# INSTITUTE OF AERONAUTICAL ENGINEERING

**(Autonomous)**

Dundigal, Hyderabad-500043

## AEROSPACE ENGINEERING

## TUTORIAL QUESTION BANK

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| **Course Title** | **ADVANCED COMPUTATIONAL AERODYNAMICS** | | | | |
| **Course Code** | BAEB05 | | | | |
| **Programme** | M.Tech | | | | |
| **Semester** | I | AE | | | |
| **Course Type** | Elective | | | | |
| **Regulation** | IARE - R18 | | | | |
| **Course Structure** | **Theory** | | | **Practical** | |
| | **Lectures** | **Tutorials** | **Credits** | **Laboratory** | **Credits** |
| | 3 | - | 3 | -- | -- |
| **Chief Coordinator** | Ms. D Anitha, Assistant Professor | | | | |
| **Course Faculty** | Ms. D Anitha, Assistant Professor | | | | |

## COURSE OBJECTIVES:

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| **The course should enable the students to:** | |
| I | Explain the concept of panel methods, analyze various boundary conditions applied and demonstrate several searching and sorting algorithms. |
| II | Describe the initial methods applied in the process of CFD tools development their advantages and disadvantages over modern developed methods. |
| III | Demonstrate different methods evolved in analyzing numerical stability of solutions and evaluate the parameters over which the stability depends and their range of values. |
| IV | Understand advanced techniques and methods in time marching steps and identify different boundary conditions for different cases in CFD techniques. |

## COURSE OUTCOMES (COs):

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| CO 1 | Understand the solution methodology and numerical solutions for the boundary layer. |
| CO 2 | Summarize various types of equations, their solution techniques including their stability. |
| CO 3 | Demonstrate to write and solve implicit and explicit equations including stability of the solution. |
| CO 4 | Illustrate the concepts of method of characteristics and its applications in nozzle designs. |
| CO 5 | Describe basic formulation techniques and boundary condition for panel methods. |

## COURSE LEARNING OUTCOMES (CLOs):

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| BAEB05.01 | Understand the concept of flux approach and its formulations. |
| BAEB05.02 | Explain the Euler equations for the aerodynamic solutions computationally. |
| BAEB05.03 | Emphasize on basic schemes to solve the differential equations. |
| BAEB05.04 | Understand the stability of the solution by time dependent methods. |
| BAEB05.05 | Explain the implicit methods for the time dependent methods to solve computationally. |
| BAEB05.06 | Develop the approximate factorization schemes for time dependent methods. |
| BAEB05.07 | Illustrate to apply concepts of discretization and its application for implicit difference equation. |
| BAEB05.08 | Distinguish implicit and explicit discretization and differentiation equations for the stability of solution. |
| BAEB05.09 | Explain the flow gradients at boundaries of unstructured grids. |
| BAEB05.10 | Understand the concept of philosophy of method of characteristics. |
| BAEB05.11 | Explain supersonic nozzle design using method of characteristics. |
| BAEB05.12 | Differentiate the domain of dependence and range of influence. |
| BAEB05.13 | Understand the basic formulation and boundary conditions. |
| BAEB05.14 | Explain the reduction of a problem to a set of linear algebraic equations. |
| BAEB05.15 | Discuss the preliminary considerations prior to establishing numerical solution. |

