Hall Ticket No | | | | | | | | | | | Question Paper Code: AAE013

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

MODEL QUESTION PAPER - II

B. Tech VI Semester End Examinations, April/May – 2020

Regulations: IARE - R16

COMPUTATIONAL AERODYNAMICS

(AERONAUTICAL ENGINEERING)

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

Answer ONE Question from each Unit
All Questions Carry Equal Marks
All parts of the question must be answered in one place only

UNIT – I

1. a) Explain how the continuity equation derived from these flow models can be converted from conservative to non-conservative form. **[7M]**

   b) Describe the details that CFD can capture in the simulation of hydro Cyclones a process commonly used in the minerals industry? **[7M]**

2. a) How CFD is helpful as a research tool, a design tool, and an educational tool in analyzing fluid dynamical problems. **[7M]**

   b) Derive momentum equation in conservation form using infinitesimal small fluid element moving with the flow. **[7M]**

UNIT – II

3. a) How will be the mathematical behaviour of various types of partial differential Equations? **[7M]**

   b) Classify the following partial differential equations according to their nature as elliptic, parabolic, hyperbolic **[7M]**
   (a)Unsteady Thermal Conduction Equation
   (b)Laplace's Equation (c)Second-order wave equation (d)First-order wave equation

4. a) Write short notes on the following: **[7M]**
   (a)Parabolized Navier-Stokes equations (b) Well-posed problems.

   b) Explain the mathematical and physical nature of flows governed by parabolic Equations with an illustration of a steady boundary layer flow. **[7M]**

UNIT – III

5. a) Discuss the main advantages and disadvantages of discretization of the Governing equations through the finite difference method. **[7M]**

   b) Explain Lax method for one dimensional wave equation and explain the stability criterion for hyperbolic equations **[7M]**

6. a) Explain the importance of grid generation in CFD process and discuss the difference between structured grid and unstructured grid. **[7M]**

b) Explain C-H, H-O-H, O-H grid topologies with sketches along with their applications. **[7M]**

UNIT – IV

7. a) Explain explicit Lax-Wendroff technique for an unsteady, two-dimensional, Inviscid flow. **[7M]**

b) Discuss numerical dissipation and numerical dispersion in the context of Numerical solution to fluid dynamical problems. **[7M]**

8. a) Describe a relaxation method for solving the elliptical partial differential equations. **[7M]**

b) Discuss MacCormack explicit predictor-corrector method using an example. **[7M]**

UNIT – V

9. a) What is a Finite Volume Method? Explain the importance of FVM in CFD. **[7M]**

b) How Finite Volume Method is different from Finite Difference Method & Finite Element Method? **[7M]**

10. a) Define finite volume discretization and explain the features which distinguish the interpretation of finite volume methods from the finite difference approach. **[7M]**

b) Explain the two-dimensional finite volume method and describe evaluation of fluxes through cell surfaces using central discretization schemes. **[7M]**

COMPUTATIONAL AERODYNAMICS

COURSE OBJECTIVES

The course should enable the students to:

S. No	Description
I	Discuss the fundamental aspects of numerical discretization and the major theories, approaches and methodologies used in computational aerodynamics
II	Analyze to build up the skills in the actual implementation of computational aerodynamics methods boundary conditions, turbulence modeling etc by using commercial CFD codes
III	Demonstrate the applications of CFD for classic fluid dynamics problems and basic thoughts and philosophy associated with CFD
IV	Understand the various grids used in practice, including some recommendations related to grid quality and choose appropriate data structure to solve problems in real world.

COURSE OUTCOMES (COs):

CO 1:	Understand the applications of CFD in various engineering fields and to generate governing equations in conservative and non-conservative form.
CO 2:	Understand the mathematical behavior of partial differential equations and classify into hyperbolic, parabolic and elliptical natures.
CO 3:	Acquire the concepts of finite difference method through discretization and grid generation techniques.
CO 4:	Identify different CFD techniques available for different partial differential equations.
CO 5:	Explore the concepts of finite volume methods, and its difference from finite difference method.

