INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

AERONAUTICAL ENGINEERING

QUESTION BANK

Department	**AERONAUTICAL ENGINEERING**					
Course Title	**COMPUTATIONAL AERODYNAMICS**					
Course Code	AAEC25					
Program	B.Tech					
Semester	VI					
Course Type	CORE					
Regulation	UG-20					
Course Structure	Theory			Practical		
	Lecture	Tutorials	Credits	Laboratory	Credits	
	3	1	4	-	-	
Course Coordinator	Mr. A Rathan Babu, Assistant Professor.					

COURSE OBJECTIVES:

The students will try to learn:

I	The concepts of grid generation techniques for simple and complex domains to model fluid flow problems.
II	The aspects of numerical discretization techniques such as finite volume and finite difference methods.
III	The mathematical modeling of different classes of partial differential equations to show their impact on computational fluid dynamics.
IV	The characteristics of different turbulence models and numerical schemes for estimating the criteria of stability, convergence, and error of fluid flow problem.

COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Summarize** the concepts of computational fluid dynamics and its applications in industries as a tool for fluid analysis.	Understand
CO 2	**Choose** the type of flow from the finite control volume and infinitesimal small fluid element for the fluid flow analysis.	Apply
CO 3	**Select** the quasi linear partial differential equation for estimating the behavior in computational fluid dynamics.	Apply

CO 4	**Identify** CFD techniques for relevant partial differential equations for getting analytical solutions for fluid flow problems.	Apply
CO 5	**Make use of** finite difference approach for numerical formulations based on fluid mechanics and heat transfer concepts for getting the solutions of fluid flow problems.	Apply
CO 6	**Utilize** the grid generation and transformation techniques in implementation of finite difference and finite volume methods in solving complex fluid and aerodynamic problems.	Apply

QUESTION BANK:

Q.No	QUESTION	Taxonomy	How does this subsume the level	CO's
MODULE I				
INTRODUCTION				
PART A-PROBLEM SOLVING AND CRITICAL THINKING QUESTIONS				
1	List out the models of flow for a continuum fluid. Differentiate the control volume and infinitesimal fluid element fixed in space with the fluid moving through it with the help of neat sketch.	Understand	The learner to **recall** the type of flow with respect fixed space and moving element and **explain** the different types of fluid elements	CO 1
2	Justify how the continuity equation derived from these flow models can be converted from conservative to non-conservative form.	Understand	The leaner to **recall** the basic governing equations and **explain**the nature of those in different types of flows.	CO 1
3	Construct the momentum equation in conservation form using infinitesimal small fluid element moving with the flow.	Understand	The leaner to **recall** the basic governing equations and **explain** the nature of those in different types of flows.	CO 1
4	Build the energy equation in conservation form using infinitesimal small fluid element fixed in space for compressible in viscid flow.	Apply	The learner to **recall** the governing equations, **explain** the importance of partial differential equations and apply in the analysis of flow	CO 1

5	Illustrate the non-conservative form of governing equations. Derive continuity equation in non-conservation form using infinitesimal small fluid element moving in space.	Understand	The leaner to **recall** the basic governing equations and **explain** the nature of those in different types of flows.	CO 1
6	Differentiate shock fitting and shock capturing methods with the suitable diagram.	Understand	The learner to **recall** different methods of CFD and **explain** concept of shock fitting method in CFD.	CO 1
7	Construct the generic form of a partial differential equation used in CFD and explain the significance of each term.	Apply	The leaner to **recall** the basic governing equations, **explain** the nature of those in different types of flows and develop the equation.	CO 2
8	Build the energy equation in conservation form using infinitesimal small fluid element moving in space for compressible viscous flow.	Apply	The leaner to **recall** the basic governing equations, explain the nature of those in different types of flows and develop the equation.	CO 2
9	Illustrate the energy equation in conservation form using infinitesimal small fluid element fixed in space in terms of internal energy for compressible flow.	Apply	The leaner to **recall** the basic governing equations, explain the nature of those in **different types** of flows and develop the equation.	CO 2
10	List out the continuity equation in conservation form using infinitesimal small fluid element moving with the flow.	Apply	The leaner to **recall** the basic governing equations, explain the nature of those in **different types of flows** and develop the equation.	CO 2
PART-B LONG ANSWER QUESTIONS				
1	Which three disciplines is CFD derived from? Discuss some of the advantages of using CFD?	Understand	The learner to recall the concepts of CFD by summarizing its use in different applications	CO 1

