BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI, PILANI CAMPUS

INSTRUCTION DIVISION

SECOND SEMESTER 2015-2016

Course Handout (Part II)

Date: 05/01/2016

In addition to part I (General Handout for all courses appended to the time table) this portion gives further specific details regarding the course.

Course No. : **ME F485**

Course Title : **NUMERICAL TECHNIQUES FOR FLUID FLOW AND HEAT TRANSFER**

Instructor-In-charge : **Dr. Ravi Inder Singh**

Course Description: Introduction to CFD, Partial Differential Equation (PDE): Physical classifications, Mathematical Classifications, Well posed problem. Basic of Discretization Methods: Finite difference method, Truncation error, consistency, error and stability analysis, convergence, various discretization schemes. Introduction to commercial software: Ansys Fluent, UDF in Ansys Fluent, M codes in Matlab. Application of numerical methods to selected model equations: Wave equation, Heat equation, Laplace's equations. Solution of Navier-Stokes equation for incompressible flows.

Scope and Objective: This course is intended to provide a comprehensive knowledge of Numerical modelling used for computational heat transfer and fluid flow simulations. Developing own code or using commercial code requires high level of skill and understanding of fundamentals of numerical modeling to enable useful results for complex engineering problems. The course will develop overall background of fluid flow and heat transfer modeling of practical problems using finite difference and finite volume method. The course will focus on discretization, method for solving discretization equations, consistency, and stability and convergence issues.

Textbook:

1. S. V. Patankar, "Numerical Heat Transfer and Fluid Flow," Hemisphere Publishing Corporation, 1980.
2. J. D. Anderson, "Computational Fluid Dynamics", Computational Fluid Dynamics, Tata McGraw-Hill, 2012

Reference book:

1. H. K. Versteeg and W. Malalasekera, "An Introduction to Computational Fluid Dynamics: The Finite Volume Method", Longman Scientific & Technical, 1995.
2. D. A. Anderson, J. C. Tannehill, and R. H. Pletcher, "Computational Fluid Mechanics and Heat Transfer," Hemisphere Publishing Corporation, 1984.
3. Computational Fluid Flow and Heat Transfer, K. Muralidhar and T. Sundararajan, Narosa publishing, 2003.

Lecture No.	Learning Objectives	Topics to be covered	Reference Chap.
1-3	Introduction	Numerical Techniques for Fluid Flow and Heat transfer: Why, Usage as Research and Design Tool, Impact and Applications. Brief description of CFD commercial software's	Lecture notes Chap 1 T2 Chap 1 T1
4-8	The Governing Equations of Fluid Dynamics: Their Derivation, a Discussion of Their Physical Meaning, and a Presentation of Forms Particularly Suitable to CFD	Introduction Models of the Flow, Finite Control Volume, Infinitesimal Fluid Element, The Substantial Derivative, The Divergence of the Velocity: Its Physical Meaning, The Continuity Equation, The Momentum Equation, Equation, The Energy Equation, Summary of the Governing Equations for Fluid Dynamics.	Chap 2, T2
9-12	Mathematical Behavior of Partial Differential Equations	Introduction, Classification of Quasi-Linear Partial Differential Equations, General Method of Determining the Classification of Partial Differential Equations: The Eigen value Method, General Behavior of the Different Classes of Partial Differential Equations: Impact on Physical and Computational Fluid Dynamics, Hyperbolic Equations, Parabolic Equations, Elliptic Equations.	Chapt 3, T2
13-15	Solution of System of Algebraic Equations	Criteria for unique solution, elimination and iteration method: Gauss elimination, Gauss Siedel and Line by Line TDMA.	Lecture notes T1 (Ch 4)
16-18	Introduction to CFD Codes : Ansys-Fluent and Coding using Matlab	Pre-processor, Solver and Post-processor, UDF, Some applications of heat transfer and fluid flow, Introduction to Matlab Codes	Lecture notes

19-20	Finite difference method	Finite difference method , central forward and backward difference, numerical errors, accuracy of solution, step size, grid independent test, modeling of sample problems	Lecture. notes
21-23	Discretization Methods	Explicit and Implicit Approaches: Definitions and Contrasts, Errors and an Analysis of Stability, Stability Analysis: A Broader Perspective, CFL condition.	Chap 4 T2
24-25	Finite volume method/ Control volume method	Finite volume formulation, Consistency, Stability and convergence issues. Source term linearization.	T1 (Ch.3) Lecture Notes
26-27	Heat Conduction problem modeling using finite volume method	Steady one dimensional heat conduction, Solution methodology TDMA etc.	T1 (Ch. 4)
28-30	Heat Conduction problem modeling using finite volume method	Unsteady one dimensional heat conduction, different schemes Explicit, Crank Nicholson, Fully Implicit Scheme. Two and Three dimensional situations.	T1 (Ch. 4)
31-33	Finite Volume Discretization: Transient Heat Conduction	Issues of discretization and consequences of transient conduction problems: Consistency, Stability, Convergence, LAX Equivalence theorem, Grid independent and time independent study.	Lecture notes T2 Ch. 6
34-36	Modeling of Convection and Diffusion problem FVM	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).	(TB1) Ch. 5
37-39	Flow Field Calculation	Discretization of the Momentum Equation: Stream Function-Vorticity approach and Primitive variable approach, Staggered grid and Collocated grid, Discretization of incompressible flow equations. Pressure based algorithms: SIMPLE Algorithm, SIMPLER Algorithm.	T1 (Ch. 6) T2 (Ch -6)
40	Closure	Review	Lecture Notes

Evaluation Scheme:

Components	Number	Duration	Weight age (%)	Max. Marks 200	Date & Time	Remarks
Mid Semester	1	90 min.	30	60	18/3 2:00 -3:30 PM	Closed
Assignment/ Project	2 + 1		30	60=A+B		
	Minor(2) + Major(1)		[10 %] (Minor)	A=[20]	# TBA in Class(For Minor)	Open Book
			[20 %] (Major)	B=[40]	# 10.4.2016(For major)	
Comprehensive Exam	1	3 hrs.	40	80	13/5 FN	Closed Book

Mid-semester grading: It will be announced normally in the month of March. It is done in the same manner as that of the final grading

Assignment/Project : Topic/Pattern will be announced in class up to 23.1.2015 The Last date will be 15-4-2016. Major Assignment will be followed by Student Presentation on Topic.

Chamber Consultation Hours: Room No.: 2230-FD-II. Time: To be announced in the class.

Notices: All notices related to this course will be put on the **Mechanical Engineering Department notice board** only.

Make-up Policy: Make-up will be given only to the genuine students as per rules. The request application for make-up test must reach the Instructor-in-charge before commencement of the scheduled test (documentary proof is essential). No make-up will be allowed for the projects/ assignments.

Instructor-in-charge