COURSE LEARNING OUTCOMES

Students, who complete the course, will be able to demonstrate the ability to do the following

AAE013.01	Understand the necessity of CFD tool as both research and design areas in modern computational world.
AAE013.02	Explain the applications of computational fluid dynamics tool in various engineering branches other than aerospace engineering.
AAE013.03	Recognize the selection of type of flow from the finite control volume and infinitesimal small fluid element depending upon the requirements.
AAE013.04	Develop the governing equations required for computational aerodynamics in both conservation and non-conservation forms.
AAE013.05	Explain the need of classification of quasi linear partial differential equations by Cramer's rule and Eigen Value Method.
AAE013.06	Understand the concepts of range of influence and domain of dependence for a flow field.
AAE013.07	Explain the general behaviour of the partial differential equations which falls in hyperbolic, parabolic and elliptic equations.
AAE013.08	Demonstrate the CFD aspects of the hyperbolic, parabolic and elliptic equations in aerodynamic problems and physical problems.
AAE013.09	Discuss the concepts of finite differences approximation for first order, second order and mixed order derivatives.
AAE013.10	Distinguish between explicit and implicit approaches that are needed for solving different finite differential equations.
AAE013.11	Explain the Consistency analysis and von Neumann stability analysis of finite difference methods and physical significance of CFL condition.
AAE013.12	Discuss the different types of grids available for different flow fields available in computational fluid dynamics.

AAE013.13	Understand the need for generating grids for solving the finite differential equations in analyzing a flow field.
AAE013.14	Describe the various CFD techniques available for solving the finite differential equations for a flow field.
AAE013.15	Discuss the aspects of numerical dissipation and numerical dispersion and explain the applications of each in CFD techniques.
AAE013.16	Explain the technique of pressure correction method with the need of staggered grid and its philosophy.
AAE013.17	Explain the numerical procedures for analysis like SIMPLE, SIMPLER SIMPLEC and PISO algorithms and differentiate with regular CFD techniques.
AAE013.18	Discuss the concepts of finite volume method and explain the difference from finite difference method for solving different flow field.
AAE013.19	Demonstrate the need of finite volume discretization and its general formulation of a numerical scheme in finite volume method.
AAE013.20	Understand the principle of two dimensional finite volume method in solving flow fields with finite control volume.

MAPPING OF SEE – COURSE OUTCOMES

SEE Question No		Course Learning Outcomes		Course Outcomes	Blooms Taxonomy Level
1	a	AAE013.04	Develop the governing equations required for computational aerodynamics in both conservation and non-conservation forms.	CO 1	Understand
	b	AAE013.02	Explain the applications of computational fluid dynamics tool in various engineering branches other than aerospace engineering.	CO 1	Understand
2	a	AAE013.01	Understand the necessity of CFD tool as both research and design areas in modern computational world.	CO 1	Remember
	b	AAE013.04	Develop the governing equations required for computational aerodynamics in both conservation and non-conservation forms.	CO 1	Remember
3	a	AAE013.08	Demonstrate the CFD aspects of the hyperbolic, parabolic and elliptic equations in aerodynamic problems and physical problems.	CO 2	Remember
	b	AAE013.07	Explain the general behaviour of the partial differential equations which falls in hyperbolic, parabolic and elliptic equations.	CO 2	Understand
4	a	AAE013.08	Demonstrate the CFD aspects of the hyperbolic, parabolic and elliptic equations in aerodynamic problems and physical problems.	CO 2	Remember
	b	AAE013.08	Explain the general behaviour of the partial differential equations which falls in hyperbolic, parabolic and elliptic equations.	CO 2	Understand
5	a	AAE013.09	Discuss the concepts of finite differences approximation for first order, second order and mixed order derivatives.	CO 3	Remember
	b	AAE013.11	Explain the Consistency analysis and von Neumann stability analysis of finite difference methods and physical significance of CFL condition.	CO 3	Understand
6	a	AAE013.11	Explain the Consistency analysis and von Neumann stability analysis of finite difference methods and physical significance of CFL condition.	CO 3	Understand
	b	AAE013.12	Discuss the different types of grids available for different flow fields available in computational fluid dynamics.	CO 3	Remember
7	a	AAE013.14	Describe the various CFD techniques available for solving the finite differential equations for a flow field.	CO 4	Remember

	b	AAE013.17	Explain the numerical procedures for analysis like SIMPLE, SIMPLER SIMPLEC and PISO algorithms and differentiate with regular CFD techniques.	CO 4	Understand
8	a	AAE013.14	Describe the various CFD techniques available for solving the finite differential equations for a flow field.	CO 4	Remember
	b	AAE013.14	Describe the various CFD techniques available for solving the finite differential equations for a flow field.	CO 4	Remember
9	a	AAE013.18	Discuss the concepts of finite volume method and explain the difference from finite difference method for solving different flow field.	CO 5	Remember
	b	AAE013.19	Demonstrate the need of finite volume discretization and its general formulation of a numerical scheme in finite volume method.	CO 5	Remember
10	a	AAE013.19	Demonstrate the need of finite volume discretization and its general formulation of a numerical scheme in finite volume method.	CO 5	Understand
	b	AAE013.19	Demonstrate the need of finite volume discretization and its general formulation of a numerical scheme in finite volume method.	CO 5	Remember

Signature of Course Coordinator **HOD, AE**