BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI
(END SEMESTER EXAMINATION)

CLASS: B.TECH **SEMESTER: VI**
BRANCH: CHEMICAL ENGINEERING **SESSION: SP/2024**
SUBJECT: CL371 COMPUTATIONAL FLUID DYNAMICS
TIME: 3 Hours **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.
5. Tables/Data hand-book/Graph paper etc. to be supplied to the candidates in the examination hall.

			CO	BL
Q.1(a)	Cite some examples of process industries where CFD can be applied. In the context of CFD, what do understand by – verification and validation?	[5]	2,5	3
Q.1(b)	What are the key differences between the differential and integral forms of the conservation equations? Based on the discussion in class, which forms are solved using finite difference and finite volume methods?	[5]	1,2	2
Q.2(a)	Provide sketches showing the following relationships among errors, discretization schemes, and mesh characteristics: roundoff error-number of cells or nodes; truncation error-number of cells or nodes; roundoff error-number of iterations; truncation error-order of discretization scheme; truncation error-cell size or Δx.	[5]	2,3	4
Q.2(b)	Briefly describe numerical dissipation and dispersion. Sketch the u-x profiles pertaining to one-dimensional wave equation when (i) only numerical dissipation is present and (b) only numerical dispersion is present.	[5]	5	4
Q.3(a)	Derive central-difference approximations of $\partial u/\partial y$ and $\partial^2 u/\partial y^2$ using Taylor series and state the order of error terms.	[5]	2	4
Q.3(b)	Show that $\left.\frac{\partial^2 u}{\partial x \partial y}\right\|_{i,j} = \frac{1}{\Delta x}\left[\frac{u_{i+1,j+1}-u_{i+1,j-1}}{2\Delta y} - \frac{u_{i,j+1}-u_{i,j-1}}{2\Delta y}\right] + O\left[\Delta x, (\Delta y)^2\right]$ using Taylor series expansions.	[5]	2	4

Q.4 The unsteady state one-dimensional heat conduction is governed by:

$$\frac{\partial T}{\partial t} = \alpha \frac{\partial^2 T}{\partial z^2}$$

Q.4(a) Using FTCS scheme of finite difference, show that T_i^{l+1} can be expressed in explicit scheme by [5] 3,4 4,5

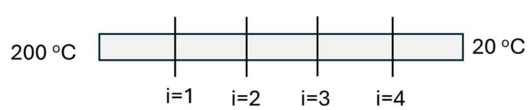
$$T_i^{l+1} = \lambda\left(T_{i+1}^l - 2T_i^l + T_{i-1}^l\right) + T_i^l$$

Now, using FTCS again, show that the implicit scheme can be expressed as:

$$T_i^l = -\lambda T_{i-1}^{l+1} + (1+2\lambda)T_i^{l+1} - \lambda T_{i+1}^{l+1}$$

Here, l denotes iteration in time, i denotes iteration in space, and $\lambda = \alpha\Delta t/(\Delta z)^2$

Q.4(b) A slender rod of 5m is exposed to a hot environment of 200 ºC. The other end of the rod stays at room temperature of 20 ºC (see figure below). Using the explicit scheme developed above in Q.4(a), calculate the temperature in the 4 internal nodes (i=1 to 4) after 0.1s. Use $\Delta t = 0.1s$, and $\Delta z = 1$. Note additionally, $T_i^0 = 20$ $(for\ i = 1\ to\ 4)$. Is the scheme stable? [5] 3,4 4,5



			CO	BL
Q.5(a)	Describe the workflow of a typical commercial CFD solver. Name some post-processing features of ANSYS Fluent used for analysis.	[5]	5	2
Q.5(b)	Two very wide thin flat plates, each of length L, are arranged horizontally such that a channel of height 2h and length L is formed between them. Provide the necessary equations and boundary conditions for an isothermal and symmetric flow of air in the channel. Show a sketch of the computational domain.	[5]	5	3