Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

A Constituent Institute of Manipal University, Manipal

VI SEMESTER B.TECH (MECHANICAL ENGG.) END SEMESTER EXAMINATIONS, JUNE 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 continuity equation for finite control volume fluid model fixed in space **03**

1B. Derive momentum equation for infinitesimal fluid element moving with the fluid. Also obtain conservation form of the equation **05**

1C. Explain the physical meaning of Total derivative with an example **02**

2A. A metallic fin of thermal conductivity 50 W/m.K and having uniform rectangular cross section 20mm X 30 mm and length 250 mm, is fitted to an engine head at 345°C. It is exposed to ambient convective air having convective heat transfer coefficient of 25 W/m^2.K. The average bulk temperature of the cooling air is 30°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, using TDMA **04**

2B. Illustrate the basic discretization rules for control volume Method **04**

2C. Enumerate the relative advantages and limitations of Euler's Explicit, Crank-Nicholson's Semi Implicit and Pure Implicit Schemes **02**

3A. Derive the non-dimensional form of the steady one dimensional convection-diffusion fluid flow equation and obtain the general solution in the form, **05**

$$\bar{T} = \frac{\left(e^{P\bar{X}} - 1\right)}{\left(e^{P} - 1\right)}$$ where P is the Peclet Number

3B. A salt solution is having density 850 kg/m^3, is flowing in an equilateral triangle shaped duct of side 10 mm and length 0.6m. It enters the duct with a temperature of 76°C. The velocity at inlet is 9 m/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 630 kg/m/s. Brine solution leaves the duct at a temperature of 22°C. Apply the following methods to obtain the temperature distribution along the duct (1) Upwind Scheme (2) Exact Analytical Method. Use five equally spaced grids to discretize the domain. **05**

4A. A two dimensional steady state thermal diffusion occurs along a very long square slab (2L x 2L size) with uniform internal heat generation, in which the exposed sides are at uniform temperature of T_∞. **05**

i) Obtain the non-dimensional GDE with corresponding BCs.
ii) Obtain the Finite Difference form using basic Taylor series formulation
iii) Discuss the solution strategy

4B. Derive the pressure correction equation for convection dominated diffusion flow. Also explain the need of staggered grid. **05**

5A. Compare the properties of CDS and UDS discretization schemes **04**

5B. What are the difficulties in solving the convection dominated diffusion problem? What are the strategies to be adopted to overcome them? **03**

5C. What is a Boundary Value Problem? Explain with an example **03**

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