## TUTORIAL QUESTION BANK

| UNIT – I | | | | |
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| **NUMERICAL SOLUTIONS** | | | | |
| **Part - A(Short Answer Questions)** | | | | |
| **S.NO** | **QUESTIONS** | **Blooms Taxonomy Level** | **Course Outcomes** | **Course Learning Outcomes** |
| 1 | What do you understand by conservative? | Remember | CO 1 | BAEB05.01 |
| 2 | Define conservative numerical fluxes. | Remember | CO 1 | BAEB05.01 |
| 3 | Sketch the stencil diagram. | Remember | CO 1 | BAEB05.01 |
| 4 | Define stencil width. | Remember | CO 1 | BAEB05.02 |
| 5 | When is a conservative approximation consistent? | Remember | CO 1 | BAEB05.02 |
| 6 | Define temporal evolution. | Remember | CO 1 | BAEB05.02 |
| 7 | What is the fundamental property for the conservative numerical methods? | Remember | CO 1 | BAEB05.02 |
| 8 | Differentiate the conservative and non-conservative methods. | Understand | CO 1 | BAEB05.02 |
| 9 | List the Forward Time Methods. | Understand | CO 1 | BAEB05.02 |
| 10 | Define spatial Reconstruction. | Remember | CO 1 | BAEB05.03 |
| 11 | What is the CFL condition for the Lax-Wendroff method? | Remember | CO 1 | BAEB05.03 |
| 12 | Define small user –adjustable parameter | Understand | CO 1 | BAEB05.02 |
| 13 | What are the upwind schemes? | Understand | CO 1 | BAEB05.02 |
| **Part - B (Long Answer Questions)** | | | | |
| 1 | Briefly explain the basic principles involved in the upwind schemes by the steady state solutions. | Understand | CO 1 | BAEB05.03 |
| 2 | Derive the expressions for the forward time methods with the help of neat sketch? | Understand | CO 1 | BAEB05.03 |
| 3 | Find a first-order reconstruction – evolution method for the linear advection equation. Use piecewise-constant reconstruction and exact evolution. | Understand | CO 1 | BAEB05.03 |
| 4 | Rederive the first-order reconstruction–evolution method. Use a reconstruction – evolution, in which step approximates u(x, tn+1) rather than u(xi+1/2, t). Form the cell- integral averages of u(x, tn+1) to approximate $\overline{u}_i^{n+1}$. | Remember | CO 1 | BAEB05.02 |
| 5 | Consider the Lax - Wendroff method. What are the advantages and disadvantages of increasing its coefficient of artificial viscosity by a constant amount? | Remember | CO 1 | BAEB05.03 |
| 6 | Find the conservative numerical flux $f^{n}_{I+2}$ of Godunov's and Roe's first- order upwind method. | Remember | CO 1 | BAEB05.03 |
| 7 | Define flux approach and list the flux approach methods for Euler equations. | Understand | CO 1 | BAEB05.02 |
| 8 | By considering the inviscid Burgers equation and a finite volume approximation with a control volume for Lax method derives the expression for control volume interface. | Understand | CO 1 | BAEB05.02 |
| 9 | Define the expansion shock and explain the expansion shock using Roe's scheme for first order upwind. | Understand | CO 1 | BAEB05.03 |
| 10 | Compare the expansion shock using Roe's scheme for first order upwind with and without entropy correction. | Understand | CO 1 | BAEB05.02 |
| **Part - C (Analytical Questions)** | | | | |
| 1 | Derive an expression for the Lax – Wendroff Methods for scalar conservation laws by Euler Equations. | Understand | CO 1 | BAEB05.01 |

