SIDDHARTH INSTITUTE OF ENGINEERING & TECHNOLOGY :: PUTTUR
(AUTONOMOUS)

(Approved by AICTE, New Delhi & Affiliated to JNTUA, Anantapuramu)
(Accredited by NBA & Accredited by NAAC with 'A' Grade)
(An ISO 9001:2008 Certified Institution)
Siddharth Nagar, Narayanavanam Road, PUTTUR-517 583

QUESTION BANK

Subject with Code: CFD (16ME8812) **Course & Branch: M. Tech(TE)**
Sem : II-Sem **Regulation: R16**

UNIT-I

1 Derive an expression for 1-D unsteady state heat conduction equation by using Explicit and implicit approach. 10

2 What is computational fluid dynamics? What are the reasons for its rapid growth in recent times? Explain with an example how computational fluid dynamics is useful as a powerful research tool. 10

3 Explain the steps involved in the process of computational fluid dynamics (CFD). How CFD can be used as a design tool? Discuss some of the applications of CFD in engineering. 10

4 Solve the following equation by Gauss-Elimination method.

$$2x + 4y + 8z = 41$$
$$4x + 6y + 10z = 56$$
$$6x + 8y + 10z = 64$$

10

5 Derive the first order accurate forward difference and backward finite difference approximation for the second derivative of with respect 'X' using Taylor's series expansion. 10

6 a Explain the different models of flow with derivation of continuity equation 4

b Explain the explicit and implicit approach with the help of one dimensional heat conduction equation. 6

7 a What are the different types of partial differential equations? Explain the physical Behavior of PDE. 4

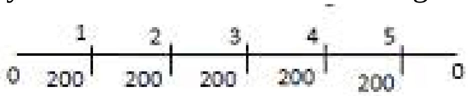
b Discuss the factors which contribute to errors in finite difference formulation 3

c Explain the difference between FDM and FVM with suitable example 3

8 a Explain the different boundary conditions used in CFD. 4

b Find the finite difference equation for Laplace equation using central difference approximation. 6

9 Determine the temperature distribution in Kelvin (K) at the nodes 1 to 5 for one-dimensional transient heat conduction process in a stainless steel rod shown in the below figure at time, t = 20 seconds by Crank Nickolson method using finite difference method.



The values at the boundary nodes are 0 K and the initial values at the nodes 1 to 5 are 200 K. Explain the stability criterion for explicit method. Take $\alpha = 1.0\times10^{-7}$ m^2/s and length 10 of the rod is 6 mm.

10 Figure 1 shows a large plate of thickness L = 1 cm with constant thermal conductivity k = 0.5 W/mK and uniform heat generation q = 2000 kW/m^3. The faces A and B are maintained at temperatures of 100^0C and 200^0C respectively. Assuming that the dimensions in the y and z directions are so large that temperature gradients are significant in the x – direction only. Calculate the steady state temperature distribution using finite volume method (FVM). Compare the numerical results with the analytical solution. The governing equation is given by

d/dx (kdT/dx) – q = 0

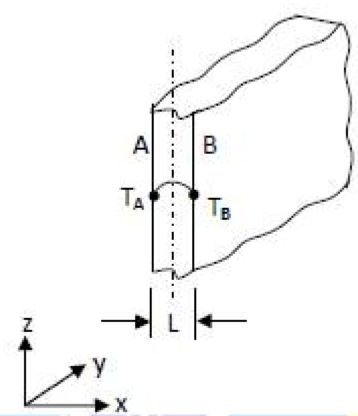


Figure: 1

Fig.1 heat conduction through a plate with heat generation.

