AE 601 - Computational Fluid Mechanics
Department of Aerospace Engineering & Engineering Mechanics
San Diego State University

MIDTERM PROJECT

Time Developing Temperature in a Parallel Plate Couette Flow

Project report due on **October 25, 2007**

Consider the time evolution of the temperature field initially at a constant temperature in a laminar flow between two parallel plates separated by a distance $2h$. Consider air as the medium. The bottom plate at y=-h is at rest. The top plate at y=h moves at constant velocity of U. The analytical fluid velocity profile is given by $u(y) = \frac{U}{2}\left(1 + \frac{y}{h}\right)$ The energy equation for this flow simplifies to:

$$\frac{\partial T}{\partial t} = \frac{k}{\rho c_p}\frac{\partial^2 T}{\partial y^2} + \frac{\mu}{\rho c_p}\left(\frac{\partial u}{\partial y}\right)^2,$$

where $\frac{\partial u}{\partial y}$ is now considered a constant source term. The intial temperature is T_0. The temperature at the bottom plate is $T_1 = T_0$. The temperature at the top plate is T_2=$2T_0$.

1. Nondimensionalize all the variables and the governing equation (including initial and boundary conditions).

Consider a flow with a Reynolds number of 10, take the Prandtl number to be 1, and the Eckert number to be 8.

2. Determine the 'exact' solution.

3. Find the numerical solution using (i) explicit and (ii) implicit methods.

Compare the results of your numerical solution with the exact solution. Investigate accuracy (show convergence rates) and stability by considering the effects of Δt, Δy, and $r = \Delta t/(\Delta y)^2$.

4. Find the numerical solution using a 4th-order Runge-Kutta method. Study the effect of Δt by running simulations with various Δt.

In the presentation of results, include plots of:
Temperature profile
Heat flux versus time

To solve systems of equations use Matlab build-in functions.

Follow the "Computer Homework" format.