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| 2 | A solution of the two dimensional heat equation $$\frac{\partial u}{\partial t} = \alpha \frac{\partial^2 u}{\partial x^2} + \alpha \frac{\partial^2 u}{\partial y^2}$$ is desired using the simple explicit scheme. What is the stability requirement for the method? | Understand | CO 1 | BAEB05.01 |
| 3 | Derive an expression for the Steger-Warming Flux vector splitting and write the expression for the entropy in sonic conditions? | Remember | CO 1 | BAEB05.03 |
| 4 | Derive an expression for the Van Leer Flux vector splitting and write the how the Mach number varies with momentum flux in sonic conditions? | Remember | CO 1 | BAEB05.02 |
| 5 | Explain the flux difference splitting method and derive the expression. Compare flux difference splitting with flux vector splitting. | Understand | CO 1 | BAEB05.02 |
| 6 | Write down the Riemann problem for the Godonov's equation for the cases shock wave and expansion waves. | Remember | CO 1 | BAEB05.03 |
| 7 | Describe how the Godonov's method solves a local Riemann problem at each cell interface to obtain a value of the flux. | Understand | CO 1 | BAEB05.03 |
| 8 | Discuss the Flux Vector splitting for the Euler equations in the scalar conservation laws explain them in detail. | Remember | CO 1 | BAEB05.02 |
| 9 | Sketch the wave diagram for Roe scheme applied to Burger's equation and explain them in detail. | Remember | CO 1 | BAEB05.02 |
| 10 | Differentiate the Godonav's and Roe first order upwind method with the suitable diagram applicable to Burger's equation. | Understand | CO 1 | BAEB05.02 |
| **UNIT II** | | | | |
| **TIME DEPENDENT METHODS** | | | | |
| **Part – A (Short Answer Questions)** | | | | |
| 1 | What is the need of stability of solution? | Remember | CO 2 | BAEB05.04 |
| 2 | Define amplification factor. | Remember | CO 2 | BAEB05.04 |
| 3 | List out the various explicit methods. | Remember | CO 2 | BAEB05.04 |
| 4 | Explain the importance of forward-time forward space method. | Remember | CO 2 | BAEB05.04 |
| 5 | Summarize the use of predictor-corrector method. | Understand | CO 2 | BAEB05.04 |
| 6 | What is the importance of forward-time backward space method? | Understand | CO 2 | BAEB05.04 |
| 7 | List the different time split methods. | Understand | CO 2 | BAEB05.04 |
| 8 | What is the importance of Crank-Nicolson method? | Understand | CO 2 | BAEB05.04 |
| 9 | List difference between forward-time central space method and forward-time backward space method. | Understand | CO 2 | BAEB05.05 |
| 10 | What are the criteria required to establish Crank Nicolson method. | Understand | CO 2 | BAEB05.04 |
| 11 | Explain the approach of Lax-Wendroff scheme. | Remember | CO 2 | BAEB05.05 |
| 12 | Show that FTCS is not positive? | Remember | CO 2 | BAEB05.05 |
| **Part - B (Long Answer Questions)** | | | | |
| 1 | Define stability. Derive the expressions for the forward time methods with the help of neat sketch? | Remember | CO 2 | BAEB05.04 |
| 2 | Mention the various explicit methods in time marching solutions. | Remember | CO 2 | BAEB05.04 |
| 3 | Derive the amplification factor for the leap frog method applied to the wave equation and determine the stability restriction for this scheme. | Understand | CO 2 | BAEB05.04 |
| 4 | Briefly explain the criteria and requirement for stability of solution. List out the various explicit methods that can be used in CFD tools. | Remember | CO 2 | BAEB05.05 |
| 5 | Do the steady state solutions of two step MacCormack's predictor corrector method depend on $\Delta t$? | Remember | CO 2 | BAEB05.05 |
| 6 | Discuss the forward-time forward space method, forward-time central space method and forward-time backward space method. | Understand | CO 2 | BAEB05.04 |
| 7 | Compare the forward-time forward space method and forward-time central space method. | Remember | CO 2 | BAEB05.04 |
| 8 | Discuss Euler's forward-time central space method and its importance. List out various implicit methods and their importance in CFD tools. | Remember | CO 2 | BAEB05.04 |

