Reg. No.										

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

VI SEMESTER B.TECH (MECHANICAL / IP ENGG.)

END SEMESTER MAKE UP EXAMINATIONS, JUNE 2018

SUBJECT: COMPUTATIONAL FLUID DYNAMICS [MME 4009]

Program Elective III

REVISED CREDIT SYSTEM

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data if any, may be suitably assumed.

1A. A steel fin of thermal conductivity 45 W/m.K and having uniform rectangular cross section 25mm X 20 mm and length 200 mm, is fitted to an engine head at $375^{o}C$. It is exposed to ambient convective air having convective heat transfer coefficient of 20 $W/m^2.K$. The average bulk temperature of the cooling air is $35^{o}C$. The fin can be treated as slender with negligible heat transfer from the open end face of the fin. Use Finite Difference approach using Taylor series to solve temperature distribution in minimum four unknown grids assuming steady one dimensional heat transfer, using TDMA. **05**

1B. Deduce Velocity Correction Equations for 2D Convection dominated Diffusion flows using Patankar's approximations. Hence derive the corresponding Pressure Correction Equation convection coupled diffusion flows. **05**

2A. Explain the methods of solving a 1D unsteady heat transfer problem in case of a heated plate of finite length. **04**

2B. Derive conservation differential form of continuity equations from conservation integral form. **03**

2C. Explain substantial derivative with an example **03**

3A. Derive Energy Equation in the non-conservative form and reduce the same to conservative form. **05**

3B. Explain and Illustrate with an example Direchlet, Neumann, and Robin Boundary conditions. **03**

3C. Consider the Fourier thermal diffusive flow equation given by **02**

$$\frac{\partial^2 T}{\partial x^2}+\frac{\partial^2 T}{\partial y^2}+\frac{\partial^2 T}{\partial z^2}=\frac{1}{\alpha}\frac{\partial T}{\partial t}$$

(a) Prove that the characteristic of flow is Elliptic in space and parabolic in time. (b) How do you determine the Boundary Conditions and Initial Conditions that are required to solve the above differential equation?

4A. Water is flowing in a pipe of diameter 35 mm. It enters the pipe with a temperature of 98^oC. The velocity at inlet is 1.5 m/s which can be assumed to remain constant along the pipe length. The diffusive flux (Γ) through the pipe can also be assumed to be constant at 815 kg/m/s. The length of the pipe is 960 mm. Water leaves the pipe at a temperature of 28^oC. Apply the Upwind discretization scheme and obtain the temperature distribution along the pipe using Control Volume technique. Use minimum four equally spaced unknown control volumes to discretize the domain in each case. Compare the results with exact analytical method. **05**

4B. Explain with neat grid arrangements the implementation of boundary conditions for: **03**

(1) Inlet Conditions

(2) Axisymmetric Condition

(3) Exit conditions

4C. Explain the basic four models of fluid flow with their characteristics with neat figures **02**

5A. Deduce the finite difference expression for second order accurate mixed derivative given by, **04**

$$\left(\frac{\partial^2 u}{\partial x\, \partial y}\right)_{i,j} = \frac{u_{i+1,j+1} - u_{i+1,j-1} - u_{i-1,j+1} + u_{i-1,j-1}}{4\Delta x\, \Delta y} + O[(\Delta x)^2, (\Delta y)^2]$$

5B. What are the difficulties in solving Convection dominated Diffusion flow equations? Explain the strategies to overcome the same **04**

5C. Explain the physical meaning of divergence of velocity with an example. **02**

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