BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI
(END SEMESTER EXAMINATION)

CLASS: BE **SEMESTER : VII**
BRANCH: CHEM. ENGG./CEP&P **SESSION : MO/18**

SUBJECT: CL7017 COMPUTATIONAL FLUID DYNAMICS
TIME: 3 HOURS **FULL MARKS: 60**

INSTRUCTIONS:
1. The question paper contains 7 questions each of 12 marks and total 84 marks.
2. Candidates may attempt any 5 questions maximum of 60 marks.
3. The missing data, if any, may be assumed suitably.
4. Before attempting the question paper, be sure that you have got the correct question paper.
5. Tables/Data hand book/Graph paper etc. to be supplied to the candidates in the examination hall.

Q.1(a) Name the four terms in the generic governing equation: [2]

$$\underbrace{\frac{\partial}{\partial t}(\rho\varphi)}_{I} + \underbrace{\nabla.\left(\rho\vec{U}\varphi\right)}_{II} = \underbrace{\nabla.\left(D_\varphi \nabla\varphi\right)}_{III} + \underbrace{S}_{IV}$$

For a scalar function φ (x, y, z), what is $\nabla\varphi$?

Q.1(b) Simplify the general governing equation in differential form for a two-dimensional, steady, incompressible flow, without source terms (show the steps and explain your working). [4]

$$\frac{\partial}{\partial t}(\rho\varphi) + \frac{\partial}{\partial x}(\rho u\varphi) + \frac{\partial}{\partial y}(\rho v\varphi) + \frac{\partial}{\partial z}(\rho w\varphi) = \frac{\partial}{\partial x}\left[D_\varphi \frac{\partial(\rho\varphi)}{\partial x}\right] + \frac{\partial}{\partial y}\left[D_\varphi \frac{\partial(\rho\varphi)}{\partial y}\right] + \frac{\partial}{\partial z}\left[D_\varphi \frac{\partial(\rho\varphi)}{\partial z}\right] + S$$

Q.1(c) Develop an expression for 3-point forward difference scheme for dy/dx for uniform grid. What is its truncation error? [6]

Q.2(a) Define consistency. [2]

Q.2(b) Write advantages and disadvantages of Explicit, Implicit and Crank-Nicolson schemes. [4]

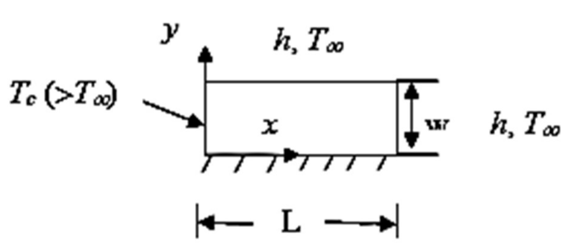
Q.2(c) Check whether the 1D transient heat conduction equation is consistent or not, where α is a positive constant. [6]

Q.3(a) Descretize the 1D transient heat conduction equation (given in Q. 3b) by the application of the Crank-Nicolson scheme. [2]

Q.3(b) Using the von Neumann stability analysis, show that the FTCS method as applied to solve 1D transient heat conduction equation (given below) is conditionally stable $\frac{\partial u}{\partial t} = \alpha \frac{\partial^2 u}{\partial x^2}$ [12]

Q.4 Consider the steady 2D heat conduction in a long rectangular body the cross-section of which is shown in figure. The boundary conditions are as indicated on the figure. Solve the problem by finite-difference scheme so that steady state temperature distribution can be computed. For discretization use the dimensional form of the governing equation printed below. [12]

$$\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} = 0$$



Q.5 Apply stream function-vorticity formulation for solving incompressible fluid flow. Write down the governing equations in discretized form. [12]

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Q.6(a) What is the difference between finite volume method and finite difference method? [2]

Q.6(b) A large plate of thickness L= 2 cm with constant thermal conductivity k = 0.5 W/m.K and uniform heat generation q = 100kW/m^3. The faces A & B are at temperatures 100°C & 200°C respectively. Calculate steady state temperature distribution using finite volume method. Assume one dimensional heat transfer. [10]

Q.7(a) Explain the VOF model with an suitable example. Mention the governing equations required for numerical simulation. [12]

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