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| 9 | Derive the modified equation for the Lax method applied to the wave equation retain terms up to and including Uxxxx. | Understand | CO 2 | BAEB05.06 |
| 10 | Determine the errors in amplitude and phase for β = 900if the Lax method is applied to the wave equation for 10 time steps with υ =0.5. | Understand | CO 2 | BAEB05.06 |
| 11 | Explain the leap-frog method which is second accurate in both time and space in detail with example. | Remember | CO 2 | BAEB05.04 |
| 12 | Design a first – order upwind method for the linear advection equation that chooses between FTBS and FTFS. | Understand | CO 2 | BAEB05.06 |
| **Part - C (Analytical Questions)** | | | | |
| 1 | Consider the following linear advection problem on a periodic domain [-1,1]: $$\frac{\partial u}{\partial t}+\frac{\partial u}{\partial x}=0$$ $U(x,0) = \begin{cases} 1 & \lvert x\rvert \le 1/3, \\ 0 & \lvert x\rvert > 1/3. \end{cases}$ Approximate u(x,2) using FTFS,FTBS and FTCS with 20 cells and $$\lambda=\frac{\Delta t}{\Delta x}=0.8.$$ | Remember | CO 2 | BAEB05.04 |
| 2 | Suppose the upstream differencing scheme is used to solve wave equation (c=0.75) with the initial condition $u(x,0) = \sin(6\Pi x)\ 0\le x\le 1$ and periodic boundary conditions. Determine the amplitude and phase errors after ten steps if Δt = 0.02 and Δx =0.02. | Remember | CO 2 | BAEB05.04 |
| 3 | Discuss Cranck - Nikolson method as implicit approach by the numerical calculation. | Remember | CO 2 | BAEB05.04 |
| 4 | Consider FTCS in the following non - conservation form: $$\bar{u}_i^{n+1}=\bar{u}_i^n-\frac{\lambda}{2}\left(f(\bar{u}_{i+1}^n)-(\bar{u}_{i-1}^n)\right).$$ Rewrite FTCS in conservation form. | Understand | CO 2 | BAEB05.05 |
| 5 | Derive the following finite- difference method: $$u_i^{n+1}=u_i^n-\frac{\lambda}{2}\left(-f(u_{i+2}^n)+4f(u_{i+1}^n)-3f(u_i^n)\right)$$ Write the method in conservation form. | Understand | CO 2 | BAEB05.05 |
| 6 | Write FTFS and FTBS is artificial viscosity form for both vector and scalar conservation laws. Discuss the relationship between stability and sign of the coefficient of artificial viscosity. | Remember | CO 2 | BAEB05.05 |
| 7 | Suppose the simple explicit method is used to solve the heat equation (α =0.05) with the initial condition. $U(x,0) = \sin(2\Pi x)\ 0 \le x \le 1$ and periodic boundary conditions. Determine the amplitude error after ten steps if Δt = 0.1 and Δx =0.1. | Remember | CO 2 | BAEB05.05 |
| 8 | Derive an expression for the conservative numerical flux of the two step MacCormack's predictor corrector method. Discuss approximate factorization schemes. | Understand | CO 2 | BAEB05.06 |
| 9 | Write the solution of FTCS for the linear advection equation in terms of Fourier series coefficients $c_m^n$. Use these expressions to show that FTCS for the linear advection equation "blows up" in time. | Remember | CO 2 | BAEB05.05 |
| 10 | Derive an expression for the conservative numerical flux of the crank Nicolson method. | Understand | CO 2 | BAEB05.05 |
| **UNIT –III** | | | | |
| **BOUNDARY CONDITIONS** | | | | |
| **Part – A (Short Answer Questions)** | | | | |
| 1 | Define discretization. | Remember | CO 3 | BAEB05.08 |
| 2 | What do you understand by pressure based? | Understand | CO 3 | BAEB05.08 |

