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B.M.S. College of Engineering, Bengaluru-560019

Autonomous Institute Affiliated to VTU

August 2024 Supplementary Examinations

Programme: B.E. **Semester: VI**
Branch: Aerospace Engineering **Duration: 3 hrs.**
Course Code: 20AE6DECFD **Max Marks: 100**
Course: Computational Fluid Dynamics

Instructions:

1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may be suitably assumed.

UNIT - I

1 a) Explain the various types of flow model with suitable sketch and bring out what type of model leads to what type of governing equation forms in continuity equation. **10**

b) Define substantial derivative, local derivative and convective derivative. Explain with suitable examples. **5**

c) List few applications of CFD in Aerospace engineering. **5**

OR

2 a) Transform non-conservation form of integral continuity equation into integral conservation form. **5**

b) Derive the continuity equation for an infinitesimal fluid element fixed in space with necessary assumptions. **10**

c) Consider the non-linear equation

$$u\frac{\partial u}{\partial x} = \mu\frac{\partial^2 u}{\partial y^2}$$

where **μ** is a constant and u is the x-component of velocity. The normal direction is y. Is this equation in conservation form? If not, suggest a conservative form of equation with suitable explanation. **5**

UNIT - II

3 a) Apply Cramer's rule to a quasi-linear PDE for the mathematical classification as elliptic and hyperbolic. **15**

b) Explain about the domain and boundaries for the solution of parabolic equations in two dimensions. **5**

UNIT - III

4 a) What is boundary-fitted co-ordinate system? Explain. **5**

b) Write short notes on adaptive grids. **5**

c) Explain the algebraic grid generation with an example. Explain briefly what quantities are necessary to solve the using finite differences if numerical methods are used? **10**

UNIT - IV

5 a) Derive the third-order accurate $[O(\Delta y)^3]$ one sided finite difference expression for the derivative at the boundary. **5**

b) Consider the viscous flow of air over a flat plate. At a given station in the flow direction, the variation of the flow velocity, u, in the direction perpendicular to the plate (the y direction) is given by the expression. **15**

$$u = 482.19\left[1 - e^{-\left(y/_L\right)}\right]$$

where L = characteristic length = 1 in. The units of u are in m/s. The viscosity co-efficient is 1.789×10^{-5} kg/m-s. The above equation is used to provide the values of u at discrete grid points equally spaced in the y-direction, with Δy = 0.1 in.

Grid point No.	y (in)	u (m/s)
1.	0	0
2.	0.1	45.89
3.	0.2	87.41
4.	0.3	124.98

Using these discrete values, calculate the shear stress at the wall (τ_w):

(i) Using a first order one-sided difference,

(ii) Using the second order one-sided difference,

(iii) Using the third order one-sided difference.

Finally, compare these calculated finite-difference results with the exact value of τ_w.

OR

6 a) The numerical domain must include all the analytical domain for stability and the converse is true for instability. Comment on the statement with respect to time and also with respect to space for either a first or second order wave equation. **10**

b) Explain the methodology of Crank-Nicholson implicit differencing scheme for the governing parabolic partial differential equation with respect to space and time. **10**

UNIT - V

7 a) Enumerate the differences between finite difference and finite volume method. **10**

b) Derive an expression for calculating the average value of u for the successive nodes using the governing equation $\frac{\partial u}{\partial t} + \frac{\partial f}{\partial x} = 0$ for one-dimensional finite volume method. **10**

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