Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY
A Constituent Institute of Manipal University, Manipal

VII SEMESTER B.TECH (MECHANICAL ENGINEERING)
END SEMESTER EXAMINATION – NOV /DEC. 2016
SUBJECT: COMPUTATIONAL FLUID DYNAMICS: MME 441 (Program Elective)
REVISED CREDIT SYSTEM

Time: 3 Hour **Max. Marks: 50**

Note: (i) Answer any 5 full questions
(ii) Missing data, if any, may be appropriately assumed
(iii) Draw the sketch as applicable
(iv) Assumptions made must be clearly mentioned

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. Explain briefly with a physical example the concepts of Substantial (Total) Derivative of a flow property and Divergence of a flux 02

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. 08
(1) Central Difference Scheme (CDS)
(2) Upwind Differencing Scheme (UDS)
(3) Exact Analytical Method.

3A. Enumerate the advantages and disadvantages of Euler, Crank-Nicholson, and Pure Implicit Numerical Methods. Explain the stability curves for the above methods considering only two unknown grids, with one of them having a prescribed temperature. 04

3B. Derive the Non-dimensional GDE and its finite element discretization for a 2-Dimensional steady state heat transfer in a **Square Plate** with uniform internal heat generation and with all its edges subjected to constant temperature of T_∞. 06

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

4B. What is meant by Numerical False Diffusion? Explain the same in the case of constant temperature hot and a cold fluid flowing in a non-aligned steady flow in a two-dimensional flow field. 04

4C. Explain the implementation of the following boundary conditions for a CFD problem: 02
(1) Axisymmetric Condition
(2) Wall Boundary condition

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 375^0C. 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^oC. The fin can be treated as slender with negligible heat transfer from the open end face of the fin. Apply **finite difference formulation 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. What are the different Models of Flow adopted in CFD to derive governing equations of flow? Explain with a **neat labelled sketch** each of the models with their physical and mathematical characteristics 04

6B. Determine the steady state temperature distribution for the one dimensional composite wall given below. Use **Control Volume Method. Use atleast three CVs.** 06