Department of Mechanical Engineering, BUET.

***ME 6189: Computational Fluid Dynamics***

# Assignment-5

(**Due date: 06 April 2013**, **Saturday**. *Submit hard-copy*)

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***Note:*** *(i) Symbols have their usual meanings.*

*(ii) Clearly sketch the C.V. (control volume), show the nodal points, and C.V. faces.*

*(iii) Consider uniform grid; show details of the discretization process.*

*(v) Submit your code with necessary results plotted.*

*(vi)* ***Show the grid independency test.***

**1.** Consider a fluid with a temperature of $T_c$ and a constant velocity of $u$ traveling from left to right in a channel. The temperature at the end of the channel is suddenly changed to $T_h$ and is maintained at that constant value. It is required to compute the time-accurate solution for the temperature distribution within the channel. The governing equation is given by the one-dimensional energy equation as

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

where $\alpha$ is the thermal diffusivity, which is assumed constant for this problem. The initial and boundary conditions are specified as,

$$t = 0,\ \ T(x,0) = T_c$$

$$t \geq 0,\ x = 0,\ T = T_c\ ; \quad x = L,\ T = T_h$$

Non-dimensionalize the equation by

$$t^* = \frac{tu_0}{L}\ , \qquad x^* = \frac{x}{L}, \qquad u^* = \frac{u}{u_0}, \qquad T^* = \frac{T - T_c}{T_h - T_c} \quad \text{and define } \alpha^* = \frac{\alpha}{Lu_0}$$

(a) Obtain the analytical solution.

(b) Obtain the numerical solution with the non-dimensionalized formulation developed.

Use any suitable method for time discretization, and

use (i) upwind difference (ii) QUICK scheme for convective term.

Print the solution at time levels of 1.0, 2.0 and 3.0 seconds.

Plot the temperature profile at these levels.

Assume a fluid with diffusivity of 0.04 m$^2$/sec, a velocity of 0.2 m/s, temperature of $T_c$ = 20 $^0$C. The sudden change in temperature $T_h$ at the boundary is $T_h$ = 100 $^0$C and the length of the channel is 2 m.

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