2	How CFD is helpful as a research tool, a design tool, and an educational tool in analyzing fluid dynamical problems.	Understand	-	CO 1
3	What is substantial derivative? Derive the expression for time rate of change of fluid element. Define local derivative, convective derivative.	Understand	The learner to recall the concept of substantial derivative and explain the time rate of fluid element.	CO 1
4	Illustrate the use of conservation form of the equations so important for the shock-capturing method by considering the flow across a normal shock wave.	Understand	The learner to recall the basic concepts of conservation form of the equations and illustrate its importance in fluid flow.	CO 1
5	How Computational Fluid Dynamics is vital in the Industrial manufacturing. fields	Understand	-	CO 1
6	Explain the computer architectures and list the types of computer architectures.	Understand	The learner to recall different Computer simulation packages available in industry and outline the procedures.	CO 1
7	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.	Understand	The learner to recall the concept of divergence of velocity and explain the time rate of fluid element.	CO 1
8	Discuss some of the applications of CFD and explain why it is so important in the modern study of fluid mechanics?	Understand	-	CO 2
9	Describe the steps involved in Computational Fluid Dynamics (CFD) process.	Understand	-	CO 1

10	How Computational Fluid Dynamics is vital in the Automobile engineering fields. Discuss.	Understand	-	CO 1
11	What are the steps involved in Computational Fluid Dynamics (CFD) process. Describe in detail.	Understand	-	CO 1
12	Discuss applications of CFD in civil engineering	Understand	-	CO 1
13	Write applications of CFD in Naval architecture applications.	Understand	-	CO 1
14	What are the available coding techniques for numerical problems? List few.	Understand	-	CO 1
15	Compare and contrast the viscous flow and inviscid flow.	Understand	The learner has to recall the definitions of types of flows in fluid dynamics and compare the flow types.	CO 1
PART-C SHORT ANSWER QUESTIONS				
1	Define substantial derivative with example	Understand	-	CO 2
2	CState the detachment distance in blunt nosed body	Understand	-	CO 2
3	State any two applications of CFD in engineering.	Understand	–	CO 2
4	Define divergence of velocity in aerodynamics.	Understand	–	CO 2
5	State the local derivative with the suitable example.	Understand	-	CO 2
6	List the forces in Newton's second law in diagrammatic form.	Understand	–	CO 2
7	Distinguish conservative and non-conservative form of the governing equation for control volume.	Understand	-	CO 2
8	State the proper physical boundary condition for a viscous flow	Understand	-	CO 2

9	Mention the applications of CFD in industrial manufacturing.	Understand	-	CO 2
10	Distinguish the Newtonian and Non-Newtonian fluids.	Understand	-	CO 2
10	Distinguish the Newtonian and Non-Newtonian fluids.	Understand	-	CO 2
11	List the types of computer architectures.	Understand	-	CO 2
12	Why it is so important in the modern study of fluid me chanics?	Understand	-	CO 2
13	What are the steps involved in CFD.	Understand	-	CO 2
14	List out the modes of fluid flow.	Understand	-	CO 2
15	What are different numerical methods?	Understand	-	CO 2
16	List some simple coding techniques for numerical problems	Understand	-	CO 2
17	What are the preprocessor steps in CFD?	Understand	-	CO 2
18	What is the role of CFD in heat transfer?	Understand	-	CO 2
19	What are inviscid flows?	Understand	-	CO 2
20	Write any two applications of CFD in engineering.	Understand	-	CO 2
MODULE II				
MATHEMATICAL BEHAVIOR OF PARTIAL DIFFERENTIAL EQUATIONS				
AND THEIR IMPACT ON COMPUTATIONAL AERODYNAMICS				
PART-A PROBLEM SOLVING AND CRITICAL THINKING QUESTIONS				
1	Classify the following set of equations for irrotational, two-dimensional, inviscid, steady flow of a compressible flow using Eigen value method: Where u', v' are small perturbation velocities measured relative to the free Stream velocity.	Understand	The learner to recall the partial differential equations and be able to explain different methods	CO 3

