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

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

MODEL QUESTION PAPER - I

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) Discuss with a neat diagram shock capturing method along with its merits and demerits. Explain why conservation form of governing equations is important for calculations using shock capturing method. **[7M]**

   b) Discuss how Computational Fluid Dynamics is vital in the following fields. **[7M]**
   i) Automobile engineering, ii) Industrial manufacturing, iii) Civil engineering, iv) Medical field

2. a) Write short notes on non-conservative form of governing equations. Derive continuity equation in non-conservation form using infinitesimal small fluid element moving in space. **[7M]**

   b) Explain the physical meaning of Divergence of Velocity that frequently appears in the equations of fluid dynamics. Define substantial Derivative and explain its physical meaning. **[7M]**

UNIT – II

3. a) Explain the classification of the following quasi-linear partial differential equations using Cramer's rule: **[7M]**
   $a1(\partial u/\partial x)+ b1(\partial u/\partial y)+ c1(\partial v/\partial x)+ d1(\partial v/\partial y)=f1$
   $a2(\partial u/\partial x)+ b2(\partial u/\partial y)+ c2(\partial v/\partial x)+ d2(\partial v/\partial y)=f2$
   Where u and v are dependent variables, continuous functions of x and y and a1, a2, b1, b2, c1, c2, d1, d2, f1, f2 can be functions of x, y, u and v.

   b) Discuss the mathematical and physical behavior of flows governed by Parabolic equations with an example of unsteady thermal conduction in two and three dimensions. **[7M]**

4. a) Discuss the physical behavior of flows governed by parabolic equations with an example of steady boundary layer flows. Explain PNS model for high speed flows and explain its merits. **[7M]**

b) Discuss the mathematical and physical nature of flows governed by elliptic equations with an illustration of incompressible, inviscid flow. Explain Neumann and Dirichlet boundary conditions. **[7M]**

UNIT – III

5. a) Write down the formulation of central difference scheme for u velocity in the X direction. What is the truncation error in terms of Δx and state the order of this discretization scheme? **[7M]**

b) Write short notes on the following properties of numerical solutions of fluid flows: i) Stability ii) Consistency iii) Accuracy iv) Convergence. **[7M]**

6. a) Define structured and unstructured grids. Discuss various configurations of Body-fitted structured grids and multi-block grids with the help of sketches. **[7M]**

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

UNIT – IV

7. a) Explain explicit MacCormack Technique for a steady, two-dimensional, supersonic, inviscid flow field in(x, y) space using the following generic conservation form without source terms:$\partial F/\partial x=-\partial G/\partial y$ where F and G represent flux vectors formed from the governing equations. **[7M]**

b) Describe the SIMPLE algorithm step by step for estimation of velocity and Pressure fields in solving incompressible viscous flow problems. **[7M]**

8. a) Explain checker-board behavior of velocity and pressure fields in central Discretization schemes using sketches and explain how such behavior can be avoided. **[7M]**

b) Explain Crank-Nicolson implicit scheme used for solving the parabolic Partial differential equations **[7M]**

UNIT – V

9. a) Explain cell-centered and cell-vertex discretization methodologies used in Finite volume approach with the help of sketches. What are the constraints to be satisfied on the choice of discretized control volumes for a consistent finite volume method? **[7M]**

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

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

b) Explain the reasons that make finite volume method superior to other discretization methods in CFD. Discuss the cell-centered and cell-vertex approaches to finite volume discretization using sketches **[7M]**

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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	AAE013.04	Develop the governing equations required for computational aerodynamics in both conservation and non-conservation forms.	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	AAE013.05	Explain the need of classification of quasi linear partial differential equations by Cramer's rule and Eigen Value Method.	CO 2	Remember
	b	AAE013.08	Demonstrate the CFD aspects of the hyperbolic, parabolic and elliptic equations in aerodynamic problems and physical problems.	CO 2	Understand
4	a	AAE013.07	Explain the general behaviour of the partial differential equations which falls in hyperbolic, parabolic and elliptic equations.	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
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	AAE013.11	Explain the Consistency analysis and von Neumann stability analysis of finite difference methods and physical significance of CFL condition.	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	AAE013.16	Explain the technique of pressure correction method with the need of staggered grid and its philosophy.	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**