Total No. of Questions : 7] **SEAT No. :**

P4640 **[Total No. of Pages : 2**

[4860] - 1062

M.E. (Mechanical) (Heat Power Engineering)

COMPUTATIONAL FLUID DYNAMICS

(2013 Pattern)

Time : 3 Hours] ***[Max. Marks : 50***

Instructions to the candidates:

1) ***Answer any five questions.***
2) ***Neat diagrams must be drawn wherever necessary.***
3) ***Use of scientific calculator is allowed.***
4) ***Assume suitable data, if necessary and mention it clearly.***

Q1) a) Write the canonical form of partial differential equations with practical examples. Explain in detail the mathematical nature of Parabolic equations with example. **[6]**

b) Explain Reynolds transport theorem and its significance in detail. **[4]**

Q2) a) Write in detail the CFD analysis process of the numerical solution of flow through backward facing step having step height as characteristics length scale. In this case assume length unity. Setup the problem with suitable initial and boundary conditions in detail. Write all the steps involved in the simulation and explain with neat sketches. **[6]**

b) Which of the following, forward difference, backward difference and central difference, is most accurate and why? **[4]**

Q3) a) Classify the following system of equations. **[5]**

$$\frac{\partial u}{\partial t} + a\frac{\partial u}{\partial x} + b\frac{\partial v}{\partial y} = 0 \quad ; \quad \frac{\partial v}{\partial t} + b\frac{\partial u}{\partial x} + a\frac{\partial v}{\partial y} = 0$$

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b) Explain finite volume method and illustrate it for the generalized two dimensional first order conservation equation written in state variable Φ.

$$\frac{\partial \varphi}{\partial t}+\frac{\partial F(\varphi)}{\partial x}+\frac{\partial G(\varphi)}{\partial y}=0$$

where, Φ is state variable vector and $F(\Phi), G(\Phi)$ are and flux vectors for two dimensional continuity equation and inviscid momentum equation in x and y direction respectively. **[5]**

Q4) a) For unsteady convection - diffusion process, what is the difference between explicit and implicit time-marching approaches? Explain any one implicit time-marching method in detail. **[5]**

b) Derive stability condition for Lax-Wendroff scheme. Comment on the stability criteria. **[5]**

Q5) a) What is upwind method? Why upwind schemes are important for strongly convective flow? **[5]**

b) Write in brief different types of grid generation used in CFD simulations. Explain in detail Delaunay triangulation. **[5]**

Q6) a) Two parallel plates with infinite length are kept 40mm apart. The fluid within the plates has kinematic viscosity of $2.17 \times 10^{-4} m^2/s$ and density $800 kg/m^3$. The lower plate is stationary and the upper plate is moving with velocity 40 m/s. Find the velocity distribution within fluid in y-direction for one time step (Δt), Discretize the domain with five nodes and apply Crank-Nicolson's implicit method. Take $\Delta t = 0.55$. The governing equation is given by **[5]**

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

b) Differentiate between density based and pressure based solvers. Explain in detail, step by step, pressure based algorithm commonly used. **[5]**

Q7) a) What is turbulence modeling? Explain any suitable two-equation model for an external flow. **[5]**

b) Write a short note on **[5]**

i) Conformal and non-conformal grids.

ii) Closure problem.