2	Justify the classification of the following quasi-linear partial differential equations using Cramer's rule: $a_1\frac{\partial u}{\partial x}+b_1\frac{\partial u}{\partial y}+c_1\frac{\partial v}{\partial x}+d_1\frac{\partial v}{\partial y}=f_1$, $a_2\frac{\partial u}{\partial x}+b_2\frac{\partial u}{\partial y}+c_2\frac{\partial v}{\partial x}+d_2\frac{\partial v}{\partial y}=f_2$ 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.	Understand	The learner to recall the partial differential equations and be able to explain different methods	CO 3
3	Illustrate the physical behavior of flows governed by hyperbolic equations with an example of steady, inviscid supersonic flow over a two dimensional circular arc airfoil.	Understand	The learner to recall the partial differential equations and explain basic features of hyperbolic equations	CO 3
4	Illustrate 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.	Understand	The learner to recall the partial differential equations and be able to explain different methods to explain the parabolic equations nature	CO 3
5	Classify the following partial differential equations according to their nature as elliptic, parabolic, hyperbolic (a)Unsteady Thermal Conduction Equation (b)Laplace's Equation (c)Second-order wave equation (d)First-order wave equation	Apply	The learners to recall the basic features of partial differential equations explain different methods and classify as per their mathematical behaviour.	CO 3
6	Construct the Parabolized Navier-Stokes equations and well-posed problems.	Understand	Explain the Parabolized Navier-Stokes equations and well-posed problems.	CO 3

7	Discuss the mathematical and physical behavior of flows governed by Parabolic equations with an example of unsteady thermal conduction in two and three dimensions.	Understand	The learner to recall the partial differential equations and be able to explain different methods	CO 3
8	Build the mathematical and physical nature of flows governed by elliptic equations with an illustration of incompressible, inviscid flow. Explain Neumann and Dirichlet boundary conditions.	Understand	The learner to recall the partial differential equations and explain basic features of elliptic equations.	CO 3
9	Justify the philosophy of the Method of characteristics. Consider the full velocity potential equation for the steady, two dimensional supersonic flows and determine the equation for characteristic curves in the physical xy space and classify the nature of velocity potential equation based on Mach number.	Understand	Explain the philosophy of the Method of characteristics. Consider the full velocity potential equation for the steady, two dimensional supersonic flows and determine the equation for characteristic curves in the physical xy space and classify the nature of velocity potential equation based on Mach number.	CO 3
10	Illustrate the physical behavior of flows governed by hyperbolic equations with an example of steady, inviscid supersonic flow over a two dimensional circular arc airfoil.	Understand	The learner to recall the partial differential equations and explain basic features of hyperbolic equations	CO 3
PART-B LONG ANSWER QUESTIONS				
1	Classify the system of equation form the general equation for a conic section from analytical geometry and derive the expression.	Understand	The learner to recall the basic principles of fluid science to derive the governing equations.	CO 3

2	Illustrate the characteristic curve with the suitable diagram. Differentiate the left running and right running characteristics with the suitable example.	Understand	The learner to recall what flows is the available in fluid to transfer.	CO 3
3	Explain the mathematical and physical nature of flows governed by parabolic Equations with an illustration of a steady boundary layer flow.	Understand	The learner to recall the partial differential equations and explain basic features of parabolic equations	CO 3
4	Explore the boundary layer flow for the parabolic equation by considering the nose region with the neat sketch.	Understand	The learner to recollect necessity of derivative in the derivation of fluid flow equations.	CO 3
5	Illustrate the typical transient temperature distributions in a constant property fluid, starting from an impulsive increase in Tw2 from T1 to T2 at time zero.	Understand	The learner to recollect necessity of derivative in the derivation of fluid flow equations	CO 3
6	Explicit the general behavior of the different classes of partial differential equation – impact on physical and computational fluid dynamics with suitable example for each.	Understand	The learner to recollect the basic principles of fluid science to derive the governing equations to Understand the.	CO 3
7	Elucidate the domain and boundaries for the solution of hyperbolic equations for the three dimensional steady flow.	Understand	The learner to recall the partial differential equations and explain basic features of hyperbolic equations.	CO 3
8	Discuss the domain and boundaries for the solution of hyperbolic equations for the one and two dimensional unsteady flow with the suitable diagram.	Understand	The learner to recall the partial differential equations and explain basic features of hyperbolic equations.	CO 3
9	Describe the combustion process in a solid propellan	Understand	–	CO 3

