Computational Heat Transfer and Fluid Flow - Web course

COURSE OUTLINE

- **Mathematical description of fluid flow and heat transfer:** conservation equations for mass, momentum, energy and chemical species, classification of partial differential equations, coordinate systems.
- **Discretisation techniques using finite difference methods:** Taylor-Series and control volume formulations; modelling of heat conduction, convection-diffusion, and flow field using finite volume method (FVM); introduction to FVM with unstructured grids; modelling of phase change problems; introduction to turbulence modelling; application to practical problems.

COURSE DETAIL

Module	Sub-Modules	Hours per topic	Total Hours
1. 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.	3 2	5
2. Discretization techniques	• Discretisation techniques using finite difference methods: Taylor-Series and control volume formulations. • Finite element discretization techniques.	2 2	4
3. 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	2 1 2	5

NP-TEL

NPTEL

http://nptel.iitm.ac.in

Mechanical Engineering

Pre-requisites:

- Mathematics background (PDE, Linear Algebra).
- Fluid mechanics, heat transfer, thermodynamics.
- Programming language (C, FORTRAN 90).

Additional Reading:

1. S. R. Mathur and J. Y. Murthy, "A Pressure- Based Method for Unstructured Meshes", Numerical Heat Transfer, Part B, Vol. 31, pp. 195- 215, 1997.
2. W. J. Minkowycz, E. M. Sparrow, J. Y. Murthy, "Handbook of Numerical Heat Transfer," Second Edition, John Wiley and Sons, 2006.

Hyperlinks:

1. CFD Flow Modeling Software & Solutions from Fluent: http://www.fluent.com
2. Flomerics Group PLC - Mentor Graphics: http://www.flomerics.com/
3. Software AEAT: http://www.software.aeat.com/cfx
4. CHAM and PHOENICS: http://www.cham.co.uk/
5. CFD Research Corporation: http://www.cfdrc.com
6. Automated Flow, Thermal, and Stress Simulation Software and Services for CFD and CAE Solutions:

	implicit and Crank-Nicolson's algorithm; stability of solutions.		
4. 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 techniqies. • Higher order schemes (QUICK algorithm).	2 1 1 1	5
5. Flow modelling	• Discretization of incompressible flow equations. • Pressure based algorithm: SIMPLE, SIMPLER etc.	3 2	5
6. Unstructured grids	• Introduction to FVM with unstructured grids.	2	2
7. Multiphase problems	• Modelling of multiphase problems: enthalpy method, volume of fluid (VOF) and Level Set Methods.	1	4
8. Introduction to turbulence modeling	• Large Eddy Simulation (LES). • Direct Numerical Simulation (DNS).	2 1	4
9. Projects / Exercises	• 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.	4 6	8

References:

1. S. V. Patankar, "Numerical Heat Transfer and Fluid Flow," Hemisphere Publishing Corporation, 1980.
2. D. A. Anderson, J. C. Tannehill, and R. H. Pletcher, "Computational Fluid Mechanics and Heat Transfer," Hemisphere Publishing Corporation, 1984.
3. J. H. Ferziger and M. Peric, "Computational Methods for Fluid Dynamics", Second Edition, Springer, Berlin, 1999.
4. H. K. Versteeg and W. Malalasekera, "An Introduction to Computational Fluid Dynamics: The Finite Volume Method",

http://www.cd-adapco.com

7. ANSYS, Inc. - corporate: http://www.ansys.com/
8. ANSYS Products Portfolio: http://www.fluent.com/software/fidap/
9. TileFlow, MacroFlow, MeltFlow | Innovative Research: http://www.inres.com
10. ANSYS Icepak: http://www.icepak.com

Coordinators:

Prof. Pradip Dutta
Department of Mechanical EngineeringIISc Bangalore

Longman Scientific & Technical, 1995.