Reg. No.										

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

VI SEMESTER B. TECH (MECHANICAL/IP ENGG.) END SEMESTER EXAMINATIONS, APRIL 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. Derive the non-dimensional form of the steady one dimensional convection-diffusion fluid flow equation and obtain the general solution in the form, **04**

$$\overline{T} = \frac{\left(e^{P\overline{X}} - 1\right)}{\left(e^{P} - 1\right)}$$

where P is the Peclet Number, $\overline{X}$ *is non-dimensional length, and* $\overline{T}$ *is non-dimensional temperature.*

1B. Explain the SIMPLE algorithm of Patankar and Spalding with a neat flow diagram. **04**

1C. How the symmetry in geometry is addressed while defining boundary conditions? Explain with an example. **02**

2A. Derive the conservation form of momentum equation from infinitesimal moving fluid element. **05**

2B. Write short note on numerical false diffusion and how it can be addressed? **03**

2C. Compare the stability and accuracy of Euler's and Crank Nicholson methods. **02**

3A. 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.

3B. Derive a difference equation for a boundary using polynomial approach. **03**

3C. Explain the basic rules of control volume formulation. **02**

4A. Water is flowing in a square shaped duct of side 20mm. It enters the duct with a temperature of 76^0 C. The velocity at inlet is 2.5m/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 900mm. Water leaves pipe at a temperature of 22^0 C. Use minimum four equally spaced control volumes to discretize the domain. Solve using TDMA in UDS and CDS to obtain the temperature distribution along the duct. Determine the scheme that gives closer results to exact analytical solution. **05**

4B. A metallic fin of thermal conductivity 50 W/m.K and having uniform circular cross section of 30mm diameter and length 325 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 28°C. The fin can be treated as slender with negligible heat transfer from the open end of the fin. Solve for temperature distribution along the fin by discretizing into minimum 5 control volumes assuming steady one dimensional heat transfer. Use any numerical method to solve. **05**

5A. For the 2-D Fourier thermal diffusive flow equation given by **04**

$$k_x \frac{d}{dx}\left[\frac{dT}{dx}\right] + k_y \frac{d}{dy}\left[\frac{dT}{dy}\right] + \dot{q}_g = 0$$

Obtain the discretized equation using Finite Volume technique in the form of

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

5B. Explain the significance of staggered grid. **03**

5C. Compare the following with respect to CDS and UDS discretization schemes: **03**

i) Boundedness
ii) Transportiveness
iii) Accuracy

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