Seat No./Enrollment No.: ________

GUJARAT TECHNOLOGICAL UNIVERSITY
BACHELOR OF ENGINEERING – SEMESTER 7 – EXAMINATION – SUMMER 2026

Subject Code: 3170512 **Date: 08/06/2026**

Subject Name: Introduction to Computational Fluid Dynamics

Time: 02:30 PM TO 05:00 PM **Total Marks: 70**

Instructions:
1. Attempt all questions.
2. Make suitable assumptions wherever necessary.
3. Figures to the right indicate full marks.
4. Simple and non-programmable scientific calculators are allowed.

Q.1
(a) With example illustrate the use of computational fluid dynamics in reactor design. **03**

(b) Enlist the various types of numerical errors with mitigation strategies for errors in computational fluid dynamics. **04**

(c) Differentiate between forward, backward and central difference formula for **07**

$$\left(\frac{du}{dx}\right)_i$$

Q.2
(a) For the partial differential equation of two variables, give the cramer's rule for classification of PDE as Hyperbolic, Parabolic, or Elliptic. **03**

$$A\,\frac{\partial^2 u}{\partial x^2} + B\,\frac{\partial^2 u}{\partial x \partial y} + C\,\frac{\partial^2 u}{\partial y^2} + F\left(x, y, u, \frac{\partial u}{\partial x}, \frac{\partial u}{\partial y}\right) = 0$$

(b) Differential between shear stress and normal stress for an arbitrary fluid element. **04**

(c) Use second order central difference formula to discretize following term in computational fluid dynamics equation, **07**

$$\left(\frac{\partial^2 u}{\partial x^2}\right)_{i,j}$$

OR

Q.2
(c) For the following one-dimensional heat conduction equation, give the explicit and implicit finite difference formula, **07**

$$\frac{\partial u}{\partial t} = \alpha \frac{\partial^2 u}{\partial x^2}$$

Q.3
(a) Explain quasi-linear partial differential equation. **03**

(b) Discuss the discretization using forward difference and backward difference formula for second order derivatives in partial differential equation. **04**

(c) A temperature T of the moving fluid at any point is dependent on x,y,z, and time. Explain the partial, total, and substantial derivative of T with respect to time with reference to observer. **07**

OR

Q.3
(a) What is the eigenvalue method for the solution of partial differential equation. **03**

(b) Enlist and compare the advantages and disadvantages of computational fluid dynamics. **04**

(c) Derive the general form of the continuity equation for an arbitrary volume. **07**

Q.4

(a) With example explain the type of boundary condition where combination of variable and its gradient is specified. **03**

(b) With Example differentiate between Dirichlet boundary condition and Neumann boundary condition. **04**

(c) Derive the general form of the momentum equation for an arbitrary volume. **07**

OR

Q.4

(a) Write short note on analysis of stability of partial differential equation using discretization methods. **03**

(b) Describe use of computational fluid dynamics in the design of thin-film evaporator. **04**

(c) For arbitrary moving fluid element, use shell balance formula to derive momentum balance equation in non-conservation form. **07**

Q.5

(a) Define the divergence of any quantity X. What is the significance of divergence of velocity. **03**

(b) Give brief about how to derive continuous stirred tank reactor performance equation using computational fluid dynamics. **04**

(c) With clear example illustrate an application of computational fluid dynamics in agitator design. **07**

OR

Q.5

(a) Give examples chemical process equipment design where the computational fluid dynamics as a tool can be used. **03**

(b) Give brief about how to derive plug flow reactor performance equation using computational fluid dynamics. **04**

(c) Define pre-processer, solver and post-processor for computational fluid dynamics setup. Give one example where they are used. **07**

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