ME615 Applied Computational Fluid Dynamics

Credit: 2.5-0.5-0-3 Approval: Approved in 3rd Senate

Students intended for: BTech 4th Year/MS/PhD

Elective or Core: Elective Semester: Odd/Even

Prerequisite: Mathematics background (PDE, Li near Algebra), Fluid mechanics, heat transfer, thermodynamics, Programming language (C, FORTRAN 90)

Course objective:

Applied Computational Fluid Dynamics (CFD) provides an introduction to the theoretical fundamentals as well as to the use of commercial CFD codes to analyze flow and heat transfer in problems of practical engineering interest. An overview of the theory and numerics of CFD is provided, but students are not expected to write programs. Students are trained to preprocess raw geometric data, mesh it and develop a CFD model. The students will understand the process of developing a geometrical model of the flow, applying appropriate boundary conditions, specifying solution parameters, and visualizing the results. They will also have an appreciation for the factors limiting the accuracy of CFD solutions.

Course content:

- Introduction: Basics of heat transfer, fluid flow; Mathematical description of fluid flow and heat 5 transfer: conservation equations for mass, momentum, energy and chemical species, classification of partial differential equations, coordinate systems.
- Discretization techniques: Discretisation techniques using finite difference methods: Taylor-Series and control volume formulations; Finite element discretization techniques.
- Modelling of diffusion problems using finite volume method: One dimensional steady state diffusion problems; discretization technique; Solution methodology for linear and non-linear problems: Point-by-point iteration, TDMA; Two and three dimensional discretization; Discretization of unsteady diffusion problems: Explicit, Implicit and Crank-Nicolson's algorithm; stability of solutions.
- Modelling of Convection- Diffusion Problems: One dimensional convection-diffusion problem: Central difference scheme; Discretization based on analytical approach (exponential scheme); Hybrid and power law discretization techniques; Higher order schemes (QUICK algorithm).
- Flow modeling: Discretization of incompressible flow equations; Pressure based algorithm: SIMPLE, SIMPLER etc; Unstructured grids; Introduction to FVM with unstructured grids; Introduction to turbulence modeling; Large Eddy Simulation (LES); Direct Numerical Simulation (DNS).
- Projects / Exercises/ Publications: Solving simplified problems: formulation, discretization with coarse grids, applying appropriate boundary and initial conditions and solving by hand calculations; Solving practical problems through software: writing user sub-routines; post-processing and interpretation of results.

References:

S. V. Patankar, "Numerical Heat Transfer and Fluid Flow, " Hemi sphere Publishing Corporation, 1980.

D. A. Anderson, J. C. Tannehill , and R. H. Pletcher, "Computational Fluid mechanics and Heat Transfer, " Hemi sphere Publishing Corporation, 1984.

J. H. Ferziger and M. Peric, "Computanional Methods for Fluid Dynamics", Second Edition, Springer, Berlin, 1999.

H. K. Versteeg and W. Malalasekera, "An Introduction to Computational Fluid Dynamics: The Finite Volume Method",