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

CLASS: BE **SEMESTER : VII**
BRANCH: CE/C&P **SESSION : MO/19**

SUBJECT: CL7017 COMPUTATIONAL FLUID DYNAMICS

TIME:3:00 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) What is Computational Fluid Dynamics? [2]
Q.1(b) Write simplified flow model for inviscid fluid flow. Name the fundamental laws and conservation quantity from which this equation is derived. [4]
Q.1(c) Write the generic transport equation and extract the equations of continuity, momentum and energy from this generic transport equation (show the steps and explain your working). [6]

Q.2(a) What are the types of boundary conditions? Explain one of them briefly. [2]
Q.2(b) Write short notes on Gauss-Elimination and Gauss-Seidel iterative method. [4]
Q.2(c) Determine the order, linearity and nature of the given partial differential equation: [6]

$$\beta\frac{\partial^2 T}{\partial t^2}+\frac{\partial T}{\partial t}=\alpha\frac{\partial^2 T}{\partial x^2}$$ where α and β are positive, real constants.

Q.3(a) What do you mean by descritization? [2]
Q.3(b) Calculate the numerical value of $(d\,(7x^3)\,/\,dx)$ at $x = 1$, using central difference approximation of second order accuracy, taking $\Delta x = 0.5$ and 0.1. Which answer will be more accurate and why? [4]
Q.3(c) Check the consistency for one dimensional diffusionless and sourceless partial differential equation by the use of FTCS scheme. [6]

Q.4(a) What is meant by grid independent solution? [2]
Q.4(b) Obtain a 3 – point backward difference expression for y_i'', having a truncation error of $O(\Delta x)$ on a uniform grid. [4]
Q.4(c) The finite difference scheme of the linear diffusion equation $\frac{\partial u}{\partial t}=\alpha\frac{\partial^2 u}{\partial x^2}$ ($\alpha > 0$) is given by [6]

$$\frac{u_i^{n+1}-u_i^n}{\Delta t}=\alpha\left[\frac{u_i^n-2u_i^n+u_{i-1}^n}{(\Delta x)^2}\right]$$ perform the von Neumann stability analysis and comment on the stability of the scheme.

Q.5(a) Consider a hot plate of finite thickness 2L that is suddenly exposed to a cool fluid at T_∞. The initial temperature of the plate is T_i ($T_i > T_\infty$). Heat transfer coefficient is moderate and thermophysical properties are constant. Set up the explicit finite-difference equations by taking four grid nodes in the computational domain. Take the left half of the physical domain as your computational domain. For discretization use the dimensional form of the governing equation as shown below. [12]

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

Q.6(a) State any two dimensionless numbers related to the stability of numerical scheme. [2]
Q.6(b) Non-dimensionalize the given governing equation and associated boundary conditions in above question 5. [4]
Q.6(c) Write the descritizated equations of one dimensional transient heat conduction problem by using all three (Euler, Crank-Nicolson and pure implicit) methods. [6]

Q.7(a) Write full form of SIMPLE. [2]
Q.7(b) Why pressure-velocity coupling is required to solve the incompressible fluid flow problems? [4]
Q.7(c) Derive the vorticity transport equation for the solution of viscous incompressible flows. [6]

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