INDIAN INSTITUTE OF ENGINEERING SCIENCE AND TECHNOLOGY, SHIBPUR

B.E. (Mech) Part-IV 8th Semester Final Examination, 2014

Subject: Computational Fluid Dynamics: (ME-805/6)

Branch: Mechanical Engineering

Time: 2 HRS. **Full Marks: 35**

Answer any three questions.
All questions carry equal marks.

1. (a) Compare analytical, numerical and experimental methods of analysis for heat transfer and fluid flow problems. Write down the differential equations in general for different conservation equations needed for the solution of CFD based problems. Identify the unsteady term, convection term, diffusion term and source term. Also, state when the general equation will be the continuity equation, momentum equation or energy equation.

   (b) What do you mean by grid independence test in case of numerical solution of fluid dynamic problems? Suggest and explain a method to find the interface conductivity in case of a thermal conduction problem.

2. (a) Explain the Explicit, Crank-Nicolson and Fully Implicit Schemes for the solution of transient problem.

   (b)How will you define Peclet number in case of ~~conduction~~ convection diffusion problem? The one dimensional governing equation for steady convection diffusion problem with no source term is

   $$\frac{d}{dx}(\rho u\phi)=\frac{d}{dx}\left(\Gamma\frac{d\phi}{dx}\right)$$, where the symbols have their usual meanings. Using one dimensional continuity equation for steady flow and central differencing scheme show that the solution is given by $a_P\phi_P = a_W\phi_W + a_E\phi_E$, where the coefficients a_W, a_E and a_P are given by

   $$a_W = D_w + \frac{F_w}{2},\quad a_E = D_e - \frac{F_e}{2} \quad \text{and} \quad a_P = a_W + a_E + (F_e - F_w)$$

   where F and D represent convective mass flux per unit area and diffusion conductance respectively at cell faces. Also write the discretized equations and the coefficients in case of two-dimensional convection diffusion problem.

3. (a) State the necessity of staggered grid arrangement for the numerical solution of convection diffusion problems. Explain briefly the sequence of operations carried out in SIMPLE algorithm.

   (b) Consider a one dimensional heat conduction situation with S = 2 and k = 1 everywhere. If four grid points at x = 0,1,2,3 are used to span the domain length 3, write the four discretization equations (including the half-control volume equations) using the following boundary conditions: At x = 0, the heat flux into the domain is 5; at x = 3, the heat flux leaving the domain is 11.

4. Write short notes (any three):

   Types of boundary conditions, Upwind Scheme, TDMA, Hybrid scheme

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