10	Discuss the domain and boundaries for the solution of elliptic equations for the two dimensions with the suitable diagram.	Understand	The learner to recall the partial differential equations and explain basic features of elliptic equations.	CO 3
PART-C SHORT ANSWER QUESTIONS				
1	Define quasi linear partial differential equations.	Understand	–	CO 3
2	Define characteristic curve and its uses.	Understand	–	CO 3
3	List the quasilinear partial differential equations by determining value of Determinant.	Understand	–	CO 3
4	Define compatibility equation for method of characteristics.	Understand	–	CO 3
5	State the boundary layer equations.	Understand	–	CO 3
6	List the types of flow are governed by the elliptic equations.	Understand	–	CO 3
7	List the types of fluid dynamic flow fields are governed by parabolic equations.	Understand	–	CO 3
8	List the advantage of the compatibility equation	Understand	–	CO 3
9	List the advantage of the compatibility equation	Understand	–	CO 3
10	List the advantage of the compatibility equation	Understand	–	CO 3
MODULE III				
BASIC ASPECTS OF DISCRETIZATION				
PART A-PROBLEM SOLVING AND CRITICAL THINKING QUESTIONS				
1	Compare and contrast on the following properties of numerical solutions of fluid flows: i) Stability ii) Consistency iii) Accuracy iv) Convergence.	Understand	The learner to recollect the concepts of grid generation and understand the finite differences using Taylor series in the formulation of explicit equations.	CO 4

2	Illustrate the time marching solution for constructing the explicit finite difference module by considering one-dimensional heat conduction equation which is parabolic partial differential solution.	Understand	The learner to recollect the concepts of heat transfer, understand the finite differences using Taylor series in the formulation of explicit equations.	CO 4
3	Calculate the differential equation by considering unsteady, one-dimensional heat conduction equation with constant thermal diffusivity with the neat sketch.	Understand	The learner to recollect the concepts of heat conduction and understand the finite differences.	CO 4
4	Build the expressions for the first order forward difference and first - order rearward difference with respect to x and y. Sketch the appropriate finite- difference modules for each by using the discrete grid points.	Understand	The learner to recall the Taylor series expansion and outline the forward difference using finite differences.	CO 4
5	Sketch the finite- difference modules for second - order central second difference with respect to x, y and second - order central mixed difference with respect to x and y by justifying the expression.	Apply	The learner to recall the Taylor series expansion and outline the forward difference using finite differences.	CO 4
6	The learner to recall the Taylor series expansion and outline the forward difference using finite differences.	Understand	The learner to recall the concepts of finite difference and understand the grid generation.	CO 4
7	Illustrate a stable case by comparing the numerical domain includethe entire analytical domain and does not include the entire analytical domain with the neat sketch.	Understand	Illustrate a stable case by comparing the numerical domain includethe entire analytical domain and does not include the entire analytical domain with the neat sketch.	CO 4

8	Illustrate a stable case by comparing the numerical domain includethe entire analytical domain and does not include the entire analytical domain with the neat sketch.	Understand	The learner to recollect different types of errors and explain different methods of its propagation.	CO 4
9	Justify the importance of grid generation in CFD process and discuss the difference between structured grid and unstructured grid.	Understand	The learner to recall the concepts of grid generation and compare the types of grids.	CO 4
10	Illustrate the unstructured hybrid grid showing the regular quadrilateral or hexahedra cells type structure near the solid walls.	Understand	The learner to recall the concepts of grid and show the types of grids.	CO 4
11	Compare structured and unstructured grids. Discuss various configurations of Body-fitted structured grids and multi-block grids with the help of sketches.	Understand	The learner to recollect the classification of grids and compare structured and unstructured grid.	CO 4
12	Summarize the hybrid grids of a turbine blade with film cool configuration for generation of unstructured grid with the suitable example.	Understand	The learner to recollect the classification of grids and explain in solid boundary application.	CO 4
13	Illustrate the triangle and tetrahedral cells for generation of unstructured grid with the suitable example.	Understand	The learner to recollect the classification of grids and explain in solid boundary application.	CO 4
14	Sketch the the quad tree grid with hanging nodes, nodes around an airfoil with staircase boundary approximation.	Understand	The learner to recollect the classification of grids and explain in solid boundary application.	CO 4

