Seat No:_____ Enrollment No:_____

PARUL UNIVERSITY

FACULTY OF APPLIED SCIENCE

M.Sc. Summer 2022-23 Examination

Semester: 4 **Date: 27/03/2023**
Subject Code: 11206256 **Time: 2:00pm to 4:30pm**
Subject Name: Computational Fluid Dynamics **Total Marks: 60**

Instructions:
1. All questions are compulsory.
2. Figures to the right indicate full marks.
3. Make suitable assumptions wherever necessary.
4. Start new question on new page.

Q.1. A) Answer the following questions: **(08)**

(a) Define Computational Fluid Dynamics (CFD). Also, state the objectives and advantages of CFD.

(b) Solve the elliptic equation $u_{xx} + u_{yy} = 0$ for the following square mesh with boundary values as shown in the following figure-1. Iterate until the maximum difference between two successive values at any point is less than 0.001 by Gauss-Seidel method.

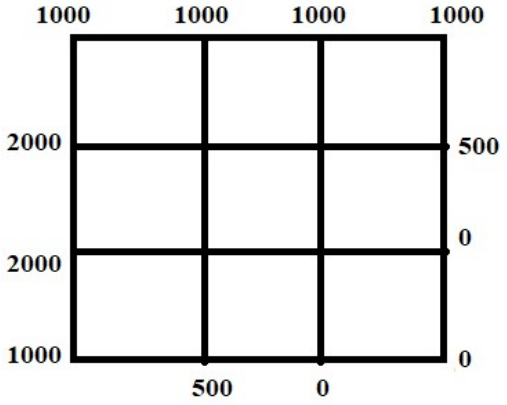

Figure-1

Q.1. B) Answer the following questions: (Any two)

(a)1. Classify the partial differential equation: $t\,u_{tt} + 3\,u_{xt} + 2\,u_{xx} + 3u_x = 0$, where $t \in R$. **(04)**

2. Define Dirichlet and Neumann boundary Conditions in CFD.

(b) Explain the Finite Volume Method steps for solving a 1- Dimensional steady state Diffusion Problem stated as $\frac{d}{dx}\left(\Gamma\frac{d\phi}{dx}\right) + s = 0$. Where, Γ is the diffusion co-efficient, s is the source term, ϕ is the unknown function to be determined. **(04)**

(c) Define consistency, stability, convergence, and truncation error in a Finite Difference Scheme. **(04)**

Q.2. A) Answer the following questions.

(a) 1. State any two advantages of the Finite Difference Method over the Finite Volume Method? **(04)**

2. Find the truncation error for first order derivative with respect to 'x' applying backward finite difference scheme on $u(x,t)$.

(b) State any two points of differences between Experiments and Simulations in CFD. **(04)**

Q.2. B) Answer the following questions (Any two)

(a) Choose any one of the following options for each multiple-choice questions given below: **(03)**

1. What is the order of accuracy of the Mac-Cormack's technique?
   a) Fourth-order b) Third-order c) First-order d) Second-order
2. CFD provides results of _____.
   a) Continuous time varying results at discrete locations
   b) Discrete points of space and time
   c) Continuous spatial results at discrete time points
   d) Continuous in time and space
3. The region of interest for analysis in CFD is called as _____.
   a) Cell b) Domain c) Mesh d) Grid

(b) Find the order of accuracy for the 1-Dimension linear convection equation: $u_t + a\,u_x = 0$ by discretizing in Forward time and Forward space in domain. **(03)**

(c) Derive equation of continuity for a fluid element. **(03)**

Q.3. A) Answer the following questions: **(08)**

(a) State the difference between FDM and FVM.

(b) Explain briefly about any four applications of CFD.

Q.3. B) Answer the following questions (Any two)

(a)1. State Lax equivalence theorem. **(04)**

2. State the number of initial and boundary conditions required for solving one dimensional heat equation and one-dimensional wave equation.

(b) Explain Mac-Cormack technique in CFD for calculating density of a fluid flow. **(04)**

(c) Define Errors and explain the types of errors in a Finite Difference Scheme. **(04)**

Q.4. A) Answer the following questions.

(a) 1. State any one name of the following: **(04)**

i. A pre-processing software ii. A post processing software

2. Which type of equation is generated by a control volume-based model?

(b) Define flux and explain types of fluxes in a fluid flow problem. **(04)**

Q.4. B) Answer the following questions (Any two)

(a) Choose any one of the following options for each multiple-choice questions given below. **(03)**

1. What are the two major types of boundary conditions?
   a) Wall and symmetry b) Inlet and outlet
   c) Dirichlet and Neumann d) Initial and physical
2. The Lax-Wendroff technique is _____
   a) explicit, finite-difference method b) implicit, finite-difference method
   c) explicit, finite volume method d) implicit, finite volume method
3. What does the mathematical model of a fluid flow contain?
   a) Partial differential equations
   b) Discretized partial differential equations
   c) Partial differential equations and boundary conditions
   d) Discretized partial differential equations and boundary conditions

(b) Write a short note on Multi-dimensional Euler equation. **(03)**

(c) Explain in detail the shock capturing method in CFD. **(03)**