Printed Page:- 03 **Subject Code:- AMTME0214**
Roll. No:

NOIDA INSTITUTE OF ENGINEERING AND TECHNOLOGY, GREATER NOIDA
(An Autonomous Institute Affiliated to AKTU, Lucknow)
M.Tech
SEM: II - THEORY EXAMINATION (2023 - 2024)
Subject: Computational Fluid Dynamics

Time: 3 Hours **Max. Marks: 70**

General Instructions:

IMP: *Verify that you have received the question paper with the correct course, code, branch etc.*
1. *This Question paper comprises of* ***three Sections -A, B, & C.*** *It consists of Multiple Choice Questions (MCQ's) & Subjective type questions.*
2. *Maximum marks for each question are indicated on right -hand side of each question.*
3. *Illustrate your answers with neat sketches wherever necessary.*
4. *Assume suitable data if necessary.*
5. *Preferably, write the answers in sequential order.*
6. *No sheet should be left blank. Any written material after a blank sheet will not be evaluated/checked.*

SECTION A 15

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1. Attempt all parts:-

1-a. Which numerical method is commonly used for solving partial differential equations in CFD? (CO1) 1

(a) Finite difference method
(b) Finite element method
(c) Finite volume method
(d) Spectral method

1-b. Which type of equation is used to model diffusion-dominated phenomena? (CO2) 1

(a) Parabolic equation
(b) Elliptic equation
(c) Hyperbolic equation
(d) Ordinary differential equation

1-c. In finite difference methods, what does the term "central differencing" refer to? (CO3) 1

(a) A method that uses neighboring grid points to approximate derivatives
(b) A method that considers only one-sided differences
(c) A method that uses forward and backward differences simultaneously
(d) A method that interpolates values at the center of the grid

1-d. What is the purpose of using the Alternating Direction Implicit (ADI) method in computational fluid dynamics simulations? (CO4) 1

(a) To achieve numerical stability in solving time-dependent equations
(b) To reduce computational cost
(c) To improve accuracy in resolving spatial gradients
(d) To handle non-linearities in the governing equations

1-e. Which numerical method is based on the minimization of a functional through a weighted residual approach? (CO5) 1

(a) Rayleigh-Ritz method

(b) Galerkin method

(c) Least square method

(d) Finite difference method

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2. Attempt all parts:-

2.a. Define the term "convective form of the equation" in the context of fluid dynamics. (CO1) 2

2.b. Define parabolic equations in the context of partial differential equations and explain their significance in modeling transient phenomena.(CO2) 2

2.c. What is the fundamental principle behind finite volume methods? (CO3) 2

2.d. Describe the concept of iterative methods in the context of solving finite difference equations. (CO4) 2

2.e. What is the objective of the Galerkin method in CFD simulations? (CO5) 2

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SECTION B 20

20

3. Answer any <u>five</u> of the following:-

3-a. Explain the concept of conservation equations in Computational Fluid Dynamics (CFD) and their role in fluid flow simulations. (CO1) 4

3-b. Analyze the significance of boundary conditions in CFD simulations and their impact on the accuracy of results. (CO1) 4

3-c. Explain the concept of boundary conditions and their role in defining the behavior of solutions in computational fluid dynamics simulations. (CO2) 4

3-d. Discuss the significance of initial conditions in solving partial differential equations, particularly in transient flow simulations. (CO2) 4

3.e. Explain the concept of Taylor series expansion and its role in formulating finite difference equations. (CO3) 4

3.f. Discuss the advantages and limitations of the Alternating Direction Implicit (ADI) method in numerical simulations. (CO4) 4

3.g. Describe the concept of phase change problems in CFD and provide an example of their application. (CO5) 4

SECTION C 35

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4. Answer any <u>one</u> of the following:-

4-a. Explain the derivation process of conservation equations for mass, momentum, and energy in fluid dynamics, emphasizing the physical principles involved and their mathematical representations. (CO1) 7

4-b. Evaluate the role of boundary conditions in Computational Fluid Dynamics (CFD) simulations, considering their impact on solution accuracy and stability, and proposing strategies to address boundary condition challenges. (CO1) 7

7

5. Answer any <u>one</u> of the following:-

5-a.	Compare and contrast the finite difference method, finite element method, and finite volume method in terms of their numerical discretization techniques, applications, and advantages in solving partial differential equations. (CO2)	7
5-b.	Analyze the challenges associated with solving elliptic equations numerically, including issues related to mesh generation, solution convergence, and computational cost. (CO2)	7

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6. Answer any <u>one</u> of the following:-

6-a.	Discuss the different approaches for treating boundary conditions in finite difference methods. Include discussions on Dirichlet, Neumann, and mixed boundary conditions, and provide examples illustrating their application in numerical simulations. (CO3)	7
6-b.	Describe the process of integrating conservation equations over elements in finite difference methods. Discuss the significance of integration and its impact on the accuracy of numerical solutions. Provide examples to support your explanation. (CO3)	7

7 7

7. Answer any <u>one</u> of the following:-

7-a.	Discuss the role of matrix inversion methods, such as LU decomposition, in solving large systems of linear equations arising from finite difference discretizations. Provide examples of their application in computational fluid dynamics simulations. (CO4)	7
7-b.	Describe the process of solving finite difference equations using iterative methods like the Successive Over-Relaxation (SOR) method. Discuss how relaxation parameters affect convergence and computational efficiency. (CO4)	7

8 7

8. Answer any <u>one</u> of the following:-

8-a.	Discuss the Rayleigh-Ritz method in detail, including its theoretical foundations, the process of approximation, and its applications in solving differential equations. Compare and contrast the Rayleigh-Ritz method with other numerical techniques used in CFD simulations. (CO5)	7
8-b.	Compare and contrast one-dimensional and two-dimensional elements in CFD meshing, considering their geometric representations, numerical properties, and applications. Evaluate the advantages and disadvantages of each type of element in different simulation scenarios. (CO5)	7