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| 3 | Define method of lines. | Understand | CO 3 | BAEB05.08 |
| 4 | What do you understand by density based? | Remember | CO 3 | BAEB05.08 |
| 5 | Differentiate the structured and unstructured grids. | Understand | CO 3 | BAEB05.08 |
| 6 | Define illposed condition. | Remember | CO 3 | BAEB05.08 |
| 7 | Illustrate the number of flow quantities required at far-field boundaries. | Remember | CO 3 | BAEB05.07 |
| 8 | Define implicit operator. | Understand | CO 3 | BAEB05.08 |
| 9 | Define Prandtl number, Reynolds number and Eckert number. | Understand | CO 3 | BAEB05.08 |
| 10 | What is Geometric conservation law? | Remember | CO 3 | BAEB05.08 |
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| 11 | List the types of Boundary conditions encountered in the numerical solution of the Euler equation and the Navier- Stokes equations. | Understand | CO 3 | BAEB05.08 |
| 12 | Define dummy cells. | Understand | CO 3 | BAEB05.08 |
| 13 | Define the concept of periodic boundaries. | Understand | CO 3 | BAEB05.09 |
| 14 | Describe viscous flow and its importance. | Remember | CO 3 | BAEB05.09 |
| 15 | Mention the importance of solid wall in viscous flows. | Remember | CO 3 | BAEB05.09 |
| 16 | Define farfield. Mention the importance of symmetry plane. | Understand | CO 3 | BAEB05.09 |
| 17 | Write down the expression for modified free stream pressure? | Remember | CO 3 | BAEB05.09 |
| 18 | Differentiate the translational and rotational periodicity. | Remember | CO 3 | BAEB05.08 |
| 19 | What is injection boundary? | Understand | CO 3 | BAEB05.09 |
| 20 | Differentiate the subsonic inflow and subsonic outflow in the farfield boundary. | Understand | CO 3 | BAEB05.09 |
| **Part – B (Long Answer Questions)** | | | | |
| 1 | Derive the boundary layer equations for compressible flow with the neat sketch. | Remember | CO 3 | BAEB05.08 |
| 2 | List the coordinate system for axisymmetric thin-shear-layer equations and sketch them. | Remember | CO 3 | BAEB05.08 |
| 3 | Write down the expressions for 3D unsteady boundary-layer equations in Cartesian coordinates, applicable to a compressible turbulent flow in the y direction normal to the wall. | Remember | CO 3 | BAEB05.07 |
| 4 | Describe the general transformation to solve the governing equations on a uniformly spaced computational grid | Remember | CO 3 | BAEB05.08 |
| 5 | Explain the suitable transformation 2 for a 2 D boundary layer type of problem by the governing fluid dynamic equations. | Understand | CO 3 | BAEB05.09 |
| 6 | Differentiate the physical plane and computational plane for grid clustering near an interior point. | Remember | CO 3 | BAEB05.08 |
| 7 | Explain the suitable transformation 3 for a 2 D boundary layer type of problem by the governing fluid dynamic equations. | Remember | CO 3 | BAEB05.08 |
| 8 | Differentiate the physical plane and computational plane for grid clustering near a wall. | Remember | CO 3 | BAEB05.07 |
| 9 | How the governing equations can be transformed from a Cartesian coordinate system to any general non orthogonal coordinate system? | Remember | CO 3 | BAEB05.09 |
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| 1 | Sketch the two layers of dummy cells and explain them in detail | Remember | CO 3 | BAEB05.08 |
| 2 | Mention the importance of solid wall in inviscid flows, the fluid slips over the surface with no friction force. | Remember | CO 3 | BAEB05.08 |
| 3 | Discuss the solid wall boundary condition for the cell-centered scheme when the dummy cells are denoted as 0 and 1 for inviscid flow. | Remember | CO 3 | BAEB05.09 |
| 4 | Explain the solid wall boundary condition for the structured cell-vertex dual control-volume scheme for inviscid flow with the neat sketch. | Understand | CO 3 | BAEB05.09 |
| 5 | What do you understand by periodic boundaries and explain the types of periodic boundaries | Remember | CO 3 | BAEB05.09 |
| 6 | Discuss the solid wall boundary condition for the cell-centered scheme when | Remember | CO 3 | BAEB05.08 |

