Birla Institute of Technology & Science, Pilani
Hyderabad Campus

FIRST SEMESTER 2023-2024

Course Handout Part II

Date: 11-08-2023

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 : Mrinal K. Jagirdar

Scope and Objective of the Course:

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 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.

Textbooks:

1. S V Patankar, "Numerical Heat Transfer and Fluid Flow", Hemisphere Publishing Corporation, 1st Edition, 1980.
2. K Muralidhar & T Sundararajan, "Computational Fluid Flow and Heat Transfer", Narosa Book Distributors Pvt Ltd, 2nd Edition, 2003.

Reference books

1. H K Versteeg & W Malalasekara, "Introduction to Computational Fluid Dynamics: The Finite Volume Method", Pearson Education (Indian Reprint), 2nd Edition, 2007.
2. John D Anderson, "Computational Fluid Dynamics", Tata-McGraw Hill Publisher, 1st Edition, 1995.

Course Plan:

Lecture No.	Learning objectives	Topics to be covered	Chapter in the Text Book
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 ordinary differential equations	Euler explicit/implicit methods; Runge-Kutta (R-K) methods; Predictor corrector methods; Examples of initial value and boundary value problems	T2-3

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

Evaluation Scheme:

Component	Duration	Weightage (%)	Date & Time	Nature of Component
Assignments	–	20	TBA	**OB**
Projects	–	20	TBA	**OB**
Mid Semester Test	90	20	13/10 - 4.00 - 5.30PM	CB
Comprehensive Exam	180	40	19/12 AN	CB

Chamber Consultation Hour: Mondays from 5:00 PM to 6:00 PM

Notices: All notices concerning this course shall be communicated only through CMS (the institute's web-based course management system). Students are advised to visit CMS regularly for latest updates.

Make-up Policy: Make-up shall be given only to the genuine cases with prior confirmation.

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