Total No of Questions: [12] ***SEAT NO. :***

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B. E. (Mechanical) 2008 course

Computational Fluid Dynamics (Code: 402049)

May 2014 (Semester - II)

Time: 3 Hours ***Max. Marks :100***

Instructions to the candidates:

1. ***Answer to the two sections should be written in separate answer- books***
2. ***Draw Diagrams wherever necessary.***
3. ***Use of scientific calculator is allowed.***
4. ***Assume suitable data where ever necessary***

SECTION-I

Q1) a) Describe the physical meaning of Substantial derivative with a practical example [8]

b) Consider a laminar boundary layer that can be approximated as having a velocity profile $u(x) = U_\infty y/\delta$ where $\delta = cx^{1/2,}$ c is a constant, U_∞ is free stream velocity. δ is the boundary layer thickness. Considering 2 dimensional flows, determine vertical component of velocity v inside the boundary layer. (Make use of differential form of continuity equation) [10]

OR

Q2) a) Describe the various flow models used to investigate a fluid flow. State what are conservation and non conservation form of the governing equations? [8]

b) Obtain the momentum equation for an infinitesimally small fluid element fixed in space. [10]

Q3) a) What is discretization? Comment further on it in relation with consistency and stability of governing equations. [8]

b) Derive the following finite difference approximation for applications in two dimensional fluid flow at point (i,j) [8]

$$\frac{\partial^2 y}{\partial x^2} = \frac{2y_{i,j} - 5y_{i+1,j} + 4\, y_{i+2,j} - y_{i-3,j}}{(\Delta x)^2} + O(\Delta x)^2$$

OR

Q4) a) Explain what you mean by an implicit solution method and an explicit solution method. Also discuss merits and demerits of these two methods. [8]

b) Why relaxation techniques are needed in numerical calculations, explain how under- relaxation and over relaxation works in numerical calculations. [8]

Q5) a) a) Solve following Tri-diagonal Matrix system using Thomas algorithm [10]

$$\begin{bmatrix} 2.25 & -1 & 0 & 0 \\ -1 & 2.25 & -1 & 0 \\ 0 & -1 & 2.25 & -1 \\ 0 & 0 & -2 & 2.25 \end{bmatrix} = \begin{bmatrix} T1 \\ T2 \\ T3 \\ T4 \end{bmatrix} = \begin{bmatrix} 1 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

b) What do you mean by Dirichlet, Neumann and Mixed boundary conditions? Give an example of each. [6]

OR

Q6) a) For one dimensional Transient heat conduction, formulate the finite difference expression [8]

i) Explicit form
ii) Crank Nicholson (Semi Implicit) form

b) Explain the solution algorithm for Tri-diagonal Matrix encountered in CFD calculations. [8]

SECTION-II

Q 7) a) Consider a linear first order wave equation [16]

$$\frac{\partial u}{\partial t} = -C\frac{\partial u}{\partial x}$$

Where C is constant and that is greater than 1. Present finite difference approximation of above equation using

i) Forward time and forward space of first order Euler's method
ii) Forward time and backward space of first order - upwind difference method
iii) Central differencing of second order for both
iv) The Lax-Wendroff method
v) Crank-Nicolson method

What is the stability condition for above methods?

OR

Q8) a) Consider the first order wave equation [16]

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

Compute the solution for this equation for first two steps using Mac Cormack scheme with initial condition

$u(x,0) = x-x^2$, $0 <= x <= 1$

$u(x,0) = 0$, $x>1$

and boundary condition $u(0,t)=0$ for all t's.

Take $\Delta x=0.5$, $r= C*(\Delta t/\Delta x)=0.5$

Q.9 a) Explain the following boundary conditions in detail [6]

i) Inlet
ii) Outlet
iii) Wall
iv) Symmetry

b) Write down step by step procedure for SIMPLE algorithm. [10]

OR

Q. 10 a) Explain step by step the Finite Volume Method with suitable example in heat transfer [8]

b) Explain : Artificial viscosity [8]

Q.11 a) Explain CFD simulation procedure with suitable example in fluid flow or heat transfer giving [14]

i) Problem definition
ii) Grid generation
iii) Boundary conditions
iv) Post processing

b) What is the convergence and stability of numerical scheme? [4]

OR

Q.12 a) Write down the Navier Stokes equations for incompressible flow. Develop the solution algorithm for the same. [12]

b) Explain: Types of grids and grid generation [6]