FLORIDA INSTITUTE OF TECHNOLOGY
MECHANICAL AND AEROSPACE ENGINEERING DEPARTMENT

MAE 5150-E1: Computational Fluid Dynamics
Fall 2017

Coding Project 1

Due October 5, 2017

1. A wall 1 ft. thick and infinite in other directions has an initial uniform temperature of 100.0°F. The surface temperatures at the two sides are suddenly increased and maintained at 300.0°F. The wall has a thermal diffusivity of 0.1 ft^2/hr. Compute the temperature distribution within the wall as a function of time.

The equation for this problem is

$$\frac{\partial T}{\partial t} = \alpha \frac{\partial^2 T}{\partial x^2}$$

where α is the thermal diffusivity.

Write a code (or multiple codes) to solve this problem for the following schemes:

a) FTCS Explicit

b) DuFort-Frankel

c) FTCS Implicit

d) Crank-Nicolson.

In each case, use a $\Delta x = 0.05$. If $i = 1$ at the left surface, then $i = 21$ at the right surface. Note that $n = 1$ corresponds to $t = 0$. Run each case twice, once for a $\Delta t = 0.01$ and again for $\Delta t = 0.05$. For each method, plot the temperature profile at 0.1 hr intervals. (You will have eight plots in all, each with four curves.) Remember to use proper plotting techniques, including title, axis labels, units, legend, and legibility. Submit a copy of your code both in hardcopy and electronically on Canvas.

Note that you will have to write a subroutine for Thomas' Algorithm to complete at least two of these schemes. This algorithm <u>**must**</u> be in its own subroutine, passing the coefficients and a solution vector to and from it. Once returned to the main program, the solution vector may be put into any other variable array at your discretion.

(over)

2) Consider the two-dimensional heat conduction equation

$$\frac{\partial T}{\partial t} = \alpha \left[\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} \right]$$

There exists a square bar of chrome steel with cross-sectional dimensions of 3.5 ft by 3.5 ft. The thermal diffusivity, α, is 0.645 ft^2/hr. The initial and boundary conditions are

Initial Condition:

$$t = 0 \qquad T = T_o = 0.0$$

Boundary Conditions:

$$t \geq 0 \qquad T(x,0) = T_1 = 200.0$$

$$T(0,y) = T_2 = 200.0$$

$$T(x,h) = T_3 = 0.0$$

$$T(b,y) = T_4 = 0.0$$

Let $\Delta x = \Delta y = 0.1\ \text{ft}$ and $\Delta t = 0.01\ \text{hr}$. Compute the solution until t = 0.5 hr. Plot your solution as a flooded contour plot at t = 0.1 hr and t = 0.4 hr, again using proper plotting techniques. Also print tables of your numeric solution for all y-nodes at x = 0.5, 1.5, 2.5, and 3.5 for the same time points of your plots. Numerical values should be formatted into decimal-aligned columns (with headers) and each non-integer number should have exactly 3 decimal places (including trailing zeros if necessary). Submit a both a hardcopy of your code and an electronic copy on Canvas.

Note: Except for the purpose of creating plots, MATLAB, Excel, or other commercially available software may not be used for this assignment. You may otherwise program in any language you wish.