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APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SECOND SEMESTER M.TECH DEGREE EXAMINATION, MAY 2019

Mechanical Engineering

(Thermal Engineering)

03 ME6012 Computational Methods in Fluid Flow and Heat Transfer

Max. Marks : 60 Duration: 3 Hrs

PART A

(Answer all questions. Each question carries 5 marks)

1. What are the advantages of line by line method in comparison with the point by point iteration method?
2. Write a short note on the polynomial fitting approach to converting derivatives to finite difference form.
3. Make an assessment of the upwind differencing scheme in terms of the conservativeness, boundedness, transportiveness and accuracy of the scheme.
4. Describe the explicit scheme for solving unsteady problems and comment on the relative advantages and disadvantages of the scheme. (4×5 – 20)

PART B

5. A) The differential equations governing fluid flow and heat transfer take a general form as follows

$$\frac{\partial}{\partial t}(\rho\varphi) + \nabla.(\rho\mathbf{u}\varphi) = \nabla.(\Gamma\ \nabla\varphi) + S$$

Identify the terms in the equation and obtain the following;

a. The expressions for φ, $\mathbf{u}$, Γ, and S for the case of the unsteady heat conduction equation (with constant specific heat, c).

b. The expressions for φ, Γ, and S for the case of the continuity equation. (10)

OR

B) Solve the linear system of equations by Gauss elimination method. (10)

$$y + z = 2$$
$$2x + 3z = 5$$
$$x + y + z = 3$$

6. A) Determine the approximate forward difference representation for $\frac{\partial^3 f}{\partial x^3}$ which is of order (Δx), given evenly spaced grid points f_i, f_{i+1}, f_{i+2}, and f_{i+3} by means of Taylor Series expansions. (10)

OR

B) Describe the body fitted coordinate grids used for discretizing complex geometries. What are the difficulties associated with body fitted coordinate grids. (10)

7. A) Consider a large plate of thickness L=1.5 cm with constant thermal conductivity k=0.5 W/mK and uniform heat generation, $\dot{q}$=1000 W/m^3. The faces A and B are at temperatures of 100 ^{o}C and 200 ^{o}C respectively. Assuming that the dimensions in y- and z- directions are so large that temperature gradients are significant in x- direction only, calculate the steady state temperature distribution. Divide the domain into 3 equal control volumes. (10)

$$\frac{d}{dx}\left[k\frac{dT}{dx}\right] + \dot{q} = 0$$

OR

B) Obtain the exact solution for the steady one-dimensional convection-diffusion equation. (10)

$$\frac{d}{dx}(\rho u \varphi) = \frac{d}{dx}\left(\Gamma\frac{d\varphi}{dx}\right)$$

8. A) The 1D heat equation given by

$$\frac{\partial u}{\partial t} = \alpha\frac{\partial^2 u}{\partial x^2}$$

i) Write a fully implicit formulation of the heat equation. (4)

ii) Use von Neumann stability analysis to determine the stability requirement of the scheme (6)

OR

B) Explain in detail the SIMPLE algorithm for the computation of the flow field. Mention its limitations. (10)

(4×10 – 40)