Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

A Constituent Institute of Manipal University, Manipal

VI SEMESTER B.TECH MECHANICAL ENGG. END SEMESTER EXAMINATIONS, APRIL/MAY 2017

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 may be suitably assumed.

1A. Derive the general governing differential equation for energy conservation for an infinitesimal control volume moving in space and convert it into conservation form. **05**

1B. Derive an equation for the second-order accurate, central difference for the mixed derivative. **05**

2A. Deduce the following discretized difference equation using the finite volume method for steady two dimensional pure diffusion flow in the form given by, **04**

$$a_P T_P = a_E T_E + a_W T_W + a_N T_N + a_S T_S + b$$

2B. In a cylindrical fin with uniform cross sectional area A, the base temperature is 123°C and end is insulated. The fin is exposed to an ambient temperature of 22°C. Calculate the temperature distribution along the fin. Length of fin is 1.25m, n^2=fin constant = hP/kA= $20m^{-2}$, note that throughout the length kA is constant. Discretize the domain into minimum 4 control volumes using volume method. **04**

2C. Explain with clear physical meaning, the concepts (i) Substantial Derivative (ii) Divergence of Velocity field **02**

3A. Derive the continuity equation in the conservative form. **03**

3B. With a neat flow diagram, explain the SIMPLE algorithm of Patankar and Spalding **04**

3C. What is meant by Numerical False Diffusion? Explain the same comparing the diffusive flux for UDS and CDS schemes. **03**

4A. Water is flowing in a pipe of diameter 35 mm. It enters the pipe with a temperature of 98^{o}C. The velocity at inlet is 11.5 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^{o}C. 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. 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°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°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 atleast three unknown grids assuming steady one dimensional heat transfer. **05**

5A. Explain the methods used in solving a transient fluid flow problem. Also mention the stability aspect of each scheme **04**

5B. Explain with regard to central differencing discretization schemes the following: **03**

(a) Conservativeness

(b) Boundedness

(c) Transportiveness

5C. Illustrate with examples, Dirichlet, Neumann and Robin type boundary conditions **03**

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