Indian Maritime University

(A Central Univers4ity, Govt of India)

Sep/Oct'25 SE

Programme Name: B Tech (ME)

Semester: V

Subject Code: UG11T4501

Subject Name: Introduction to CFD

Date: 07.10.2025 Max Marks: 70

Duration: 03 Hrs Pass Marks: 35

General Instructions

(i) All Sections (A, B & C) are to be attempted.
(ii) Options, if any, are specified in respective section.

Section A

Choose the correct answer as applicable. [1x10=10]

1. Where do we encounter partial differential equations in CFD?
   a) Physical models b) Assumptions
   c) Governing equations d) Discretized equations

2. What is the physical principle behind momentum equation?
   a) Newton's second law of motion b) Newton's first law of motion
   c) Zeroth law of thermodynamics d) First law of thermodynamics

3. Which of these is used to analyse the stability of a system?
   a) Nusselt number b) Courant number
   c) Peclet number d) Von Neumann's method

4. What is the method used in CFD to solve partial differential equations?
   a) Variable separation b) Method of characteristics
   c) Change of variables d) Discretization

5. Which of these equations is hyperbolic?
   a) Unsteady Navier-Stokes b) Steady Navier-Stokes
   c) Steady Euler d) Unsteady Euler

6. For which of the following purposes can an automobile company not use the CFD tool?
   a) Study heat transfer between its parts
   b) Increase aerodynamic performance
   c) Increasing load capacity
   d) Increasing fuel economy

7. MacCormack's technique is
   a) implicit, finite difference method
   b) implicit, finite volume method
   c) explicit, finite difference method
   d) explicit, finite volume method

8. The approach of observing a moving fluid element from a fixed point in space is called as ___________ approach.

9. Find the central second difference of u in y-direction using the Taylor series expansion
   a) $\frac{u_{i,j+1} + 2u_{i,j} + u_{i,j-1}}{(\Delta y)^2}$
   b) $\frac{u_{i,j+1} - 2u_{i,j} + u_{i,j-1}}{(\Delta y)^2}$
   c) $\frac{u_{i,j+1} - 2u_{i,j} - u_{i,j-1}}{(\Delta y)^2}$
   d) $\frac{u_{i,j+1} + 2u_{i,j} - u_{i,j-1}}{(\Delta y)^2}$

10. The time rate of change of the volume of a moving fluid element per unit volume is ___________________

Section B

Five Questions of 02 Marks each [2x5=10]

11. Write steps involved in modelling of the flow.

12. Explain Lagrangian approach in fluid dynamics.

13. Explain substantial derivative and write the notation for it.

14. What do you understand by finite control volume?

15. Evaluate $\int_1^5 \frac{1}{x} dx$ using Simpson's one third rule.

Section C

Answer any 05 questions [10x5=50]

16. Derive Navier-Stokes equation in conservation form.

17. Derive the non-conservation form of the energy equation.

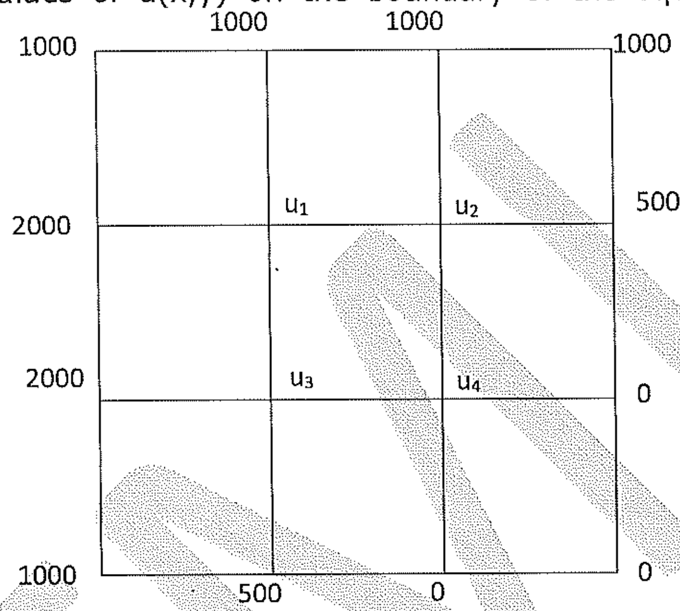
18. (a) Apply Runge-Kutta fourth order method to find an approximate value of y when x = 0.2 given that dy/dx = x + y and y = 1 when x = 0.
    (b) Explain in detail about the divergence of velocity?

19. (a) Derive integral form of the continuity equation with Eulerian approach.
    (b) Define CFD with its applications. What are its advantages?

20. Apply Du Fort and Frankel method on parabolic partial differential equation and show difference scheme for both.

21. Find the solution of the initial boundary value problem: $\frac{\partial^2 u}{\partial t^2} = \frac{\partial^2 u}{\partial x^2}, 0 \le x \le 1$; subject to the initial conditions $u(x,0) = \sin \pi x, 0 \le x \le 1$, $\left(\frac{\partial u}{\partial t}\right)(x,0) = 0$, $0 \le x \le 1$ and the boundary conditions u(0,t) = 0, u(1,t) = 0, t>0; by using in the (i) explicit scheme, (ii) implicit scheme.

22. Given the values of u(x,y) on the boundary of the square in the figure shown.



Evaluate the function u(x,y) satisfying the Laplace equation $\nabla^2 u = 0$ at the pivotal points of this figure by (a) Jacobi's method and (b) Gauss Seidal method.