15	Compare structured and unstructured grids. Discuss various configurations of Body-fitted structured grids and multi-block grids with the help of sketches.	Understand	The learner to recollect the classification of grids and compare structured and unstructured grid.	CO 4
PART-B LONG ANSWER QUESTIONS				
1	Obtain the expression for first - order forward difference and first - order rearward difference by using the Taylor series.	Understand	The learner to recall the Taylor series expansion and outline the forward difference using finite differences.	CO 3
2	Explain Lax method for one dimensional wave equation and explain the stability criterion for hyperbolic equations.	Understand	The learner to recall the concept of stability criterion and relate the same to the hyperbolic equations.	CO 3
3	Explain the explicit formulation by using one dimensional heat conduction equation as an example with its relative merits and demerits.	Understand	The learner to recollect the concepts of heat conduction and understand the finite differences.	CO 3
4	Construct the implicit finite difference module using seven point spatial grid by considering one-dimensional heat conduction equation which is parabolic partial differential solution.	Apply	The learner to recollect the concepts of heat conduction understand the finite differences using Taylor series and apply for parabolic partial differential equation.	CO 3
5	Explain the von Neumann stability method which is used to study the stability properties of linear difference equations.	Understand	The learner to recollect the concepts of stability and understand the finite differences.	CO 3
6	Construct a finite difference quotient by using the polynomial approach by assuming the boundary and obtain a expression for one sided finite difference.	Apply	The learner to recollect the concepts of heat transfer understand the finite differences using Taylor series and apply for parabolic partial differential equation.	CO 3

7	List out the advantages and disadvantages of implicit approach and explicit approach.	Understand	The learner should recollect the explicit and implicit method and explain the advantages and disadvantages of them in industrial applications.	CO 3
8	Illustrate the maximum and minimum wavelengths for the Fourier components of the round-off error.	Understand	The learner to recall the concepts of Fourier transform and explain the errors in grid generation.	CO 3
9	Explain the stability criterion depends on the form of the difference equation by considering the first order wave equation which is a hyperbolic behavior.	Understand	The learner to recollect the concepts of stability and understand the finite differences.	CO 3
10	Interpret the Courant number and Courant-Friedrichs-Lewy(CFL) condition and explain the physical behavior of CFL condition.	Understand	The learner to recollect the concepts of stability and understand the finite differences.	CO 3
11	Explain and sketch the structured multi-block body-fitted grid of the H-O-H type.	Understand	The learner to recall the concepts of grid and show the types of grids.	CO 3
12	Explain and sketch the structured curvilinear body-fitted of the C-H type.	Understand	The learner to recall the concepts of grid and show the types of grids.	CO 3
13	Illustrate the matching and non-matching block boundary interfaces of a multi-block-structured grid with a channel connecting two circular ducts.	Understand	The learner to recollect the classification of grids and able to explain in circular duct application.	CO 3
14	Discuss the structured multi-block body-fitted grid of the 'butterfly' type for internal flows.	Understand	The learner to recollect the classification of grids and explain in solid boundary application.	CO 3