The analytical solution is given by: $T(x) = ((T_B - T_A) * x/L) + qL_x/2K – qx^2/2K + T_A$. 10

UNIT-II

1 Find out the temperatures of a 1-D pipe with a length 4 units, heat generation S=1, and by taking cell size as 1. Assume K=1. By using finite volume method. Take $T_0=20^0C$, & $T_L=45^0C$. 10

2 a Using finite volume method (FVM), formulate the solution methodology for solving three Dimensional steady heat conduction equation with heat generation 4

b Discuss briefly about the rules for discretization. 6

3 a Derive an expression for 1-D steady state heat conduction equation in cylindrical Co-ordinates by finite volume method. 5

b Derive an expression for 1-D steady state heat conduction equation in spherical Co-ordinates. 5

4 Derive an expression for 2-D steady state heat conduction equation in Cartesian co-ordinates by finite volume method. State the stability criteria. 10

5 Find out the temperatures of the given 2-D problem with no heat generation and by taking cell size as 1 in all directions. Assume K=1. by using finite volume method. Temperatures at Left and Top Boundaries as 0^0C and Remaining As 1^0C. 10

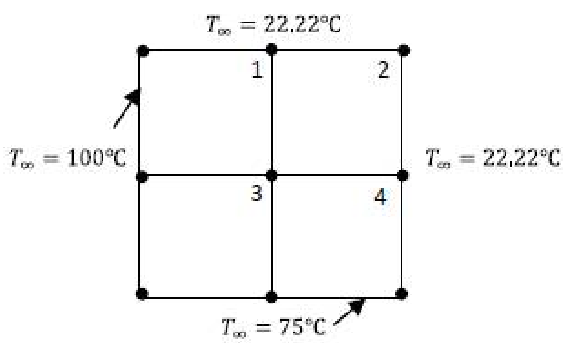
6 Derive an expression for unsteady state 2-D heat conduction equation in Cartesian coordinates by using Explicit approach. State the stability criteria. 10

7 Consider the problem of source-free heat conduction in an insulated rod whose end are maintained at constant temperatures of 100 and 500. Calculate the steady state temperature distribution in the rod with k=1000 W/mK, Area = $10e^{-3}$ m^2 and length=0.5m 10

8 Derive the stability criteria for unsteady one dimensional heat transfer phenomena and list the assumptions. 10

9 Consider the square shown in figure below, the top face, top-right corner and right face are exposed to air at 22.22. The bottom face is maintained at 75 while the left face is maintained at 100. Use the nodal equations and the finite difference method to evaluate the temperatures at nodes 1 to 4. The thermal conductivity of the material is assumed to be constant at 1 W/m.. When calculating the Biot numbers for each node use spacing between nodes of 0.1 m. The free convection coefficients are as follows:

$h_{top\ face} = 10\ W/m^2{}^\circ C$, $h_{corner}\ at\ node\ 2 = 7\ W/m^2{}^\circ C$, $h_{right\ face} = 5\ W/m^2{}^\circ C$.



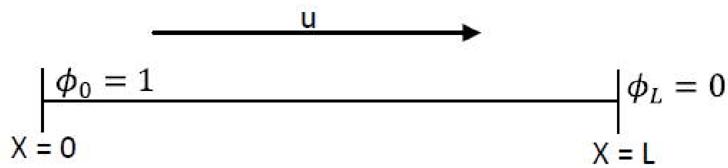
10

10 A thin plate is initially at a uniform temperature of 200^0C. At a certain time of t = 0 second the temperature at the east side of the plate is suddenly reduced to 0^0C. The other surface is insulated. Using the implicit finite volume method (FVM) in conjunction with a suitable time step size to calculate the transient temperature distribution of the slab and 10

compare it with the analytical solution at time t = 50 seconds. The data are: plate thickness L = 2 cm, thermal conductivity k = 10 W/mK and $\rho c = 10\times10^{6} J/m^{3}/K$.

UNIT-III

1 A property Φ is transported by means of convection and diffusion through the one-dimensional domain sketched in figure below. Boundary conditions are $\Phi_0 = 1$ at x = 0 and $\Phi_L = 1$ at x = L. Calculate the value of Φ for u = 2.0 m/s with central differencing scheme and suggest which differencing scheme would be more appropriate and why. The following data apply: Length L = 1.0 m, ρ= 1.0 kg/m^3, Γ = 0.1 kg/m/s.



