MAE 423
Heat Transfer

Problem Set 5

Date: Thu, 14 Nov ‘19
Due: Fri, 22 Nov ’19 Please turn in either in class or in the boxes outside my office, D302 EQ by ‘midnight’

Important: Please read and follow the guidelines for problem set preparation as outlined in the introduction to the course (posted on BB in Course Materials). As a reminder: be sure to draw any relevant sketches, list any assumptions and/or simplifications, show all analyses, and be very sure to check dimensions/units of your final answer, along with ascertaining that the sign and rough order-of-magnitude of the answer appears reasonable (and if it doesn’t, please comment accordingly).

There are four (4) problems in this problem set.

1. Calculate the ratio of the thermal to velocity boundary layer thicknesses for the following fluids:
   a. Air at 1atm and 20°C
   b. Water at 20°C
   c. Helium at 1 atm and 20°C
   d. Glycerin at 20°C

2. Air at 90°C and 1 atm flows over a flat plate at a velocity of 30 m/s. Find the thickness of the boundary layer 5 cm from the leading edge of the plate.

3. Air at 7 kPa and 35°C flows across a 30 cm square flat plate at 7.5 m/s. The surface of the plate is maintained at 65°C. Estimate the heat lost from the plate

4. 4-91 in Holman, 10^{th} ed. Note that this problem refers to the steady-state simulation in Problem 3-51 in Holman. However, for our work here, increase the number of grid points from 3 x 3 to 30 x 30. All boundary conditions remain the same. Write a MATLAB, C, Java, or similar code to numerically solve the grid for temperature. Instead of reporting the temperatures at nodes 1,2,4,5 referred to in 4-91 (which you will have scaled up appropriately in the finer grid), do the following:

   a. Plot the temperature distribution, T(y) on the left convective boundary after 100 time steps
   b. Plot the temperature distribution, T(x) on the upper insulated boundary after 100 time steps
   c. Plot the unsteady temperature, T(t), halfway up the left convective boundary (corresponding to node 2 in the course grid given in the problem statement) from t = 0 to steady-state
   d. Plot the total heat convected across the left, convective boundary, from t = 0 to steady-state