ME 543 Computational Fluid Dynamics (3-0-0-6)

Basic equations of Fluid Dynamics: General form of a conservation law; Equation of mass conservation; Conservation law of momentum; Conservation equation of energy. The dynamic levels of approximation. Mathematical nature of PDEs and flow equations. Basic Discretization techniques: Finite Difference Method (FDM); The Finite Volume Method (FVM) and conservative discretization. Analysis and Application of Numerical Schemes: Consistency; Stability; Convergence; Fourier or von Neumann stability analysis; Modified equation; Application of FDM to wave, Heat, Laplace and Burgers equations. Integration methods for systems of ODEs: Linear multi-step methods; Predictor-corrector schemes; ADI methods; The Runge-Kutta schemes. Numerical solution of the compressible Euler equations: Mathematical formulation of the system of Euler equations; Space-centred schemes; Upwind schemes for the Euler equations – flux vector and flux difference splitting; Shock-tube problem. Numerical solution of the incompressible Navier-Stokes equations: Stream function-vorticity formulation; Primitive variable formulation; Pressure correction techniques like SIMPLE, SIMPLER and SIMPLEC; Lid-driven cavity flow. Numerical heat transfer: Brief discussion of numerical methods for conduction and convection.

Textsbooks:
[1] Richard Pletcher, John Tannehill and Dale Anderson, `Computational Fluid Mechanics and Heat Transfer 3e', CRC Press, 2012
[2] H.K. Versteeg and W. Malalasekera, `An introduction to computational fluid dynamics: The finite volume method 3e', Pearson Education, 2007.
[3] Charles Hirsch, `Numerical Computation of Internal and External Flows', Vol.1 (1988) and Vol.2 (1990), John Wiley & Sons.

References:
[1] J. H. Fergiger, M. Peric, `Computational Methods for Fluid Dynamics 3e', Springer, 2002.
[2] T. J. Chung `Computational Fluid Dynamics 2e', Cambridge University Press, 2010.
[3] C. A. J. Fletcher, `Computational Techniques for Fluid Dynamics Vol. 1 and 2 2e', Springer, 1991.
[4] S.V. Patankar, `Numerical Heat Transfer and Fluid Flow', Hemisphere, 1980.
[5] J. D. Anderson Jr., `Computational Fluid Dynamics', McGraw-Hill International Edition, 1995.