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| <b>INSTITUTE</b>      | <b>FACULTY OF TECHNOLOGY</b>                        |
| <b>PROGRAM</b>        | <b>MASTER OF TECHNOLOGY in CHEMICAL ENGINEERING</b> |
| <b>SEMESTER</b>       | <b>3</b>  |
| <b>COURSE TITLE</b>   | <b>COMPUTATIONAL FLUID DYNAMICS</b>                 |
| <b>COURSE CODE</b>    | <b>01CM0307</b>                                     |
| <b>COURSE CREDITS</b> | <b>3</b>  |

**Objective:**

- 1 The course deals with the numerical solution of equations governing fluid flow and would be of interest to engineers and scientists.

**Course Outcomes:** After completion of this course, student will be able to:

- 1 Apply the fundamental governing equations of fluid flow and heat transfer, including their derivation and applicability to different flow regimes
- 2 Apply discretization techniques such as finite difference, finite volume, and finite element methods to formulate numerical solutions for transport equations.
- 3 Analyze the stability, consistency, and convergence of numerical schemes and evaluate the accuracy of CFD solutions
- 4 Develop and implement CFD algorithms to solve coupled flow problems using structured/unstructured grids and pressure-velocity coupling techniques

**Pre-requisite of course:**Chemical Reaction Engineering

**Teaching and Examination Scheme**

| <b>Theory Hours</b> | <b>Tutorial Hours</b> | <b>Practical Hours</b> | <b>ESE</b> | <b>IA</b> | <b>CSE</b> | <b>Viva</b> | <b>Term Work</b> |
|---------------------|-----------------------|------------------------|------------|-----------|------------|-------------|------------------|
| 3                   | 0                     | 0                      | 50         | 30        | 20         | 0           | 0                |

| <b>Contents : Unit</b> | <b>Topics</b>   | <b>Contact Hours</b> |
|------------------------|---|----------------------|
| 1                      | <b>Illustration of the CFD approach</b><br>Illustration of the CFD approach; CFD as an engineering analysis tool  | 5                    |
| 2                      | <b>Derivation of flow governing equations</b><br>Turbulence modeling; modeling approaches for multiphase flow, Initial and boundary conditions; Well-posedness, Turbulence modeling   | 10                   |
| 3                      | <b>Discretization of the governing equations using finite difference/volume/element methods</b><br>Concepts of consistency, stability and convergence, Template for the discretization of a generic unsteady transport equation | 10                   |

| <b>Contents :<br/>Unit</b> | <b>Topics</b>   | <b>Contact<br/>Hours</b> |
|----------------------------|---|--------------------------|
| 4                          | <b>Solution of discretized equations</b><br>Direct methods; classical iterative methods; advanced methods for structured matrices; conjugate gradient techniques; multigrid methods, Solution of coupled equations: methods for compressible flows, Evaluation of pressure in incompressible flows; pressure-velocity coupling algorithms | 12                       |
| 5                          | <b>Structured and unstructured grids</b><br>Structured and unstructured grids; structured grid generation; unstructured grid generation   | 5                        |
| <b>Total Hours</b>         |   | <b>42</b>                |

#### **Textbook :**

- 1 Computational Fluid Dynamics for Engineers and Scientists, Jayanti, S., Berlin: Springer., 2018

#### **References:**

- 1 Numerical computation of internal and external flows: The fundamentals of computational fluid dynamics, Numerical computation of internal and external flows: The fundamentals of computational fluid dynamics, Hirsch, C. , Elsevier, 2007
- 2 Computational methods for fluid dynamics, Computational methods for fluid dynamics, Ferziger, J. H., & Peric, M. , Springer, 2002

#### **Suggested Theory Distribution:**

The suggested theory distribution as per Bloom's taxonomy is as follows. This distribution serves as guidelines for teachers and students to achieve effective teaching-learning process

| Distribution of Theory for course delivery and evaluation |                   |              |                |                 |   |
|---|-------------------|--------------|----------------|-----------------|---|
| <b>Remember /<br/>Knowledge</b>                           | <b>Understand</b> | <b>Apply</b> | <b>Analyze</b> | <b>Evaluate</b> | <b>Higher order<br/>Thinking /<br/>Creative</b> |
| 10.00   | 20.00             | 25.00        | 25.00          | 10.00           | 10.00   |

#### **Instructional Method:**

- 1 The course delivery method will depend upon the requirement of content and need of students. The teacher in addition to conventional teaching method by black board, may also use any of tools such as demonstration, role play, Quiz, brainstorming, MOOCs etc.
- 2 The internal evaluation will be done on the basis of continuous evaluation of students in the laboratory and class-room.
- 3 Students will use supplementary resources such as online videos, NPTEL videos, e-courses.

**Supplementary Resources:**

- 1 <https://nptel.ac.in/courses/103106073>
- 2 <https://nptel.ac.in/courses/103106119>