CBCS SCHEME

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18ME733

Seventh Semester B.E. Degree Examination, Feb./Mar. 2022
Computational Fluid Dynamics

Time: 3 hrs. Max. Marks: 100

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

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.

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Module-1

1 a. What is the need of a CFD tool? Elaborate on two applications of CFD in detail. **(04 Marks)**

b. What is a substantial derivative? Write an expression for the substantial derivative of velocity. **(06 Marks)**

c. Derive the Navier-Stokes equation (PDE form) in the Cartesian coordinate system. **(10 Marks)**

OR

2 a. Write a short note on gradient, divergence and curl operators. **(06 Marks)**

b. Explain the mathematical classification of second order PDE's with examples. **(06 Marks)**

c. Derive the integral form of Navier-Stokes equation from PDE's. **(08 Marks)**

Module-2

3 a. Explain the conserved and primitive variables. **(04 Marks)**

b. Obtain the eigen values and eigen vectors of gas dynamics equation as given below:

$$\frac{\partial \rho}{\partial t} + \rho_0 \frac{\partial u}{\partial x} = 0$$

$$\frac{\partial u}{\partial t} + \frac{a^2}{\rho_0} \frac{\partial \rho}{\partial x} = 0$$

ρ_0 = constant reference density

a = sound speed **(06 Marks)**

c. Derive the Reynolds averaged momentum equations. **(10 Marks)**

OR

4 a. With the help of a telescoping series, write the conservative and non conservative forms of the following derivative and explain the significance of boundary terms.

$$\frac{\partial \rho u}{\partial x}$$

Consider a one-dimensional domain which is spatially discretized using three elements and four nodes. How to choose the scheme (conservative and non conservative) for a given fluid flow? **(06 Marks)**

b. Explain the terms: (i) turbulent kinetic energy (ii) dissipation rate **(04 Marks)**

c. Derive the conservative form of the Navier-Stokes equation from its non conservative form. **(10 Marks)**

Module-3

5 a. Find $< f, g >$, $||f||$ and $||g||$ for the following functions on the interval $(-1, 1)$, $f(x) = x^2$ and $g(x) = x^3$. **(04 Marks)**

b. What is a representation error? **(04 Marks)**

c. Using box function, find the representations for the following function on the interval $x \in [0, 1]$ $p(x) = x = p_f f + p_g g + p_h h$

Use four nodes $\left\{0.0, \frac{1}{3}, \frac{2}{3}, 1.0\right\}$. Find the error in the representations. **(12 Marks)**

OR

6 a. On the interval of [−1, 1], find the angle between the functions f(x) = 1 and g(x) = x. How about if the interval considered is [0, 1]? **(06 Marks)**

b. With the necessary equations, explain linear approximation using Hat functions. With the help of schematics, explain the representation of sin(πx) using five nodes on the interval [0, 1]. **(10 Marks)**

c. With necessary equations, explain machine epsilon. **(04 Marks)**

Module-4

7 a. Compute forward, backward and central difference approximations for the first derivative of $f(x) = \frac{3x + 5}{x - 4}$ at x = 2. Use a step size of 0.01. Compare these values with the exact values and comment on your calculations. **(10 Marks)**

b. Explain the explicit and implicit approaches as applied to linear convection equations. **(10 Marks)**

OR

8 a. Why iterative methods are preferred in numerical methods. Differentiate Jacobi and Gauss-Siedel iterative methods. **(08 Marks)**

b. Describe the First Order Forward Time and Centered Space (FTCS) method of solving one dimensional transient diffusion equation

$$\frac{\partial u}{\partial t} = D\frac{\partial^2 u}{\partial x^2}$$

where D is the diffusion coefficient. **(08 Marks)**

c. Discuss the upwind scheme in finite difference method. **(04 Marks)**

Module-5

9 a. State the disadvantages of Lax-Wendroff technique and explain MacCormack's technique. **(10 Marks)**

b. Describe the Flux Splitting Method. **(05 Marks)**

c. Write a short note on Finite Volume Method. **(05 Marks)**

OR

10 a. Derive the MacCormack scheme for two-dimensional time dependent compressible flow. **(10 Marks)**

b. Compare the finite volume flux splitting for the Euler equation using:
(i) Steger and Warming Method
(ii) Roe's Method **(10 Marks)**

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