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| | the dummy cells are denoted as 0 and 1 for viscous flow. | | | |
| 7 | Explain the solid wall boundary condition for the structured cell-vertex dual control-volume scheme for viscous flow with the neat sketch. | Remember | CO 3 | BAEB05.08 |
| 8 | Derive the expression for the vortex correction in 3 D for modification of lifting bodies. | Remember | CO 3 | BAEB05.09 |
| 9 | Differentiate the subsonic inlet and outlet for the implementation for boundary conditions and derive the expression for the subsonic inlet. | Understand | CO 3 | BAEB05.09 |
| 10 | Describe the rotational periodicity which is based on the rotation of the coordinate system with the neat sketch. | Remember | CO 3 | BAEB05.09 |
| **Part - C (Analytical Questions)** | | | | |
| 1 | Obtain the basic explicit time integration scheme by setting $\beta$ =0 and $\omega$ =0 in nonlinear scheme where we can approximate by a forward difference. | Remember | CO 3 | BAEB05.08 |
| 2 | Derive the generalized transformation to the compressible Navier - stokes equation in the vector form. | Understand | CO 3 | BAEB05.07 |
| 3 | Explain the suitable transformation 1 for a 2 D boundary layer type of problem by the governing fluid dynamic equations. | Remember | CO 3 | BAEB05.08 |
| 4 | Define implicit residual smoothing andJacobi preconditioning. Differentiate the upwind implicit residual smoothing and implicit - explicit residual smoothing. | Understand | CO 3 | BAEB05.07 |
| 5 | Explain the Notation and coordinate system for a boundary layer on a flat plate by assuming the thickness of the viscous and thermal boundary layers are small relative to a characteristic length in the primary flow direction. | Remember | CO 3 | BAEB05.08 |
| 6 | Explain the suitable transformation 4 for a 2 D boundary layer type of problem by the governing fluid dynamic equations. | Understand | CO 3 | BAEB05.09 |
| 7 | Compare the periodic boundaries in the case of 2 D unstructured and structured Cell- Centered schemes and utilization of dummy cells for periodic boundaries with the neat sketch. | Understand | CO 3 | BAEB05.07 |
| 8 | Mention the importance of symmetry plane with the reference of cell centered scheme and cell - Vertex scheme. | Remember | CO 3 | BAEB05.08 |
| 9 | Explain the coordinate cut for the boundary condition whether it is suitable for structured or unstructured case with the help of neat sketch. | Understand | CO 3 | BAEB05.09 |
| 10 | Derive the expression to obtain the boundary layer approximations to the Navier-Stokes and Reynolds equations for steady 2D incompressible constant-property flow along an isothermal surface at temperature $T_w$. | Understand | CO 3 | BAEB05.09 |
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| 1 | Differentiate the unstructured cell- centered and Meridian – Dual scheme for the solid wall boundary condition for inviscid flow | Remember | CO 3 | BAEB05.08 |
| 2 | Compare and contrast the solid wall boundary condition for the 2D unstructured , Dual –control volume mixed-grid scheme and 3D unstructured, mixed – grid scheme for inviscid flow | Remember | CO 3 | BAEB05.08 |
| 3 | Differentiate the cell-centered scheme and structured cell-vertex dual control-volume scheme for the solid wall boundary condition. | Remember | CO 3 | BAEB05.08 |
| 4 | Summarize the concept of characteristic variables and list the different types of far field boundary conditions. | Understand | CO 3 | BAEB05.09 |
| 5 | Differentiate the supersonic inflow and supersonic outflow in the farfield boundary with the help of neat sketch | Understand | CO 3 | BAEB05.09 |
| 6 | Derive the expression for the vortex correction in 2 D for modification of lifting bodies by understanding the effects of distance to the farfield boundary and of single vortex on the lift coefficient | Remember | CO 3 | BAEB05.08 |
| 7 | Compare the periodic boundaries in the case of 2 D unstructured and structured cell - Vertex schemes with dual control volumes and utilization of dummy cells for periodic boundaries with the neat sketch. | Understand | CO 3 | BAEB05.09 |
| 8 | To generate a single grid inside a geometrically complex domain Briefly explain the basic implementation issues of the multi block approach for the interface between grid blocks. | Understand | CO 3 | BAEB05.09 |