15	Show the Cartesian mesh around a solid boundary with immersed boundary method and Sketch cut-cell configuration.	Understand	The learner to recollect the classification of grids and able to explain in solid boundary application.	CO 3
PART-C SHORT ANSWER QUESTIONS				
1	What are the errors that influence numerical solutions the PDE?	Understand	–	CO 4
2	Define Courant number. What is the important stability criterion for hyperbolic equation?	Understand	–	CO 4
3	Define discretization error in numerical approach.	Understand	–	CO 4
4	Define Round-off error and its effects.	Understand	–	CO 4
5	Write disadvantages of the implicit approach.	Understand	–	CO 4
6	Define the need of grid point in discretization.	Understand	–	CO 4
7	State CFD technique and list the approaches.	Understand	–	CO 4
8	List out the types of errors and state them.	Understand	–	CO 4
9	What is truncation error in numerical approach.	Understand	–	CO 4
10	Define first order forward difference with example.	Understand	–	CO 4
11	State reflection boundary condition.	Understand	–	CO 4
12	List the pros and cons of higher – order accuracy.	Understand	–	CO 4
13	What are the discrete gird points.	Understand	–	CO 4
14	Define finite- difference modules.	Understand	–	CO 4
15	Write two differences between structured and unstructured grids?	Understand	–	CO 4
16	Draw triangular and Tetrahedral cells.	Understand	–	CO 4

17	Draw the structured curvilinear body-fitted grid of the C-type.	Understand	–	CO 4
18	Listout the methods for the curved solid bodies – non uniform Cartesian grids	Understand	–	CO 4
19	Draw the structured curvilinear body-fitted grid of the O-type.	Understand	–	CO 4
20	Draw the structured curvilinear body-fitted grid of the H-type.	Understand	–	CO 4
21	Draw the Cartesian grid with non-uniform cell sizes for a cavity.	Understand	–	CO 4
22	Write the advantages of adaptive grid?	Understand	–	CO 4
23	Distinguish Cartesian grid and non-uniform Cartesian grids	Understand	–	CO 4
24	List out the types of Body fitted structured grids.	Understand	–	CO 4
25	Draw the structured curvilinear body-fitted grid of the I-type for turbo machinery blades.	Understand	–	CO 4
MODULE IV				
CFD TECHNIQUES				
PART A- PROBLEM SOLVING AND CRITICAL THINKING QUESTIONS				
1	Construct the 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:where F and G represent flux vectors formed from the governing equations.	Understand	The learner to recall the different techniques for implicit formulations , summarize the methods and apply McCormack method	CO 5

2	Illustrate the sequence of operation in a Computational fluid dynamics procedure which employs the SIMPLER algorithm with the flow chart.	Understand	The learner to recall the processes of CFD in fluid dynamics applications and Summarise the processes involved in it	CO 5
3	Illustrate the sequence of operation in a Computational fluid dynamics procedure which employs the PISO algorithm with the flow chart.	Understand	The learner to recall the processes of CFD in fluid dynamics applications and Summarise the processes involved in it	CO 5
4	Justify the boundary condition for the pressure correction method with schematic of staggered grid by incompressible viscous flow.	Understand	The learner to recall the different techniques for implicit formulations and summarize the numerical methods.	CO 5
5	Illustrate the relaxation technique for the inviscid, incompressible, two dimensional, irrotational flows under explicit approach.	Understand	The learner to recall the different techniques for implicit formulations and summarize the numerical methods.	CO 5
6	Build an expression of computational module for y momentum equation for an incompressible viscous flow for the pressure correction formula.	Understand	The learner to recollect the concepts of computational module, understand the momentum equation and develop the pressure correction formula.	CO 5
7	Illustrate the basic formulation for the two-dimensional finite volume method by using the area of an arbitrary plane quadrilateral.	Understand	The learner to recollect the classification of grids and able to explain in both physical and computational plane.	CO 5
8	Construct the numerical dissipation and numerical dispersion in the context of Numerical solution to fluid dynamical problems.	Understand	The learner to recall the concept of dissipation and dispersion in summarizing numerical methods in the CFD applications.	CO 5