Boundary conditions for convection-diffusion problem are given in above figure 10

2 Discuss about 1-D Convection Diffusion equation by using upwind scheme. 10

3 Discuss about 1-D Convection Diffusion equation by using Exponential scheme. 10

4 Discuss about 1-D Convection Diffusion equation by using hybrid scheme. 10

5 Discuss about 1-D Convection Diffusion equation by using power law scheme. 10

6 Discuss about 1-D Convection Diffusion equation by using central difference scheme. 10

7 Find the distribution of Φ of 1-D rod with length of 7 units, F=0.5, $\Phi_0 = 100^0$C and $\Phi_L = 20^0$C, Δx =1 & Γ = 1. 10

8 Why boundary conditions are needed? List common thermal and flow boundary conditions used in CFD. 10

9 The one dimensional convection and diffusion of a scalar φ is described by central differencing φ_w and φ_e being 100 and 200 respectively, with usual notation. Let F = ρu and D = Γ / Δx, where Γ is the diffusion coefficient and Δx is the mesh spacing. Obtain the value of φ_p for $F_e = F_w = 4$ and $D_e = D_w = 1$ and comment on the result. 10

10 From the general partial differential equation for continuity, momentum and energy equation, derive the continuity, momentum and energy equation for compressible flow. 10

11 Derive the energy equation from the first principles 10

UNIT - IV

1		Develop the vorticity and stream function formulation for steady axisymmetric flow over a solid sphere.	10
2		Explain Semi-Implicit method for pressure linked equation (SIMPLE), pressure correction method.	10
3		Discretize the governing equation for 2D incompressible, viscous flow neglecting body force using respective staggered grid arrangement.	10
4		Explain the various computer graphic techniques used in CFD	10
5		Explain the method of solving an incompressible flow problem using stream function-vorticity formulation.	10
6		Explain the concept of SIMPLE algorithm with pressure correction and velocity correction equations. What is the difference between SIMPLE and SIMPLER algorithms?	10
7	a	Give the difference between collocated grid and staggered grid and explain their relative, merits and demerits.	6
	b	What is checker board arrangement and how staggered grid helps in overcoming this problem.	4
8	a	Give the difference between laminar and turbulent flows. What do you understand by vortex stretching, energy cascade, length-scale ratio, time-scale ratio and velocity-scale ratio?	7
	b	It modeling of turbulence, a necessary? If so give explanation.	3
9	a	How the continuity and momentum equations are coupled in case of compressible flows?	5
	b	While solving compressible flows energy equation should also be solved. If so why and give the relation between pressure, density and velocity terms.	5
10	a	How the continuity and momentum equations are coupled in case of compressible flows?	5
	b	While solving compressible flows energy equation should also be solved. If so why and give the relation between pressure, density and velocity terms.	5

UNIT - V

1	Explain Reynold's time averaging concept of turbulence. Derive RANS equation.	
2	From the general partial differential equation for continuity, momentum and energy equation, derive the continuity, momentum and energy equation for compressible flow.	10
3	Derive the Quasi one-dimensional compressible flow equations for flow through a nozzle. Explain the method of capturing the shock in dealing with the nozzle flows.	10
4	Explain the concept of artificial viscosity in the finite difference schemes. Is it a fluid or a trouble maker in dealing with CFD problems?	10
5	Air motion is accelerated through a convergent divergent nozzle which is compressible in nature. Explain how the physics of fluid flow is captured inside the nozzle and establish the coupling between pressure, velocity and density terms.	10
6	Explain the difference turbulence models namely standard k=ε, and standard $k-\omega$, SST $k-\omega$, and RSM models	10
7	What is turbulence motion and how it could be captured with DNS, LES and RANS models	10
8	Explain the concept of SIMPLE algorithm with pressure correction and velocity correction equations for and incompressible fluid and give the importance of SIMPLER algorithm.	10
9	Explain how staggered grid arrangement helps in coupling the pressure velocity terms for solving the governing equation and bring out the concept of checker board arrangement	10
10	Explain the significance of the wall function for solving the turbulence problems.	10

Prepared by
Er. G.RAVINDRA REDDY