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| **UNIT -IV** | | | | |
| **METHOD OF CHARACTERISTICS** | | | | |
| **Part – A (Short Answer Questions)** | | | | |
| 1 | Define compatibility equation. | Remember | CO 4 | BAEB05.11 |
| 2 | What do you understand by Mach lines? | Remember | CO 4 | BAEB05.11 |
| 3 | DefineMach angle and write the expression for the Mach angle. | Remember | CO 4 | BAEB05.11 |
| 4 | What is full velocity potential? | Remember | CO 4 | BAEB05.11 |
| 5 | Differentiate the non-simple region and simple region. | Remember | CO 4 | BAEB05.11 |
| 6 | What do you understand by unit processes? | Remember | CO 4 | BAEB05.11 |
| 7 | Define hyperbolic partial differential equation. | Understand | CO 4 | BAEB05.11 |
| 8 | List the steps for solving the flow field. | Remember | CO 4 | BAEB05.11 |
| 9 | Define initial data line in method of characteristics. | Remember | CO 4 | BAEB05.11 |
| 10 | Define parabolic partial differential equation. | Understand | CO 4 | BAEB05.11 |
| **Part – B (Long Answer Questions)** | | | | |
| 1 | Derive the characteristic line for two dimensional irrotational flows. | Remember | CO 4 | BAEB05.10 |
| 2 | Explain the importance of characteristic lines and its effect in fluiddynamics. | Remember | CO 4 | BAEB05.12 |
| 3 | Summarize the philosophy of method of characteristics with the help of neat sketch. | Remember | CO 4 | BAEB05.11 |
| 4 | Explain the relationship of characteristics in unsteady one dimensional flow with the help of neat sketch. | Remember | CO 4 | BAEB05.12 |
| 5 | Discuss how to produce the method of unit process for the conditions at wall, internal flow and shock wave. | Remember | CO 4 | BAEB05.12 |
| 6 | Illustrate the left - running characteristics and right - running characteristic lines with the suitable diagram. | Remember | CO 4 | BAEB05.12 |
| 7 | Discuss the design of the supersonic wind tunnel nozzle by using the method of characteristics. | Understand | CO 4 | BAEB05.11 |
| 8 | Determine the compatibility equation which describes the variation of flow properties along the characteristic lines. | Remember | CO 4 | BAEB05.12 |
| 9 | Illustration of the characteristic line and explain the relationship of characteristics in unsteady one-dimensional flow. | Remember | CO 4 | BAEB05.11 |
| 10 | Discuss the concept of characteristic variable in farfield for the method of characteristics. | Understand | CO 4 | BAEB05.11 |
| **Part – C (Analytical Questions)** | | | | |
| 1 | Determine the characteristic lines by consider steady, adiabatic, two dimensional, irrotational supersonic flow? | Remember | CO 4 | BAEB05.11 |
| 2 | Briefly explain the Internal flow of the unit processes for the steady flow, two dimensional irrotational Method of characteristics. | Understand | CO 4 | BAEB05.11 |
| 3 | Derive an expression for the steady, two dimensional supersonic and the illustration of the characteristic lines | Remember | CO 4 | BAEB05.11 |
| 4 | Briefly explain the wall point of the unit processes for the steady flow, two dimensional irrotational Method of characteristics. | Remember | CO 4 | BAEB05.11 |
| 5 | Differentiate the wall point and shock point of the unit processes for the steady flow, two dimensional irrotational Method of characteristics. | Understand | CO 4 | BAEB05.11 |
| 6 | Briefly explain the shock point of the unit processes for the steady flow, two dimensional irrotational Method of characteristics. | Remember | CO 4 | BAEB05.11 |
| 7 | Differentiate the regions of influence and domain of dependence to understand the propagation of disturbances in a steady supersonic flow. | Understand | CO 4 | BAEB05.11 |
| 8 | Explain the Method of characteristics how it will be helpful to design the contour of a supersonic nozzle for shock free and isentropic flow. | Remember | CO 4 | BAEB05.10 |
| 9 | Prove the for a minimum- length nozzle the expansion angle of the wall downstream of the throat is equal to the one- half of the Prandtl - Meyer function for the design exit Mach number. | Remember | CO 4 | BAEB05.11 |

