Reg.No.										

Manipal Institute of Technology, Manipal

(A Constituent Institute of Manipal University)

IISEMESTER M.TECH (ATPES) END SEMESTER EXAMINATIONS JUNE 2016 (MAKE-UP EXAM)

SUBJECT: COMPUTATIONAL FLUID DYNAMICS [MME 548]

REVISED CREDIT SYSTEM

Time 3 Hours. MAX.MARKS: 50

Instructions to Candidates:

- Answer **ANY FIVE** full questions.
- Missing data may be suitably assumed.

Q.1A Explain with the Four Basic Laws of Control Volume formulation **-04-**

Q.1B Derive x–directional Navier-Stokes (Momemtum) Equation and using scaling laws, non-dimensionalize the same, to the form given by, **-06-**

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

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

Q.2A What is meant by Numerical False Diffusion? Explain the same with a neat schematic for grid-aligned and grid-non aligned flows. **-04-**

Q.2B Water is flowing in a square duct of side 25 mm. It enters the duct with a temperature of 150 ^oC. The velocity at inlet is 8 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 800 kg/m/s. The length of the pipe is 900 mm. Water leaves the pipe at a temperature of 30 ^oC. Apply the Central Difference Scheme (CDS) discretization and obtain the temperature distribution along the pipe. Verify your answer using the exact analytical expression. **-06-**

Q.3A Derive the exponential scheme discretization equation for one dimensional convection dominated diffusion steady flow using the exact exponential solution for discretizing the convective and gradient terms. **-06-**

Q.3B Show that the second order mixed differential can be discretised as **-04-**

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

Q.4A Illustrate clearly with a physical example, Dirichlet, Neumann, Cauchy and Robbin Boundary conditions to bring out their applications. **-04-**

Q.4B Steady state heat transfer is assumed to be one dimensional, occurring through a pin fin (K= 45 W/m.K) of length 150 mm and of equilateral triangular cross section of side 5 mm. The base of the fin is at a temperature of 250 ^{o}C and the fin is exposed to convective ambience having a convective heat transfer coefficient of 20 W/m^2.K and average bulk temperature of 40 ^{0}C. The other end of the fin is at 125 ^{0}C. Determine the temperature distribution and steady state heat transfer rate using five equidistant grids and applying finite difference formulation based discretization using Taylor series. **-06-**

Q.5A Explain the different models of flow that could be used to describe the physics of fluid flow. **-04-**

Q.5B Explain the stability curves for the Explicit Eular, Crank-Nicholson, and Pure Implicit Numerical Methods, considering only two unknown grids, with one of them having a prescribed temperature**.** Enumerate the limitations of each method as well as their relative advantages. **-06-**

Q.6A Derive the **Velocity Correction Equations** for Convection dominated Diffusion flow. **-04-**

Q.6B Deduce the discretized difference equation using the Finite Volume Method for **unsteady one dimensional diffusion flow** in the form given by, **-06-**

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