Computational Fluid Dynamics - Video course

COURSE OUTLINE

Computational fluid dynamics (CFD) has become an essential tool in analysis and design of thermal and fluid flow systems in wide range of industries. Few prominent areas of applications of CFD include meteorology, transport systems (aerospace, automobile, highspeed trains), energy systems, environment, electronics, bio-medical (design of lifesupport and drug delivery systems), etc.

The correct use of CFD as a design analysis or diagnostic tool requires a thorough understanding of underlying physics, mathematical modeling and numerical techniques. The user must be fully aware of the properties and limitations of the numerical techniques incorporated in CFD software. This course aims to provide precisely these insights of CFD.

Contents:
Mathematical modeling: Governing equations of fluid flow and heat transfer; Introduction to discretization methods: Finite difference and finite volume methods for heat transfer problems; Time stepping methods for unsteady problems; Solution techniques for system of algebraic equations; Grid generation techniques; Solution techniques for Navier-Stokes equation; Finite element method for heat transfer and fluid flow problems; Turbulence modeling.

NP-TEL

NPTEL

http://nptel.ac.in

Mechanical Engineering

Pre-requisites:

Fluid Mechanics.

Coordinators:

Dr. K. M. Singh
Department of Mechanical and Industrial EngineeringIIT Roorkee

COURSE DETAIL

Sl. No	Topic	Hours
1.	Introduction: Conservation equation; mass; momentum and energy equations; convective forms of the equations and general description.	3
2.	Classification and Overview of Numerical Methods: Classification into various types of equation; parabolic elliptic and	4

	hyperbolic; boundary and initial conditions; over view of numerical methods.		
3.	Finite Difference Technique: Finite difference methods; different means for formulating finite difference equation; Taylor series expansion, integration over element, local function method; treatment of boundary conditions; boundary layer treatment; variable property; interface and free surface treatment; accuracy of f.d. method.	3	
4.	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.	4	
5.	Finite Element Methods: Finite element methods; Rayleigh-Ritz, Galerkin and Least square methods; interpolation functions; one and two dimensional elements; applications.	4	
6.	Methods of Solution: Solution of finite difference equations; iterative methods; matrix inversion methods; ADI method; operator splitting; fast Fourier transform.	4	
7.	Time integration Methods: Single and multilevel methods; predictorcorrector methods; stability analysis; Applications to transient conduction and advection-diffusion problems.	4	
8.	Numerical Grid Generation: Numerical grid generation; basic ideas; transformation and mapping.	4	
9.	Navier-Stokes Equations: Explicit and implicit methods; SIMPLE type methods; fractional step methods.	4	

10.	Turbulence modeling: Reynolds averaged Navier-Stokes equations, RANS modeling, DNS and LES.	4

References:

1. Ferziger, J. H. and Peric, M. (2003). Computational Methods for Fluid Dynamics. Third Edition, Springer-Verlag, Berlin.

2. Versteeg, H. K. and Malalasekara, W. (2008). Introduction to Computational Fluid Dynamics: The Finite Volume Method. Second Edition (Indian Reprint) Pearson Education.

3. Anderson, D.A., Tannehill, J.C. and Pletcher, R.H. (1997). Computational Fluid Mechanics and Heat Transfer. Taylor & Francis.