Department of Chemical Engineering
Indian Institute of Technology-Delhi

CHL 768: Fundamentals of Computational Fluid Dynamics

Major Test

Total marks: 30, Duration: 2 Hr, Closed book/notes

Notes: Solution steps also carry the marks.

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1. **Numerical solution of flow equations**

   (a) Draw the flowcharts of the SIMPLE and SIMPLER algorithms showing each step of the solution procedure. Write down the equations that are solved at each step and indicate the flow variables that are computed after each step in the flow chart. **(8 marks)**

   (b) Using the above flowcharts, explain the reasons for the improved performance of the SIMPLER algorithm over the SIMPLE algorithm. **(2 marks)**

2. **Transient convection-diffusion problem**
   Formulate the finite volume method to predict the transient temperature distribution in a 1-D domain as shown in Figure 1.

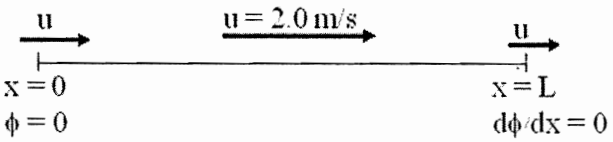

Figure 1:

The transient temperature distribution in this cases in governed by the following unsteady convection-diffusion equation.

$$\frac{\partial(\rho\phi)}{\partial t} + \frac{\partial(\rho u\phi)}{\partial x} = \frac{\partial}{\partial x}\left(\Gamma\frac{\partial\phi}{\partial x}\right) \tag{1}$$

Initial conditions: ϕ=0 at t=0, for all x
Boundary conditions: ϕ=0 at x=0 and $\partial\phi/\partial x$=0 at x=L
Physical data: L=1.0 m, u=2 m/s, ρ=1.0 kg/m^3 and Γ=0.1 kg/m/s

Using 5 control volumes, solve the above problem using the **hybrid differencing scheme** for the spatial derivatives and **Crank-Nicolson scheme** for the time derivative. **(12 marks)**

P.T.O

Instructions:

- Derive the discretized equations and tabulate the coefficients of the discretization equations for nodes 1, 2-4 and 5 in their general form.
- **Neither substitute the numerical values of parameters** nor solve the problem further.

3. Comment on the stability, accuracy and positive coefficient criterion for (1) Explicit, (2) Crank-Nicolson and (3) Implicit schemes. **(3 marks)**

4. With the help of a staggered grid arrangement, explain the implementations of the outlet boundary condition and the constant pressure boundary condition . **(5 marks)**
