

FLORIDA INSTITUTE OF TECHNOLOGY
AEROSPACE, PHYSICS, AND SPACE SCIENCES DEPARTMENT

AEE 5150-E1: Computational Fluid Dynamics

Fall 2021

Coding Project 1

Due September 30, 2021

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 ft²/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 for each of the following schemes that solves this problem:

- a) FTCS Explicit
- b) DuFort-Frankel
- c) FTCS Implicit
- d) Crank-Nicolson.

In each case, use a $\Delta x = 0.05$ ft. 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 $\Delta t = 0.01$ hr, and again for $\Delta t = 0.05$ hr. Each calculation should run for 0.4 hrs total. 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. Plots should be submitted in hardcopy. Remember that curves must be distinguishable (color or line style).

Note that you will have to write a subroutine for Thomas' Algorithm to complete at least two of these schemes. This algorithm **must** 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 ft²/hr. The initial and boundary conditions are

Initial Condition:

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

Boundary Conditions:

$$\begin{aligned} t \geq 0 \quad T(x, 0) &= T_1 = 200.0 \\ T(0, y) &= T_2 = 200.0 \\ T(x, h) &= T_3 = 0.0 \\ T(b, y) &= T_4 = 0.0 \end{aligned}$$

Let $\Delta x = \Delta y = 0.1$ ft and $\Delta t = 0.01$ hr. Compute the solution until $t = 0.5$ hr. using the ADI scheme. Plot your solution as a 2-D 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 (raw computer output) 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 with units) and each non-integer number should have exactly 3 decimal places (including trailing zeros if necessary). Submit both a hardcopy of your code and an electronic copy on Canvas. Plots and data should be in hardcopy unless you do not have access to a color printer, in which case submit plots on Canvas as well.

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 except Python.

DILBERT SCOTT ADAMS

