Ref. No. : Ex/PG/MEC/PE/T/113D/2025

M.E. MECHANICAL ENGG 1st YR. 1st SEM. EXAM - 2025

Computational Fluid Dynamics

Time: 3 Hours **Full Marks: 100**

Use a Separate ANSWER SCRIPT for EACH PART.

Part A – Answer Any TWO Questions (50 Marks)

1. a) Explain how partial differential equations are categorized. *8*

   b) Discuss the general behavior of different classes of partial differential equations and their impact on CFD. *12*

   c) What do you mean by a *well posed problem*? *5*

2. a) Explain forward, rearward and central differencing. *8*

   b) Obtain expression for the second order accurate finite difference discretization expression for $\partial^2 u/\partial x \partial y$. *12*

   c) Distinguish between Dirichlet and Neumann boundary conditions. *5*

3. a) Briefly discuss the different types of errors encountered in CFD analysis of a physical problem. *10*

   b) Obtain the stability condition for 1-D heat conduction equation using von Neumann stability method. 15

Part B – Answer Any TWO Questions (50 Marks)

4. a) Describe the key steps in using the Finite Volume (FV) Method (FVM) to solve diffusion problems. *10*

   b) A 0.5m solid rod (thermal conductivity k = 800 W/m·K) has its ends maintained at 50°C and 150°C. Using FVM with 5 equal control volumes, i) formulate the discretized equations for all nodes, ii) solve temperature at each node, iii) compare your numerical solution with the analytical solution. 15

5. a) Compare the central differencing scheme and the upwind differencing scheme for a simple 1D convection–diffusion equation. *10*

   b) Define conservativeness, boundedness, and transportiveness in the context of Finite Volume Discretization. 15

6. a) Extend the 1D discretization to 2D by deriving the general expression for an interior node in a 2D diffusion problem. *12*

   b) Explain the SIMPLE algorithm using a flowchart. Discuss the role of the pressure-correction equation in ensuring mass conservation. 13