

# 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:

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| **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 |

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| 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:**

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| **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