BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE-PILANI - HYDERABAD CAMPUS

SECOND SEMESTER 2018 - 2019

(COURSE HANDOUT PART II)

Date: 07/01/2019

In addition to part-I (general handout for all courses in the time-table), this handout provides the specific details regarding the course.

Course No.: ME F485

Course Title: NUMERICAL TECHNIQUES FOR FLUID FLOW AND HEAT TRANSFER

Instructor-in-charge: K. RAM CHANDRA MURTHY

1. **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 commercial software: Open FOAM or Fluent. Application of numerical methods to selected model equations: Wave equation, Heat equation, Laplace's equations. Solution of Navier-Stokes equation for incompressible flows.

2. **Scope and Objective:** The primary objective of this course is to provide an overview on the numerical techniques being used for solving the heat transfer and fluid flow problems. Developing one's own code or using commercial code demands thorough understanding of numerical methods suitable for equations governing the heat transfer and fluid flow. This course covers on numerical modeling of heat transfer and fluid flow problems of practical importance using finite difference and finite volume methods. Focus is given on discretization, method for solving discretization equations, consistency, and stability and convergence issues.

3. **Text Books**:

   T1. **S V Patankar**, "Numerical Heat Transfer and Fluid Flow", Hemisphere Publishing Corporation, 1st Edition, 1980.

   T2. **K Muralidhar & T Sundararajan**, "Computational Fluid Flow and Heat Transfer", Narosa Book Distributors Pvt Ltd, 2nd Edition, 2003.

   Reference Books:

   R1. **H K Versteeg & W Malalasekara**, "Introduction to Computational Fluid Dynamics: The Finite Volume Method", Pearson Education (Indian Reprint), 2nd Edition, 2007.

   R2. **John D Anderson,** "Computational Fluid Dynamics", Tata-McGraw Hill Publisher, 1st Edition, 1995.

4. **Course Plan**:

Lecture Nos.	Learning Objectives	Topics to be covered	Chapter in Textbook
01-02	Introduction	Introduction to CFD, Advantages and applications of CFD	T1-1 & R2-1
03-05	Solution to system of algebraic equations	Direct solvers, Gauss elimination, LU decomposition, tri-diagonal algorithm; Iterative solution methods, under and over relaxation	T2-2
06-09	Solutions of	Euler explicit/implicit methods; Runge-Kutta (R-K)	T2-3

Lecture Nos.	Learning Objectives	Topics to be covered	Chapter in Textbook
	ordinary differential equations	methods; Predictor corrector methods; Examples of initial value and boundary value problems	
10-12	Introduction to governing equations	Models of flow; Governing equations: Continuity equation, Momentum equation, Energy equation	T1-2 & R2-2
13-17	Classification of partial differential equations	Parabolic, elliptic and hyperbolic equations; Well posed and ill posed problems; Initial and boundary conditions	T1-2 & R2-3
18-22	Finite difference method	Taylor's series: Finite difference formulation, 1D & 2D steady state heat transfer problems; Boundary conditions; Unsteady state heat conduction, Errors associated with FDM; Explicit method; Stability criteria; Implicit method; Crank Nicolson method; ADI	T1-3&4
23-26	Finite volume method	Basic rules for control volume approach; Steady and unsteady heat conduction: 1-D, Extension to 2D & 3D problems	R1-4
27-30	Discretization of convection and diffusion equations	1D convection diffusion, Discretization schemes and their assessment, Treatment of boundary conditions	T1-5 & R1-5
31-35	Discretization of Navier-Stokes equations	Discretization of the momentum equation: Stream function-Vorticity approach and Primitive variable approach; Staggered grid and Collocated grid, SIMPLE algorithm, SIMPLER algorithm	T1-6 & R1-6
36-39	Turbulent flows	Basics; DNS, LES and RANS models	R1-3
40-42	Introduction to CFD Codes	Pre-processor, Solver and Post-processor, Some applications of heat transfer and fluid flow	Lecture notes

5. Evaluation Scheme:

Evaluation Component	Duration (minute)	Weightage (%)	Date & Time	Nature of Component
Assignments	–	10	Shall be announced in the classroom	**OB**
Project & Seminar	–	15	Shall be announced in the classroom	**OB**
Quiz	–	10	Surprise in nature	CB
Mid Semester Test	90	25	12/3 11.00 -12.30 PM	CB
Comprehensive Exam	180	40	03/05 AN	CB

* Students in a group of not exceeding two, shall present & submit two reports (preliminary and final) on a **topic** of their choice that **aligns** with the **course description** and **course plan**. The preliminary and final reports (only **softcopy**), not exceeding to two and six pages (A4 size) respectively, shall be submitted before the due dates.

6. **Chamber Consultation Hour**: To be announced in the class room.

7. **Notices**: All notices concerning this course shall be displayed on the Mechanical Engineering Notice Board. Students are advised also to visit regularly **CMS** (institute's web based course management system) for updates on the course matters.

8. **Make-up Policy**: Make-up for the Mid Semester Test needs prior permission and strictly meant only for serious hospitalization cases with proper documents.

9. **Academic Honesty and Integrity Policy**: Academic honesty and integrity are to be maintained by all the students throughout the semester and no type of academic dishonesty is acceptable.

Instructor-in-charge
ME F485