Reg.No.										

MANIPAL INSTITUTE OF TECHNOLOGY
(A constituent institute of Manipal University)

VII SEMESTER. B.Tech. (MECHANICAL ENGINEERING)
END SEMESTER EXAMINATIONS, NOV/DEC 2015

SUBJECT: COMPUTATIONAL FLUID DYNAMICS (MME 441)
(REVISED CREDIT SYSTEM)

Time: 3 Hours. MAX.MARKS: 50

Instructions to Candidates:
- Answer **ANY FIVE** full questions.
- Missing data may be suitably assumed.

1A For the x–directional Navier-Stokes (Momentum) Equation (no derivation) use scaling laws to deduce **scale-free equation** as given below: **-04-**

$$\frac{\partial u'}{\partial t'}+u'\frac{\partial u'}{\partial x'}+v'\frac{\partial u'}{\partial y'}+w'\frac{\partial u'}{\partial z'}=-\frac{1}{F^2}-P\frac{\partial p'}{\partial x'}+\frac{1}{R}\left(\frac{\partial^2 u'}{\partial x'^2}+\frac{\partial^2 u'}{\partial y'^2}+\frac{\partial^2 u'}{\partial z'^2}\right)$$

where, prime sign indicate the corresponding scale-free properties and F and R represents the Dimensionless Froude and Reynold's Numbers where as $P=\frac{P_\infty}{\rho U_\infty}$ is the Non-dimensional Pressure Coefficient, with P_∞ and U_∞ being the free stream pressure and velocity where as ρ is the density of the medium.

1B Derive the **Pressure Correction Equation** for Convection dominated Diffusion flow. Explain with a neat flow diagram SIMPLE algorithm of Patankar & Spalding **-06 -**

2A Derive the continuity equation in the conservative form given by **-03-**

$$\frac{\partial}{\partial t}\iiint_{\mathcal{V}}\rho\, d\mathcal{V}+\iint_{S}\rho\mathbf{V}\bullet\mathbf{dS}=\mathbf{0}$$

2B Water is flowing in a pipe of diameter 25 mm. It enters the pipe with a temperature of 150°C. The velocity at inlet is 8 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 800 kg/m/s. The length of the pipe is 900 mm. Water leaves the pipe at a temperature of 30°C. Apply the following discretization schemes and obtain the temperature distribution along the pipe **using Control Volume technique.** Use three equally spaced unknown control volumes to discretize the domain in each case. **-07-**
(1) Central Difference Scheme (CDS)
(2) Upwind Differencing Scheme (UDS)
(3) Exact Analytical Method.

3A Derive the non-dimensional form of the steady one dimensional convection-diffusion fluid flow equation and obtain the general solution in the standard form, **-06-**

$$\theta = \frac{\left(e^{PX} - 1\right)}{\left(e^{P} - 1\right)} \quad \text{where P is the Peclet Number}$$

3B Illustrate with a physical example Dirichlet, Neumann Cauchy and Robin Boundary conditions. **-04-**

4A Explain the **Basic Four Rules** enunciated for control volume formulation. **-04-**

4B What is meant by Numerical False Diffusion? Explain the same comparing the diffusive flux for UDS and CDS schemes. **-03-**

4C Explain with neat grid arrangements the implementation of boundary conditions for: **-03-**

(1) Inlet Conditions
(2) Axisymmetric Condition
(3) Exit conditions

5A 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^{0}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 atleast FIVE unknown grids assuming steady one dimensional heat transfer, using TDMA **-07-**

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

6A Compute the steady state temperature distribution along a one dimensional slender fin rod having 25 mm diameter and thermal conductivity of 50 w/m.K as shown in **Fig. 1** below. Set up the solution using Control Volume formulation. The fin is exposed to an ambient at 60 ^{0}C and a convective heat transfer coefficient of 15 W/m^2.K.Use TDMA for computation of grid temperatures. **-06-**

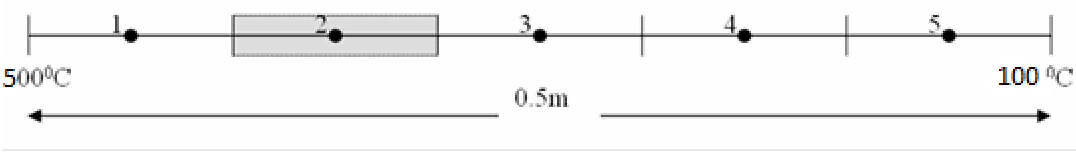

Fig. 1

6B Explain with regard to finite difference discretization schemes the following: **-04-**

(a) Consistency
(b) Boundedness
(c) Transportiveness
(d) Accuracy