Course Type	Course Code	Name of Course	L	T	P	Credit
DC	NMEC522	Computational Fluid Dynamics	3	1	0	4

Course Objective
• The prime objective of this course is to provide the students with in depth understanding of the computational approach for modeling and solving fluid dynamics as well as heat transfer problems. • To enable the students to mathematically represent a physical phenomenon, so that they can generate a mathematical model and finally, a numerical statement of a given problem and solve the problem via implementation of the theoretical knowledge gained. • To make the students initially believe and then understand that many of the results in heat transfer/fluid flow that they have studied in undergraduate/post-graduate courses can be generated accurately by themselves using CFD.
Learning Outcomes
• The students will be familiar to a powerful tool for solving flow and heat transfer problems. This experience will enable them to numerically model a thermo-fluids problem using FDM and FVM. • The students will have the feel of the essential role the matrix algebra plays in approximate computations of ODEs and PDEs. • The students will be more inclined towards computer programming which will turn out to be very helpful in their Masters research and thereafter.

Unit No.	Topics to be Covered Lecture	Lecture Hours (L+T)	Learning Outcomes
1	Review of governing equations for conservation of mass, momentum and energy in primitive variable form	4+2	After this revision module, the students will be able to derive the conservation equations using Reynolds transport theorem and will also be able to interpret each equation
2	Mathematical behaviour of the conservation equations, equilibrium and marching problems	4+2	This important module will enable the students to distinguish given equations based on their characteristics (mathematical nature) and also to choose later, the appropriate differencing schemes as applicable
3	The finite difference method (FDM) and the variational methods, discretization, comparison of finite difference method, finite volume method (FVM) and finite element method (FEM)	3+1	The students will be acquainted with the brief history of development of the three basic discretization techniques as well as foundation of discretization
4	Review of Taylor's series, implicit, explicit and semi-implicit schemes, alternate direction implicit method	4+1	This module deals with the foundation of FDM; the students will be able to logically approximate a derivative and a differential equation
5	Convergence, stability analysis of a numerical scheme	6+2	This module will provide the concept of numerical error and guidelines for using or not using a differencing scheme while solving a CFD problem
6	Solution of linear matrix equation system	3+1	This module will familiarize the students

	and programming		with the role of linear algebra in solving fluid dynamics problems
7	Application of FDM in one- and two dimensional steady and unsteady heat conduction and computer programming, artificial viscosity, upwinding	3+1	Practical implementation of all the topics covered up to module VI, introduction to numerical diffusion and CFD in fluid flow, students will be able to differentiate between CFD in heat conduction and CFD in fluid dynamics
8	Stream function-vorticity formulation	5+1	The students will learn the alternate flow equations as well as their solution methods used in early days of numerical treatment of flow problems
9	The finite volume method in orthogonal and non-orthogonal meshes, Green-Gauss theorem, application of FVM for heat conduction and convection-diffusion problem	6+2	The students will be able to discretize a given equation via direct integration on orthogonal and non-orthogonal meshes. This module will make the limitations of FDM more obvious to the students
10	Implementation of SIMPLE algorithm in two dimensions, Introduction to commercial package ANSYS-FLUENT	2+1	The students will have the flavour of a segregated fluid flow solver. In this context, they will learn the difficulties posed by the nonlinear convective terms and coupling between pressure and velocity. Thus, they can appreciate the depth and involvement in numerical treatment of a flow problem compared to a heat conduction problem.
	Total	42+14	

Text Books:

1. John D. Anderson, Computational Fluid Dynamics The basics with applications, McGraw-Hill Education, 1st Edition, 2017.

2. Joel H. Ferziger and M. Peric, Computational Methods for Fluid Dynamics, Springer, 3rd Edition, 2002.

References:

1. Richard H. Pletcher, John C. Tannehill and Dale A. Anderson, Computational Fluid Mechanics and Heat Transfer, CRC Press, 3rd Edition, 2012.

2. Clive A. J. Fletcher, Computational Techniques for Fluid Dynamics, Springer, 1st Edition, 1988.

3. T. J. Chung, Computational Fluid Dynamics, Cambridge University Press, 2nd Edition, 2010.

4. K. Muralidhar and T. R. Sundararajan, Computational Fluid Flow and Heat Transfer, Narosa Publishing House, 2nd Revised Edition, 2003.

5. S. V. Patankar, Numerical Heat Transfer and Fluid Flow, CRC Press, 1st Edition, 1980.