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:

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

	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 (2nd 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 the necessary skills for the training and working with Computational Fluid Mechanics to solve complex problems in fluid mechanics and heat transfer.