MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent institution of MAHE, Manipal)

II SEMESTER M. TECH (DEFENCE TECHNOLOGY)
END-SEMESTER EXAMINATION, JULY, 2022
COURSE: COMPUTATIONAL AERODYNAMICS (AAE 5059)

REVISED CREDIT SYSTEM

Duration: 3 Hours **Date: 22/07/2022** **MAX. MARKS: 50**

Note:

- *All questions are compulsory*
- *Draw a neat diagram wherever necessary*
- *Stepwise answers carry marks*
- *Assume suitable data if necessary*

Q1. Describe the significance of governing equations of fluid dynamics. **[2M]**

Q2. Derive an expression for the continuity equation. **[3M]**

Q3. Consider the initial boundary value problem, **[5M]**

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

Where, u is non-dimensional temperature, α is constant and t > 0.

The initial conditions are $u(x,0) = e^{2x}$ for $0 < x < 1$ and
boundary conditions are u(0, t) = 1, u(1, t) = 7.389 for all time, $t \geq 0$

Use, $r = \frac{\alpha t}{(\Delta x)^2} = 0.8 \; and \; \Delta x = 0.25$

Determine the non-dimensional temperatures using the Cranck-Nicolson method.

Q4. Describe the significance of implicit scheme. **[2M]**

Q5. With an example, describe the Neumann and Dirichlet boundary conditions. **[3M]**

Q6. Consider a 1 m thick wall. The left wall surface is maintained at a temperature of 110^{o}C. The right side of the wall is subjected to the ambient temperature of 35^{o}C and heat transfer coefficient of 80 W/m^{2}K. The thermal conductivity of the wall material is 45 W/m-K and internal heat generation rate is 25000 W/m^3. Considering total 5 equally spaced nodes, determine the temperature distribution inside the wall. **[5M]**

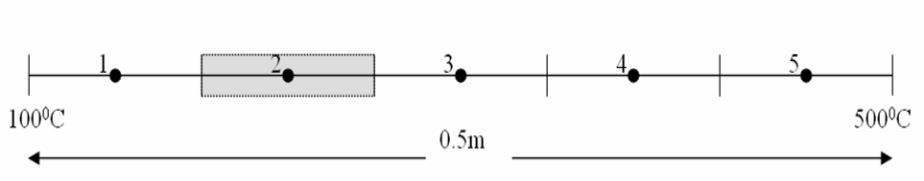
Q7. Explain the closure problem in turbulence. **[2M]**

Q8. Write a note on mixing length turbulence model and state it's advantages and disadvantages. **[3M]**

Q9. Using control volume approach solve for temperature distribution with the following value: **[5M]**

Conductivity k = 1000W/m/K, A = 10X 10^{-3} m^2.

Governing equation $\frac{d}{dx}\left(k\frac{dT}{dx}\right)=0$



Q10. Describe the importance of Peclet number with reference to CDS and UDS methods. **[2M]**

Q11. With a Flow Chart explain SIMPLE algorithm **[3M]**

Q12. Water is flowing in a square duct of side 20 mm. It enters the duct with a temperature of 80°C. The velocity at inlet is 80 mm/s which can be assumed to remain constant along the duct. The diffusive flux (Γ) through the duct can also be assumed to be constant at 800 kg/m/s. The length of the pipe is 900 mm. Water leaves the pipe at a temperature of 20°C. Apply the following discretization schemes and obtain the temperature distribution along the pipe. Upwind Differencing Scheme (UDS), Use Three equally spaced grids to descritize the domain. **[5M]**

Q13. What is meant by Numerical False Diffusion? Explain the same with a neat schematic of flow and the remedy to mitigate this error **[2M]**

Q14. With suitable examples explain the properties of numerical solution scheme **[3M]**

Q15. With a neat sketch explain the need for the staggered grid arrangement to solve pressure velocity linked equations and discretize the x momentum equation using Staggered grid arrangement. **[5M]**