



# CBCS SCHEME

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  $\frac{\partial(\rho u)}{\partial t} + \nabla \cdot (\rho u V)$  (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  $(1 - M_\infty^2) \frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0$ , where u and v are perturbation velocities in the flow.  $M_\infty$  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)

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.  
2. Any revealing of identification, appeal to evaluator and /or equations written eg. 42+8 = 50, will be treated as malpractice.

- 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 :  $T(0, t) = T(1, t) = 0$  ( $t \geq 0$ ) ;  $T(x, 0) = \sin(\pi x)$  ( $0 \leq x \leq 1$ )

Both ends held at zero temperature given initial temperature distribution.

Use the following parameters.

$\Delta t = 0.1$      $\Delta x = 0.25$      $a = 0.1$  ; Carry out iterations till 0.3 sec. (07 Marks)

**OR**

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

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

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.

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

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

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

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