BENGAL ENGINEERING AND SCIENCE UNIVERSITY, SHIBPUR, HOW-3

B.E. (Mech) Part-IV 8th Semester Final Examination, 2013

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) What do you mean by governing equations of fluid flow and heat transfer? Write different governing equations used in numerical heat transfer and fluid flow problem in vector form also in the expanded form for three dimensional cases. Include and mark the unsteady term, convection term, diffusion term and source term whenever possible.
(b) What are the advantages of numerical computation over experimental investigation in fluid flow and heat transfer problem? Also state the limitations of numerical methods.
2. (a) How do you classify a partial differential equation as elliptic, parabolic and hyperbolic? Explain with suitable examples.
(b) The one dimensional governing equation for steady convection diffusion problem with no source term is

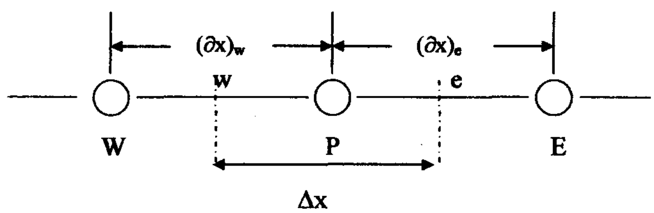
$\frac{d}{dx}(\rho u\phi) = \frac{d}{dx}\left(\Gamma\frac{d\phi}{dx}\right)$ where the symbols have their usual meanings. Using one dimensional continuity equation for steady flow and central differencing scheme show that the solution is given by $a_P\phi_P = a_W\phi_W + a_E\phi_E$, where the coefficients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

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

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 geometry.

3. (a) Using the Taylor-series expansion around point P as shown in the figure, show that the finite difference approximation for $\frac{d^2T}{dx^2}$ is given by

$$\frac{d^2T}{dx^2} = \frac{2}{(\partial x)_e + (\partial x)_w}\left[\frac{T_E - T_P}{(\partial x)_e} - \frac{T_P - T_W}{(\partial x)_w}\right]$$



(b) Consider one dimensional heat transfer problem through an insulated 1 m long rod whose ends are maintained at 100°C and 0°C. You can also assume that there is no heat generation and the thermal conductivity of the material of the rod is constant and having a value of 1000 W/m-K. Write the governing differential equation. Take 5 grid points and form the discretized equations for the grid points. Suggest an effective method to solve these equations.
4. Write short notes (any three):
Momentum equation, Necessity of Staggered Grid, Power Law Scheme; SIMPLE Algorithm