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| 10 | Using the Method of characteristics, compute and graph the contour of a two dimensional minimum- length nozzle for the expansion of air to a design exit Mach number of 2.4. | Understand | CO 4 | BAEB05.12 |
| **UNIT – V** | | | | |
| **PANELMETHODS** | | | | |
| **Part - A (Short Answer Questions)** | | | | |
| 1 | Define influence coefficients? | Remember | CO 5 | BAEB05.13 |
| 2 | Explain what you mean by discretization in computational fluid dynamics. | Remember | CO 5 | BAEB05.13 |
| 3 | Define the Mixed boundary condition problem. | Remember | CO 5 | BAEB05.13 |
| 4 | What are the singularity distribution strengths? | Remember | CO 5 | BAEB05.14 |
| 5 | Define collocation points which can be selected on the body surface. | Remember | CO 5 | BAEB05.13 |
| 6 | Differentiate the wake strength and wake shape. | Remember | CO 5 | BAEB05.15 |
| 7 | What are the additional conditions to design a wake model? | Understand | CO 5 | BAEB05.15 |
| 8 | Define local velocity vector. | Understand | CO 5 | BAEB05.13 |
| 9 | Define compressibility factor | Understand | CO 5 | BAEB05.14 |
| 10 | What is Prandtl – Glauert rule? | Understand | CO 5 | BAEB05.15 |
| **Part - B (Long Answer Questions)** | | | | |
| 1 | Explain briefly about the steps toward constructing a numerical solution for the panel methods? | Understand | CO 5 | BAEB05.13 |
| 2 | Derive the expression to set the wake strength at the trailing edge by the implementation of the Kutta condition when using surface doublet distribution. | Understand | CO 5 | BAEB05.13 |
| 3 | For developing the three dimensional panel code what is the effect of compressibility in the case of incompressible potential flow? | Remember | CO 5 | BAEB05.14 |
| 4 | Differentiate the possible conditions that can be applied at cusp and finite trailing edges with the help of neat sketch. | Remember | CO 5 | BAEB05.14 |
| 5 | Define the wake shape. Explain the effect of prescribed wake geometry on the aerodynamics of an AR = 1.5 wing. | Understand | CO 5 | BAEB05.15 |
| 6 | Explain which type of singularity that will be used, type of boundary condition and wake model is prior to establish a numerical solution. | Remember | CO 5 | BAEB05.15 |
| 7 | Discuss how the method of discretizing surface and singularity distributions is prior to establish a numerical solution. | Remember | CO 5 | BAEB05.15 |
| 8 | Explain how the considerations of numerical efficiency are important to establish a numerical solution. | Understand | CO 5 | BAEB05.15 |
| 9 | Discuss the selection of singularity element for constructing a numerical solution. | Remember | CO 5 | BAEB05.14 |
| 10 | Briefly explain the discretization of geometry and grid generation for constructing a numerical solution. | Understand | CO 5 | BAEB05.13 |
| 11 | Define influence coefficients and explain them in detail generation for constructing a numerical solution. | Remember | CO 5 | BAEB05.14 |
| 12 | Derive the expression to set the wake strength at the trailing edge by the implementation of the Kutta condition when using vortex ring elements. | Remember | CO 5 | BAEB05.14 |
| 13 | Discuss the Models for Wake roll up, Jets and Flow separations foe the effect of compressibility and viscosity. | Understand | CO 5 | BAEB05.15 |
| 14 | Describe the effect of compressibility and viscosity that to be accounted for thin airfoil theory. | Understand | CO 5 | BAEB05.15 |
| **Part - C (Analytical Questions)** | | | | |
| 1 | Explain the preliminary considerations prior to establishing the numerical solution? | Remember | CO 5 | BAEB05.13 |
| 2 | Differentiate the discretization of the geometry of a thin airfoil by using the lumped vortex element and a three dimensional body using constant – strength surface doublets and sources. | Understand | CO 5 | BAEB05.13 |
| 3 | Briefly explain the typical flow chart for the numerical solution of the surface singularity distribution problem. | Remember | CO 5 | BAEB05.13 |

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| 4 | Explain the concept of reduction of a problem to a set of linear algebraic equations? | Understand | CO 5 | BAEB05.14 |
| 5 | Briefly explain about the secondary computation or about aerodynamics loads and how are they calculated? | Remember | CO 5 | BAEB05.13 |
| 6 | Consider the solution for symmetric, thin airfoil with Lumped – Vortex element; explain how the selection of singularity element takes place. | Understand | CO 5 | BAEB05.14 |
| 7 | Explain the nomenclature and flowchart for the influence of a panel element at a point P for the thin airfoil with Lumped – Vortex element. | Remember | CO 5 | BAEB05.13 |
| 8 | Discuss the influence coefficients for the thin airfoil with Lumped – Vortex element. | Remember | CO 5 | BAEB05.13 |
| 9 | Describe the discretization of geometry and grid generation for the thin airfoil with Lumped – Vortex element. | Understand | CO 5 | BAEB05.13 |
| 10 | Illustrate the establishment of RHS and linear set of equations to solve for the thin airfoil with Lumped – Vortex element. | Remember | CO 5 | BAEB05.13 |
| 11 | Derive the secondary computations such as pressure and loads for the thin airfoil with Lumped – Vortex element. | Understand | CO 5 | BAEB05.13 |
| 12 | Explain the methods for combining the displacement thickness and friction drag solution by using boundary layer. | Understand | CO 5 | BAEB05.14 |
| 13 | For developing the three dimensional panel code what is the effect of thin boundary layers in the account of viscosity in the case of potential flow? | Remember | CO 5 | BAEB05.13 |
| 14 | Explain about the effects of flow compressibility and viscosity in the computational fluid dynamics. | Understand | CO 5 | BAEB05.15 |

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