9	Justify the checker-board behaviour of velocity and pressure fields in central Discretization schemes using sketches and explain how such behaviour can be avoided.	Understand	The learner to recall the different techniques for implicit formulations and summarize the numerical methods.	CO 5
10	Illustrate the pressure correction technique. List out the process for the philosophy of the pressure correction method.	Understand	The learner to recall the different techniques for implicit formulations and summarize the numerical methods.	CO 5
PART-B LONG ANSWER QUESTIONS				
1	Build an expression for second order accuracy in both space and time by using the Lax Wendroff method explicitly.	Apply	The learner to recall the different techniques for implicit formulations; summarize the methods by applying Numerical method.	CO 5
2	Build an expression for second order accuracy in both space and time by using the Maccormack method explicitly.	Apply	The learner to recall the different techniques for implicit formulations , summarize the methods and apply McCormack method	CO 5
3	What is a Crank Nicholson technique? Explain its advantages in field of CFD techniques.	Understand	–	CO 5
4	Obtain an expression for finite difference method, relaxation technique for the solution of elliptic partial differential equation. Explain its applications.	Apply	The learner to recollect the concepts of heat transfer understand the finite differences using Taylor series and formulate explicit equations.	CO 5
5	Illustrate the simple form of artificial viscosity by considering unsteady two dimensional flows.	Understand	The learner to recollect the concept of artificial viscosity concept and explain the flow characteristics.	CO 5

6	Build an expression of computational module for x momentum equation for an incompressible viscous flow for the pressure correction formula.	Apply	The learner to recollect the concepts of computational module, understand the momentum equation and develop the pressure correction formula.	CO 5
7	List out the sequence of operation in a Computational fluid dynamics procedure which employs the SIMPLE algorithm with the flow chart.	Understand	–	CO 5
8	Explain the sequence of operation in a Computational fluid dynamics procedure which employs the SIMPLEC algorithm with the flow chart.	Understand	The learner to recall the processes of CFD in fluid dynamics applications and Summarise the processes involved in it	CO 5
9	Illustrate the first step in the alternating direction implicit (ADI) technique by sweeping in the x direction to obtain T at time t+δt/2.	Understand	The learner to recall the concept of heat transfer and explain the step by step procedure using ADI technique.	CO 5
10	What is the need for staggered grid and sketch? List out the advantages of staggered grid.	Understand	–	CO 5
	PART-C SHORT ANSWER QUESTIONS			
1	Define point iterative method.	Understand	—	CO 5
2	What extent does the addition of artificial viscosity effect the accuracy of the problem?	Understand	—	CO 5
3	What is Relaxation technique?	Understand	—	CO 5
4	Show the effect of numerical dispersion when initial wave at time t=0 and t>0.	Understand	—	CO 5
5	Define approximate factorization.	Understand	—	CO 5

6	Write down the expression for relaxation factor.	Understand	—	CO 5
7	What is Pressure correction technique?	Understand	—	CO 5
8	Differentiate successive over relaxation and under relaxation.	Understand	—	CO 5
9	What is the need for staggered grid?	Understand	—	CO 5
10	Show the effect of numerical dissipation when initial wave at time t=0 and t¿0.	Understand	—	CO 5
MODULE V				
FINITE VOLUME METHODS				
PART A-PROBLEM SOLVING AND CRITICAL THINKING QUESTIONS)				
1	Differentiate 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?	Understand	The learner to recall the concept of discretization and explain step by step procedure in the determination of temperatures using finite volume method.	CO 6
2	Identify the fluxes for the upwind schemes and cell-centered finite volumes methods, upwind schemes determine the cell face fluxes according to the propagation direction of the convection velocity.	Apply	The learner to recall the concept of discretization and explain the step by step procedure using finite volume method.	CO 6
3	Distinguish the cell-centered approach and cell-vertex approach for the unstructured finite volume mesh with the help of neat sketch.	Understand	The learner to recall the concept of discretization and explain the step by step procedure using finite volume method.	CO 6

