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

CLASS: BTECH **SEMESTER : V**
BRANCH: MECHANICAL **SESSION : MO/2025**

SUBJECT: ME353 COMPUTATIONAL FLUID DYNAMICS

TIME: 3 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.
4. Before attempting the question paper, be sure that you have got the correct question paper.

			CO	BL
Q.1(a)	Show the analysis of rate of work done by various forces that represents a term in energy equation considering a three dimensional differential volume element of thicknesses dx, dy, and dz.	[5]	1	4
Q.1(b)	Explaining each steps followed, show the analysis of rate of change of momentum in terms of substantial derivative in a three dimensional differential volume element of thicknesses dx, dy, and dz as shown below: $$m.a = \rho \frac{D\bar{V}}{Dt} dx.dy.dz$$	[5]	1	4
Q.2(a)	The governing equations of motion for one dimensional invicid flow are given by the Euler equations. If the assumption of perfect gas is imposed, the system is written as shown below. Classify the system of equations. $$\frac{\partial \rho}{\partial t} + u\frac{\partial \rho}{\partial x} + \rho\frac{\partial u}{\partial x} = 0$$ $$\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + \frac{1}{\rho}\frac{\partial p}{\partial x} = 0$$ $$\frac{\partial p}{\partial t} + u\frac{\partial p}{\partial x} + \rho a^2\frac{\partial u}{\partial x} = 0$$	[5]	2	4
Q.2(b)	Explain various initial and boundary conditions used in CFD solution.	[5]	2	3
Q.3(a)	Evaluate the finite difference approximations of the following: (i) Backward difference approximation $\frac{\partial^2 f}{\partial x^2}$ of $O(\Delta x)$ (ii) Forward difference approximation $\frac{\partial f}{\partial x}$ of $O[(\Delta x)^2$	[5]	3	4
Q.3(b)	Analyze the finite difference approximation of the following mixed partial derivative using any of the methods 'Taylor Expansion' or 'with respect to one independent variable'. $$\frac{\partial^2 f}{\partial x \partial y} \; of \; O[\Delta x^2, \Delta y^2]$$	[5]	3	4
Q.4(a)	Explain the difference between Implicit and Explicit schemes.	[5]	4	3
Q.4(b)	Explain the following scheme for a model equation shown below with their stability condition. (i)FTCS scheme (ii)Crank-Nicolson scheme Model equation: $$\frac{\partial u}{\partial t} = \alpha\frac{\partial^2 u}{\partial x^2}$$ where *a* is a constant.	[5]	4	4

PTO

Q.5(a)	Why stability analysis of finite difference schemes is needed for a CFD solution? Interpret in few words about “Dynamic instability” and “Static instability”.	[5]	5	3
Q.5(b)	Explain the ‘Fourier component’ for Von Neumann Stability Analysis. For the model equation shown below, evaluate the stability criteria in terms of diffusion number ($d = \alpha\Delta t/\Delta x^2$). Model equation: $\frac{\partial \varphi}{\partial t} = \alpha \frac{\partial^2 \varphi}{\partial x^2}$ where α is a constant.	[5]	5	4

::::::25/11/2025::::::M