Determine the mass flow rate, the hydrodynamic entry length, and the thermal entry length for water and engine oil at 300 and 400 K and a mean velocity of 0.02 m/s.

8.23 An experimental nuclear core simulation apparatus consists of a long thin-walled metallic tube of diameter D and length L, which is electrically heated to produce the sinusoidal heat flux distribution

$$q_s''(x) = q_o'' \sin\left(\frac{\pi x}{L}\right)$$

where x is the distance measured from the tube inlet. Fluid at an inlet temperature $T_{m,i}$ flows through the tube at a rate of $\dot{m}$. Assuming the flow is turbulent and fully developed over the entire length of the tube, develop expressions for:

(a) the total rate of heat transfer, q, from the tube to the fluid;

(b) the fluid outlet temperature, $T_{m,o}$;

(c) the axial distribution of the wall temperature, $T_s(x)$; and

(d) the magnitude and position of the highest wall temperature.