Total No. of printed pages = 6

ME 1317 E 013

Roll No. of candidate [ ][ ][ ][ ][ ][ ][ ][ ][ ][ ]

2018

B.Tech. 7th Semester End-Term Examination

COMPUTATIONAL FLUID DYNAMICS

(Elective — I)

Full Marks – 100 Time – Three hours

The figures in the margin indicate full marks for the questions.

Answer question No. 1 and any six from the rest.

1. Chose the correct answer for the following questions: (10 × 1 = 10)

   (i) For partial differential equation, if $b^2 - 4ac < 0$ then the equation is called

   (a) Hyperbolic (b) Parabolic

   (c) Elliptic (d) None of these

   (ii) Boundary condition which includes derivative of boundary value is

   (a) Dirichlet boundary condition

   (b) Neumann boundary condition

   (c) Forced boundary condition

   (d) Discrete boundary condition

[Turn over

(iii) The continuity equation for steady compressible flow can be written as

(a) $\frac{\partial u_m}{\partial x_m} = 0$ (b) $\frac{\partial u_i}{\partial x_j} = 0$

(c) $D\rho / Dt = 0$ (d) None of these

(iv) Finite difference method is

(a) Exact solution method

(b) Approximate solution method

(c) Unique solution method

(d) None of these

(v) When a dirichlet computation of dependent variables can be made in terms of known quantities, computation is said to be

(a) Implicit (b) Explicit

(c) Unique (d) Dependent

(vi) Difference between exact solution to mathematical model and discretized equations used to approximate is called

(a) Modeling error

(b) Discretization error

(c) Convergence error

(d) None of these

(vii) For a Newtonian fluid, τ_{zz} in compressible flow is given by

(a) $\frac{1}{2}\mu\left(\frac{\partial u_i}{\partial x_j} + \frac{\partial u_j}{\partial x_i}\right)$

(b) $\frac{1}{2}\mu\left(\frac{\partial u}{\partial y} + \frac{\partial v}{\partial x}\right)$

(c) $\mu\frac{\partial w}{\partial z}$

(d) None of the above

(viii) The ratio of inertia force to viscous force is

(a) Reynolds number

(b) Mach number

(c) Euler number

(d) Froude number

(ix) One dimensional Heat conduction equation is of

(a) Boundary value problem

(b) Initial value problem

(c) Both initial and boundary value problem

(d) None of the above

(x) Which of the following is of second order accurate?

(a) First order forward difference approximation

(b) First order backward difference approximation

(c) First order central difference approximation

(d) None of the above

2. (a) What do you mean by conservative and non conservative form of governing equation? (5)

(b) Derive the continuity equation for any of the models of flow. (10)

3. (a) Describe how boundary layer is formed on a flat surface. What are the boundary layer assumptions? (7)

(b) Using non dimensionalization derive the three dimensional X-momentum equation. (8)

4. (a) What do you mean by well posed problem? (5)

(b) How partial differential equations can be classified? Give examples. (5)

(c) Describe explicit and implicit schemes with examples. (5)

5. (a) Derive the expression for 2nd order central difference with respect to x. What will be the truncation error for this? (5)

(b) Discretize the equation $\frac{\partial U}{\partial t}=k\frac{\partial^2 U}{\partial x^2}$ using (2 × 5)

(i) Crank Nicholson scheme

(ii) Leap frog scheme.

6. (a) Derive the finite difference expression for second order mixed derivative. (5)

(b) Explain alternating direction implicit method with the help of two dimensional heat conduction equation. (10)

7. (a) Explain the explicit approach for one dimensional heat conduction equation. (5)

(b) Find the temperature distribution in an insulated long bar of uniform cross sectional area with boundary conditions at left end temperature is 1°C, at the right end temperature is 0°C. The initial condition is

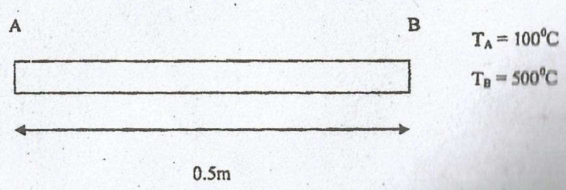
$T(x,0) = \sin(\pi x)$ for $0 < x < 1$

Assume $r = 1/2 = k(\Delta T)/(\Delta x)^2$. Solve up to three time step. (10)

8. (a) Describe the finite volume method for one dimensional diffusion problem. (5)

(b) Consider the problem of source free heat conduction in an insulated rod whose ends are maintained at constant temperatures of 100°C and 500°C. The ID problem is sketched in fig is governed by $\frac{d}{dx}\left(k\frac{dT}{dx}\right)=0$.

Calculate the steady state temperature distribution in the rod. Thermal conductivity $k = 1000$ W/mk, cross sectional area $A = 10 \times 10^{-3}$ m^2. (10)



9. (a) Discretize one dimensional wave equation using Lax scheme. (5)

(b) Compute the solution of equation for the 1st two time step using upwind scheme.

$$\frac{\partial u}{\partial t}+c\frac{\partial u}{\partial x}=0 \text{ ; where c is a constant, } c\geq 0$$

Initial condition $u(x, 0) \begin{cases} x-x^2, & 0<x\leq 1 \\ 0, & x>1 \end{cases}$

And the boundary conditions are $u(0,t) = 0$; for all t.

Consider $\Delta x = \frac{1}{4}, v=\frac{c\Delta t}{\Delta x} = 0.5$. (10)