BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI

CLASS:MTech | **SEMESTER : II**
BRANCH: SER | **SESSION : SP/22**

SUBJECT: Computational Combustion (SR603)

TIME: 2:00-4:00 PM | **FULL MARKS: 50**

INSTRUCTIONS:
1. The question paper contains 5 questions each of 10 marks and total 50 marks.
2. Attempt all questions.
3. The missing data, if any, may be assumed suitably.
4. Before attempting the question paper, be sure that you have got the correct question paper.

Q.1 Write the most general form of heat transport equation and reduce it to obtain an equation to solve the transient heating problem of a solid rod. (BT Level: 3, CO: 1) [5+5]

Q.2(a) Identify appropriate boundary conditions for solving the problem of combustion in a Bunsen burner. (BT Level: 4, CO: 2) [5]

Q.2(b) Identify appropriate initial conditions for solving the problem of combustion in a Bunsen burner. (BT Level: 4, CO: 2) [5]

Q.3(a) Beginning with the form of Navier-Stokes equation given below, obtain a suitable form for describing the turbulent flow characterized by fluctuations u', v', w', and p'. (BT Level: 3, CO: 4) [8]

$$\frac{\partial u_i}{\partial t}+\frac{\partial}{\partial x_j}\left(u_i u_j\right)=-\frac{1}{\rho}\frac{\partial p}{\partial x_i}+\upsilon\frac{\partial^2 u_i}{\partial x_j^2} \ldots \text{(i)}$$

Q.3(b) Briefly describe the concept behind the eddy breakup model for accounting of turbulence-chemistry interactions. (BT Level: 2, CO: 4) [2]

Q.4(a) Provide a scheme (including number of equations), for tracking the trajectories of droplets in a turbulent flow field of cold gases. Assume that the turbulent flow field is computed using standard *k*-ε model. It is not essential to write the equations. (BT Level: 5, CO: 1,4) [8]

Q.4(b) Explain the statement given below. (BT Level: 4, CO: 1,4) [2]
"Heat and mass exchange between hot gases and droplets does not cause global imbalance in the heat and mass transport."

Q.5 The most general forms of Navier-Stokes equations in tensorial notations are given in Eq. (ii) and (iii). State where these forms could be used. Using Eq. (ii) and (iii) and assuming M → 0, derive Eq. (iv). (BT Level: 4, CO: 1,4) [10]

$$\frac{\partial}{\partial t}\left(\rho u_i\right)+\frac{\partial}{\partial x_j}\left(\rho u_i u_j\right)=-\frac{\partial p}{\partial x_i}+\mu\frac{\partial}{\partial x_j}\left(\frac{\partial u_i}{\partial x_j}+\frac{\partial u_j}{\partial x_i}\right) \ldots \text{(ii)}$$

$$\frac{\partial \rho}{\partial t}+\frac{\partial}{\partial x_i}\left(\rho u_i\right)=0 \ldots \text{(iii)}$$

$$\frac{\partial u_i}{\partial t}+\frac{\partial}{\partial x_j}\left(u_i u_j\right)=-\frac{1}{\rho}\frac{\partial p}{\partial x_i}+\upsilon\frac{\partial^2 u_i}{\partial x_j^2} \ldots \text{(iv)}$$

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