CBCS SCHEME

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15AE72

Seventh Semester B.E. Degree Examination, Aug./Sept.2020
Computational Fluid Dynamics

Time: 3 hrs. Max. Marks: 80

Note: Answer any FIVE full questions, choosing ONE full question from each module.

Module-1

1 a. Derive momentum equation for small fluid element fixed in space and for small element moving in space, with viscous terms. **(10 Marks)**

b. Show that substantial derivative $\rho\frac{Du}{Dt}$ occurring in non-conservative form of momentum equation can be written in the following way that is representative of conservative form $\frac{\partial(\rho u)}{\partial t}+\nabla.(\rho u V)$ **(06 Marks)**

OR

2 a. What are the various boundary conditions? **(06 Marks)**

b. What are CFD ideas to understand? **(10 Marks)**

Module-2

3 a. Through the Cramer rule determine the slopes of characteristic lines for potential 2-D flow equation $\left(1-M_\infty^2\right)\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}=0$, where u and v are perturbation velocities in the flow. M_∞ is free stream Mach number. **(12 Marks)**

b. Explain how steady boundary layer flow can be governed by Parabolic equations. **(04 Marks)**

OR

4 Explain the different mathematical behavior of CFD equations that reflects different physical behavior of flow field. Give an example of each case. **(16 Marks)**

Module-3

5 a. Describe Hermite Polynomial Interpolation. **(08 Marks)**

b. Develop a cubic Hermite Polynomial for following function

$$f(x) = x^4 + x^3 + x^2 + x + 1$$ **(08 Marks)**

OR

6 a. Explain elliptic grid generation technique. **(08 Marks)**

b. Describe the following for structured adaptive grid generation:
(i) Control function approach
(ii) Variational methods **(08 Marks)**

Module-4

7 a. Describe the following :
(i) Upwind differencing
(ii) Midpoint leap frog differencing techniques
(iii) Reflection Boundary condition. **(09 Marks)**

b. Use an explicit numerical method to solve the heat conduction equation

$$\frac{\partial T}{\partial t} = a\frac{\partial^2 T}{\partial x^2}$$

Boundary conditions : $T(0, t) = T(1, t) = 0 \quad (t \geq 0)$; $T(x, 0) = \text{Sin}(\pi x) \quad (0 \leq x \leq 1)$
Both ends held at zero temperature given initial temperature distribution.
Use the following parameters.
$\Delta t = 0.1 \qquad \Delta x = 0.25 \qquad a = 0.1$; Carry out iterations till 0.3 sec. **(07 Marks)**

OR

8 a. Consider the following transformation for accomplishing grid stretching :

$$\xi = x, \quad n = \ln(y + 1)$$

What happens to governing flow equations in both the physical and computational plane with this transformation? Show this with an example of 2-D continuity equation for compressible flow through matrices technique for transformation of grids. **(10 Marks)**

b. Explain the above with Inverse Transformation through use of Jacobean. **(06 Marks)**

Module-5

9 Write short notes on following :

a. Numerical viscosity **(04 Marks)**
b. Flux vector splitting **(06 Marks)**
c. Approximate Factorisation **(06 Marks)**

OR

10 Explain the following :

a. Artificial viscosity **(04 Marks)**
b. Finite volume solution to diffusion problem below.

$$\frac{d}{dx}\left(k\frac{\partial T}{\partial x}\right) = 0$$ **(05 Marks)**

c. Finite volume solution to convection and diffusion problem below.

$$\frac{d}{dx}\left(k\frac{\partial T}{\partial x}\right) - \frac{d(\rho u T)}{dx} = 0$$ **(07 Marks)**

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