Birla Institute of Technology & Science, Pilani
Hyderabad Campus

INSTRUCTION DIVISION
SECOND SEMESTER 2023-2024
Course Handout Part II

Date: 1/1/2024

In addition to Part-I (a general handout for all the courses appended in the time table), this handout gives further specific details of the course.

Course No. : ME G515
Course Title : COMPUTATIONAL FLUID DYNAMICS
Instructor-in-Charge : JEEVAN JAIDI
Instructors : Jeevan Jaidi, Bagadi Ramana Murthy

1. Course Description:

Philosophy of computational fluid dynamics (CFD), governing equations of fluid dynamics, mathematical behavior of partial differential equations, basics of the numerics: basic aspects of discretization, grids with appropriate transformations, and simple CFD techniques, applications, numerical solutions of quasi-one-dimensional nozzle flows, numerical solution of a two-dimensional supersonic flow, incompressible couette flow, and supersonic flow over a flat plate, advanced topics in CFD.

Computational fluid dynamics (CFD) has become an essential tool in analysis and design of thermal and fluid flow systems in wide range of applications. Few prominent areas of them include meteorology (wind, hurricanes, floods, fires), environmental hazards (air pollution, transport of contaminants), heating, ventilation and air conditioning of buildings, energy systems, electronics, processes in human body (blood flow, breathing) etc. It gives an insight into flow patterns that are difficult, expensive or impossible to study using traditional (experimental) techniques.

2. Scope and Objective:

The primary objective of this course is to highlight the physics of the considered problem and then select the set of governing equations, initial conditions and boundary conditions. The course aims to provide students with a working knowledge of a variety of computational techniques that can be used for solving the engineering problems.

3. Text Book (TB) and Reference Book (RB):

(a) TB1: John D Anderson, "Computational Fluid Dynamics", Tata-McGraw Hill Publisher, 1st Edition, 1995.
(b) TB2: K Muralidhar & T Sundararajan, "Computational Fluid Flow and Heat Transfer", Narosa Book Distributors Pvt Ltd, 2nd Edition, 2009.
(c) TB3: H K Versteeg & W Malalasekara, "Introduction to Computational Fluid Dynamics: The Finite Volume Method", Pearson Education (Indian Reprint), 2nd Edition, 2007.
(d) RB1: S V Patankar, "Numerical Heat Transfer and Fluid Flow", Taylor & Francis, 1st Edition, 1980.
(e) RB2: R H Pletcher, J C Tannehill & D A Anderson, "Computational Fluid Mechanics and Heat Transfer", CRC Press, 3rd Edition, 2012.

4. Course Plan:

Lecture No.	*Learning objectives*	*Topics to be covered*	*Chapter & Sections in TB*
1 – 2	Introduction to CFD; Solution to linear algebraic equations	Direct solvers (LU decomposition, tri-diagonal algorithm); Iterative solution methods (under and over relaxation); Well-conditioned and ill-conditioned	TB2
3-6	Introduction to governing equations	Models of flow; Governing equations: Continuity equation, Momentum equation, Energy equation	TB1
7-10	Classification of partial differential equations	Parabolic, elliptic and hyperbolic equations; Well posed and ill posed problems; Initial and boundary conditions	TB1
11-13	Finite volume method	Basic rules for control volume approach; Steady and unsteady heat conduction: 1-D, Extension to 2D & 3D problems	TB3
14-16	FVM based discretization of convection and diffusion equations	1D convection diffusion, Discretization schemes and their assessment, Treatment of boundary conditions	TB3
17-20	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	TB3
21-23	Numerical solutions of ordinary differential equations	Euler explicit/implicit methods; Predictor corrector methods; Examples of initial value and boundary value problems	TB2
24-27	Grids with appropriate transformations	Transformation of equations, Metrics and Jacobians, Compressed grids, boundary fitted systems, Elliptic grid generation, Adaptive grids.	TB1
28-30	Finite difference methods	Taylor's series: Finite difference formulation, 1D & 2D steady state heat transfer problems; Boundary conditions; Unsteady state heat conduction	TB2
31-33	Finite difference methods	Errors associated with FDM; Explicit method; Stability criteria; Implicit method; Crank Nicolson method; ADI	TB2
34-36	Turbulent flows	Basics; DNS, LES and RANS models	TB3
37-39	Compressible flows	Introduction: Pressure, velocity and density coupling	TB1
40-42	Special topics & Seminars	Will be announced in the class	---

5. Evaluation Scheme:

Evaluation Component	*Duration (min.)*	*Weightage (%)*	*Date & Time*	*Nature of Component*
Midsem Test	90	25	---	Closed Book
Assignment	---	5	To be announced in class	Open Book
Lab	---	20	Continuous	Open Book
Project + Seminar	---	15	To be announced in class	Open Book
Comprehensive Exam	180	35	---	Closed Book

6. **Chamber Consultation Hour:** To be announced by the respective tutorial instructor. Students are encouraged to utilize this opportunity to clear doubts, after attending the regular lecture and tutorial classes.

7. Notices:

All notices concerning this course will be displayed in *CMS* (*institute's web-based Course Management System*). Students are advised to visit *CMS* regularly for all the updates.

8. Make-up Policy:

Make-up request for Midsem test and Comprehensive exam shall be granted only for the *genuine* cases with sufficient evidence. Request letter duly signed by the students must reach the undersigned at least one day before the scheduled exam. No make-up for tutorial tests and quizzes.

9. Academic Integrity Policy:

It is expected that in compliance with institute rules and regulations, academic integrity should be adhered to in all the evaluation components. Any type of academic dishonesty is NOT acceptable and malpractice in any form will have serious implications.

Instructor-in-Charge (ME G515)