Hall Ticket No | | | | | | | | | | | Question Paper Code: AAEC25

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal-500043, Hyderabad

B.Tech VI SEMESTER END EXAMINATIONS (REGULAR) - JULY 2023

Regulation: UG-20

COMPUTATIONAL AERODYNAMICS

Time: 3 Hours (AERONAUTICAL ENGINEERING) **Max Marks: 70**

Answer ALL questions in Module I and II
Answer ONE out of two questions in Modules III, IV and V
All Questions Carry Equal Marks
All parts of the question must be answered in one place only

MODULE – I

1. (a) Elucidate the utility of computational fluid dynamics (CFD) as a research tool, design tool, and educational tool for investigating fluid dynamical problems. [BL: Understand| CO: 1|Marks: 7]

   (b) Obtain the momentum equation in conservation form by considering an infinitesimally small fluid element moving with the flow. [BL: Apply| CO: 1|Marks: 7]

MODULE – II

2. (a) Examine the physical behavior of flows governed by parabolic equations, with a specific focus on steady boundary layer flows. [BL: Understand| CO: 2|Marks: 7]

   (b) Consider the full velocity potential equation for steady, two-dimensional supersonic flows, and determine the equation for characteristic curves in the physical xy space. Classify the nature of the velocity potential equation based on the Mach number [BL: Apply| CO: 2|Marks: 7]

MODULE – III

3. (a) Describe the explicit formulation by utilizing the one-dimensional heat conduction equation as an example. Mention its relative advantages and disadvantages

   [BL: Understand| CO: 3|Marks: 7]

   (b) Construct the difference equation using implicit approach by considering the unsteady, one-dimensional heat conduction equation with constant thermal diffusivity. Support the explanation with a clear sketch. [BL: Apply| CO: 3|Marks: 7]

4. (a) Illustrate a stable case by comparing the numerical domain, including the analytical domain, with one that does not include the entire analytical domain. Provide a neat sketch to clarify the concept. [BL: Understand| CO: 4|Marks: 7]

   (b) Sketch the finite-difference modules for the second-order central second difference with respect to x and y, as well as the second-order central mixed difference with respect to x and y. Provide a justification for each expression [BL: Apply| CO: 4|Marks: 7]

MODULE – IV

5. (a) Discuss the boundary conditions for the pressure correction method using a schematic of a staggered grid in the context of incompressible viscous flow. [BL: Understand| CO: 5|Marks: 7]

   (b) Find the expression for the finite difference method and relaxation technique used to solve elliptic partial differential equations. Mention the applications of this method.
   [BL: Apply| CO: 5|Marks: 7]

6. (a) Outline the sequence of operations in a computational fluid dynamics procedure that utilizes the SIMPLE algorithm. Present a flowchart to illustrate the process.
   [BL: Understand| CO: 5|Marks: 7]

   (b) Determine the second step in the Alternating Direction Implicit (ADI) technique, which involves sweeping in the y direction to determine T at time t+$\triangle t$. [BL: Apply| CO: 5|Marks: 7]

MODULE – V

7. (a) Differentiate between a non-uniform finite volume mesh and an orthogonal non-uniform finite volume mesh, accompanied by a suitable diagram. [BL: Understand| CO: 6|Marks: 7]

   (b) Consider a cylindrical fin with uniform cross-sectional area A. the base is at a temperature of 100^0C (T B) and the end is insulated. The fin is exposed to an ambient temperature of 20^0C. One-dimensional heat transfer in this situation is governed by $\frac{\mathrm{d}}{\mathrm{d}x}\{kA(\frac{\mathrm{d}T}{\mathrm{d}x})\} - hP(T - T_\infty) = 0$ where h is the convective heat transfer coefficient, P the perimeter, k- the thermal conductivity of the material and T_∞ the ambient temperature. Calculate the temperature distribution along the fin using five equally placed control volumes. Take hp / (kA) =25 (note: kA is constant)
   [BL: Apply| CO: 6|Marks: 7]

8. (a) Evaluate the fluxes for the upwind schemes and cell-centered finite volume methods. Explain how upwind schemes determine the cell face fluxes based on the propagation direction of the convection velocity. [BL: Understand| CO: 6|Marks: 7]

   (b) Solve a finite volume estimation of gradients for an arbitrary quadrilateral by observing the differences $\triangle y$ grouped for opposite nodes. Support the explanation with a clear diagram.
   [BL: Apply| CO: 6|Marks: 7]

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