4	Illustrate the cell-vertex finite volume method with the example of two-dimensional control surfaces by selecting hexagonal control volume and trapezoidal control surface.	Understand	The learner to recall the concept of discretization and explain the step by step procedure using finite volume method.	CO 6
5	Compare the interpretation of finite volume methods from the finite difference and finite element approaches.	Understand	The learner to recall the concept of finite difference and finite volume methods and compare its process in the application.	CO 6
6	Build the general formulation of a numerical scheme. The formulation is to be valid for all possible cases such as structured gird or unstructured grids either cell-centered or cell-vertex defines variables.	Understand	The learner to recall the concept of discretization and explain it for 2 D application while developing step by step procedure using finite volume method.	CO 6
7	Illustrate the basic formulation for the two-dimensional finite volume method by using the area of an arbitrary plane quadrilateral.	Understand	The learner to recall the concept of finite difference and finite volume methods and compare its process in the application.	CO 6
8	Build the finite volume estimation of gradients for an arbitrary quadrilateral by noticing differences δy grouped for opposite nodes with the suitable diagram.	Understand	The learner to recall the concept of discretization and explain it for 2 D application while developing step by step procedure using finite volume method.	CO 6
9	Construct the upwind scheme on Cartesian mesh by considering the discretization of the Two-dimensional linear convection equation and the fluxes are f=aU and g=bU.	Understand	The learner to recall the concept of finite difference and finite volume methods and compare its process in the application.	CO 6

10	Build the finite volume estimation of gradients by application of the Gauss divergence theorem for two dimensional control cells.	Understand	The learner to recall the concept of discretization and explain it for 2 D application while developing step by step procedure in the determination of temperatures using finite volume method.	CO 6
PART-B LONG ANSWER QUESTIONS				
1	Illustrate the conservative discretization on a one-dimensional form of conservation law by subdivision of a one dimensional space into mesh cells with the flux vector in x-component.	Understand	The learner to recollect the concepts of discretization and explain significance in 1 D heat transfer equations.	CO 6
2	What do you understand by conservative discretization and explain the importance of it in FVM.V	Understand	Understand-	CO 6
3	Build the formal expression of a conservative discretization by stating the theorem for the discretized equation.	Apply	The learner to recall finite volumes method, explain it for conservative discretization and develop step by step procedure using finite volume method.	CO 6
4	Explain the cell-centered approach for the structured finite volume mesh and unstructured finite volume mesh with the help of neat sketch.	Understand	The learner to recall the concepts of basic numerical methods, classification and Discuss the finite volume methods in CFD applications.	CO 11
5	Illustrate the non-conservative discretization on a one-dimensional form of conservation law.	Understand	The learner to recall the concepts of basic numerical methods and its classification and explain the finite volume methods in CFD applications	CO 6

6	Explain the fluxes for the upwind schemes and cell-vertex finite volumes methods, upwind schemes determine the cell face fluxes according to the propagation direction of the convection velocity.	Understand	The learner to recall finite volumes method and explain the upwind schemes.	CO 6
7	Compare the non-uniform finite volume mesh and orthogonal non-uniform finite volume mesh with the suitable diagram.	Understand	The learner to recall discretization and compare the non-uniform finite volume mesh with orthogonal non-uniform finite volume mesh.	CO 6
8	Construct the standard finite difference discretization on the mesh by considering the two-dimensional diffusion equation and Cartesian grid.	Apply	The learner to recall finite volumes method, explain the two-dimensional diffusion equation and develop the finite difference discretization on the mesh.	CO 6
9	Explain the finite volume estimation of gradients by considering control cell and applying trapezoidal integration formulas.	Understand	The learner to recall finite volumes method and explain the finite volume estimation.	CO 6
10	Compare the non-uniform finite volume mesh and orthogonal non-uniform finite volume mesh with the suitable diagram.	Understand	The learner to recall discretization and compare the non-uniform finite volume mesh with orthogonal non-uniform finite volume mesh.	CO 6
PART-C SHORT ANSWER QUESTIONS				
1	Define Finite volume method and list the advantages and disadvantages	Understand	—	CO 6
2	State control volume for the Finite volume method?	Understand	—	CO 6
3	What is the basis of Finite Volume Method?	Understand	—	CO 6
4	Discuss and sketch the incorrect finite volume decomposition.	Understand	—	CO 6

5	Sketch the cell-centered and cell-vertex cells for structured grid.	Understand	—	CO 6
6	Sketch the cell-centered and cell-vertex cells for structured grid.s	Understand		CO 6
7	Define residual in finite volume method.	Understand	–	CO 6
8	Discuss the alternative formulation of the conservation condition.	Understand	–	CO 6
9	Write down the expression used for the estimation of the area of an arbitrary cell.	Understand	–	CO 6
10	Define one condition for finite volume selection.	Understand	–	CO 6

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