# Computational Fluid Dynamics

1.1 Course Number: PE444

1.2 Contact Hours: 3- 0- 0 Credits: 9

1.3 Semester-offered: 4th Year-Even

1.4 Prerequisite: Engineering Thermodynamics, Fluid Flow operations

1.5 Syllabus Committee Member: Dr. Tushar Sharma

2. **Objective:** This course is for students who have little or no experience in CFD, and with little prior knowledge of fluid-dynamics, heat transfer and numerical-methods. The major emphasis is on simplification of the mathematics involved by presenting physical-law (instead of the traditional differential equations) based algebraic-formulations, discussions, and solution-methodology for enabling better work in CFD.

3. **Course Content:**

Unit-wise distribution of content and number of lectures

| Unit | Topics | Sub-topic | Lectures |
|---|---|---|---|
| 1 | Conservation Basics of fluid flow and PDE approaches | Introduction to Computational Fluid Dynamics and Principles of Conservation, Conservation of Mass and Momentum: Continuity and Navier Stokes Equation Energy Equation and General Structure of Conservation Equations, Classification of Partial Differential Equations and Physical Behaviour, Approximate Solutions of Differential Equations: Error Minimization Principles Approximate Solutions of Differential Equations: Variational Principles and Weighted Residual Approach, Weighted Residual Approach and Introduction to Discretization, Fundamentals of Discretization: Finite Element | 12 |
| 2 | Steady and unsteady state DEs and different methods to solve PDE | Boundary Condition Implementation and Discretization of Unsteady State Problems, Discretization of Unsteady State Problems, Important Consequences of Discretization of Unsteady State Fundamentals of Discretization: Finite Difference and Finite Volume Method, Conceptual Basics and Illustrations through 1-D Steady State Diffusion Discretization of Hyperbolic Equations: Stability Analysis, Stability of Second Order Hyperbolic Equations, Finite Volume Discretization of 2-D Unsteady State Diffusion Type | 10 |
| 3 | Solution techniques of | Solution of Systems of Linear Algebraic Equations, Elimination Methods, Error Analysis, Iterative Methods | 10 |

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| | linear algebraic equations | for Numerical Solution of Systems of Linear Algebraic Iteration & Elimination Techniques, Introduction to Gradient Search Methods, Discretization of Convection-Diffusion Equations Discretization of Naiver Stokes Equations and solutions. | |
| 4 | CFD formulation steps and basics | Fundamentals of Unstructured Grid Formulation.Writing and implementing a CFD code. Turbulence Modeling Working with CFD software and applications to oil & gas industry. | 8 |
| | | **Total** | 40 |

## 2. Readings

4.1 Textbook:

a) Introduction to Computational Fluid Dynamics: Development, Application and Analysis, Dr. Atul Sharma, Wiley, 2016

b) An Introduction to Computational Fluid Dynamics, Pearson Education Limited, 2007 ($2^{nd}$ Ed.)

4.2 Reference books:

a) Computational Fluid Dynamics, Jiyuan Tu Guan Heng Yeoh Chaoqun Liu, Butterworth-Heinemann, 2018.

b) Elements of Computational Fluid Dynamics

## 5 Outcome of the Course:

The course will provide advanced undergraduates and first-year graduate students, the necessary skills for the training and working with Computational Fluid Mechanics to solve complex problems in fluid mechanics and heat transfer.