BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI
(END SEMESTER EXAMINATION SP2023)

CLASS:	**B.Tech**	**SEMESTER : VI**
BRANCH:	**Mechanical**	**SESSION : SP/2023**

SUBJECT: ME353 COMPUTATIONAL FLUID DYNAMICS

TIME:	**03 Hours**	**FULL MARKS: 50**

INSTRUCTIONS:
1. The question paper contains 5 questions each of 10 marks and total 50 marks.
2. Attempt all questions.
3. The missing data, if any, may be assumed suitably.

			CO	BL
Q.1(a)	Answer the following questions in brief in one or two sentences. (i) Write down the continuity equation for a compressible flow in conservation form for both finite and infinitesimally small control volumes. (ii) What are the difficulties associated with solving the mass, momentum and energy equations using analytical methods? (iii) What is the difference between the conservative and non-conservative forms of the flow equations? Do they represent different equations? (iv) What is the underlying principle behind application of any numerical technique like FDM, FVM, etc. for any PDE associated with fluid flow? (v) For determining the temperature variation in a steady non-isothermal flow in a non-viscous fluid, what are the essential terms that need to be resolved in the energy equation.	[2x5=10]	1	2,3
Q.2(a)	State the significance of initial conditions (IC) and boundary conditions (BC) for solving the governing PDEs using FDM in the given problem domain. How does the IC affect the elliptic, parabolic and hyperbolic type PDEs?	[3]	2	2
Q.2(b)	Derive the central and forward difference scheme for a second order derivative. What is their order of accuracies?	[4]	2	2
Q.2(c)	Define consistency of a numerical scheme. What are the different type of errors associated with numerical modelling in a computing machine. What basic steps can be taken to reduce these errors?	[3]	2	2,3
Q.3(a)	What are the essential characteristics of a well-posed problem? What is the Lax Equivalence theorem?	[2]	3	1
Q.3(b)	For the equation, $\frac{\partial \emptyset}{\partial t} = \frac{\partial^2 \emptyset}{\partial x^2}$, carry out the stability analysis using both the Matrix method and the Fourier Series method for explicit formulation.	[8]	3	2,3
Q.4(a)	Using Richtmeyer linearization technique, determine the value of φ for the equation given below over the entire domain after the first time-step only. Take domain length equal to 1 m. Use FDM and take 4 interior nodes, apart from 2 boundary nodes. Take time step equal to 0.1 s. Use line TDMA wherever applicable. $$\frac{\partial \emptyset}{\partial t} = \frac{\partial^2 \emptyset^2}{\partial x^2}$$ $$IC: \emptyset = 4x(1-x), 0 \le x \le 1, \quad BC: \emptyset = 0 \; at \; x = 0,1$$	[10]	4	4
Q.5(a)	Consider the 1D transient diffusion equation shown below, over a domain of 10 mm. Discretize the domain into 5 control volumes showing the position of their nodes and faces. It is given that left boundary is maintained at a value of φ = 100, and the right boundary is insulated. Also, the initial value of φ over the entire domain is equal to 1. Take time step size =0.1s. Solve for the value of the variable 'φ' at 0.1s and 0.2 s at all the nodes and the right boundary, using explicit Finite Volume Method formulation, showing all the steps involved. $$\frac{\partial \emptyset}{\partial t} = \frac{\partial^2 \emptyset}{\partial x^2} + S, where \; S = 5 - 3\emptyset$$	[10]	5	4