B. Tech. Civil Engineering				
Course code: Course Title	**Course Structure**			**Pre-Requisite**
CE321: Computational Fluid Dynamics	**L**	**T**	**P**	Nil
	3	**0**	**2**	

Course Objectives: To familiarise the students with the concepts of the subject and its related applications in Civil Engineering.

S. No.	Contents	Contact Hours
Unit 1	**Introduction to Computational Fluid Dynamics (CFD):** Introduction to Computational Fluid Dynamics, Applications of Computational Fluid Dynamics, Advantages of Computational Fluid Dynamics. Governing Equations: Principles of Conservation: Continuity Equation, Navier-Stokes Equation, Energy Equation. General Structure of Conservation Equations.	6
Unit 2	**Classification of Partial Differential Equations and Physical Behaviour:** Mathematical classification of Partial Differential Equations: Illustrative examples of elliptic, parabolic and hyperbolic equations, Physical examples of elliptic, parabolic and hyperbolic partial differential equations.	6
Unit 3	**Discretisation** Basics of discretisation. Boundary conditions: Possible types of boundary conditions, Conservativeness, Boundedness, Transportive Ness, boundary layer treatment, variable property, interface and free surface treatment. Well posed problem. Classification and Overview of Numerical Methods: Classification into various types of equations, parabolic, elliptic and hyperbolic; boundary and initial conditions; overview of numerical methods.	6
Unit 4	**Discretisation Methods: Finite Difference Methods,** Finite Difference Technique: Finite difference methods; different means for formulating finite difference equations; Taylor series expansion. Implicit, fully explicit and Crank-Nicolson scheme. **Finite Volume Methods** Finite Volume Technique: Finite volume methods; different types of finite volume grids; approximation of surface and volume integrals; interpolation methods; central, upwind and hybrid formulations and comparison for convection-diffusion problem. **Finite Element Methods:** Finite element methods; Rayleigh-Ritz, Galerkin and Least square methods; interpolation functions; one and two-dimensional elements; applications.	8

Unit 5	**Solution Methods:** Methods of Solution: Solution of finite difference equations; iterative methods; matrix inversion methods; ADI method; operator splitting; fast Fourier transform. Time integration Methods: Single and multilevel methods; predictor-corrector methods; stability analysis; Applications to transient conduction and advection-diffusion problems.	6
Unit 6	**Grid Generation** Numerical Grid Generation: Numerical grid generation; basic ideas; transformation and mapping.	2
Unit 7	**Turbulence Modelling** Turbulence modelling: Reynolds averaged Navier-Stokes (RANS) equations, RANS modelling, DNS and LES.	6
	Total	**40**

Lab Work: The students would be expected to gain hands on experience on simulation of some classical fluid dynamics problems using related software in the laboratory: Viscous flow across flat plate, Flow past a sphere, Study of laminar flow through a pipe, Study of turbulent flow through pipe, Study of sudden expansion in a pipe, Study of steady and unsteady flow past a cylinder.

References:

S. No.	**Name of Books/ Authors**	**Year of Publication/ Reprint**
1	Computational Fluid Dynamics, John D Anderson Jr, McGraw Hill Publications(ISBN 0-07-07592-7).	2000
2	Computational Methods for Fluid Dynamics, John Freziger, Miloven Peric, Springer(ISBN 0-07-94562-6).	1999
3	Computational Fluid Dynamics for Engineers Bengt Andersson, Ronnie Andersson, Love Ka Kansson, Mikael Mrtensen, Rahman Sudiyo, Berend Van Wachem, Cambridge University Press (ISBN 0-07-146498-7).	1996
4	Computational Fluid Dynamics – A Practical Approach, Jiyuan Tu, Guan Heng Yeoh, Chaoqun Liu(ISBN 0-07-0228847-9).	2005