BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI
INSTRUCTION DIVISION
FIRST SEMESTER 2016-2017
Course Handout (Part II)

Date: 02.08.2016

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 G515

Course Title : COMPUTATIONAL FLUID DYNAMICS

Instructor-in-charge: Shyam Sunder Yadav

1. **Course Description:** Philosophy of Computational Fluid Dynamics (CFD); governing equations of fluid dynamics; mathematical behaviour of partial differential equations and their impact on CFD; finite volume and finite difference discretization on nonuniform grids, stationary and non-stationary convection-diffusion equation, the incompressible Navier-Stokes equations. Iterative methods.

2. **Scope and Objective:** This course is intended to develop the skill of solving fluid flow, heat transfer, mass transfer and related phenomena numerically. This course starts with a discussion on mathematical behavior and physical meaning of governing equations of fluid dynamics. Then it covers different discretization methods. Finally, students will learn different CFD techniques and they will apply these techniques for solving simple problems.

3. **Text Book:**

   T1: J.D.Anderson, Computational Fluid Dynamics, Mcgraw Hill Inc., 1995, 6th Edition.
   T2: An introduction to computational fluid dynamics: The finite volume method H.K.Versteeg and W.Malajasekra, Longman

4. **Reference Books**:

   R1: J H Ferziger, M Peric, Computational methods for Fluid Dynamics, Springer, 2002, 3rd Edition.
   R2: Doyle D. Knight, Numerical methods for compressible flows, Cambridge University Press
   R3: Charles Hirsch, Numerical computing of internal and external flows, Vol. 1, Elsevier, second edition
   R4: Pletcher, Tannehill, Anderson, Computational fluid mechanics and heat transfer, CRC press, 3rd edition,

5. Course Plan:

Lect No.	Learning Objectives	Topics to be covered	Chapter in Text / Reference book
1-3	Philosophy of Computational Fluid Dynamics	Computational Fluid Dynamics: Why, Computational Fluid Dynamics as a Research Tool, Computational Fluid Dynamics as a Design Tool, The Impact of Computational Fluid Dynamics, Applications, Computational Fluid Dynamics	Chapt 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 to the models of the fluid flow, Finite Control Volume, Infinitesimal Fluid Element, The Substantial Derivative, The Divergence of the Velocity: Its Physical Meaning, The Continuity Equation, The Momentum Equation, The Energy Equation, Summary of the Governing Equations for Fluid Dynamics.	Chapt 2, T1 Chapt 5, R4
9-14	Mathematical Behavior of Partial Differential Equations: The Impact on CFD	Introduction, Classification of Quasi-Linear Partial Differential Equations, General Method of Determining the Classification of Partial Differential Equations: The Eigenvalue Method, General Behavior of the Different Classes of Partial Differential Equations: Impact on Physical and Computational Fluid Dynamics, Hyperbolic Equations, Parabolic Equations, Elliptic Equations, The Supersonic Blunt Body	Chapt 3, T1 Chapt. 3, R3 Chapt. 2, R4
15-20	Basic Aspects of Discretization	Introduction, Introduction to Finite Differences, Difference Equations, Explicit and Implicit Approaches: Definitions and Contrasts, Errors and an Analysis of Stability, Stability Analysis: A Broader Perspective	Chapt 4 T1 Chapt 4 R3 Chapt 7 R3
21-25	Grids with Appropriate Transformations	General Transformation of the Equations, Metrics and Jacobians, Form of the Governing Equations Particularly Suited for CFD Revisited	Chapt 5 T1
26-29	Some Simple CFD Techniques: A Beginning Introduction	The Lax-Wendroff Technique, MacCormack's Technique, Conservation Form and Space Marching, The Relaxation Technique and Its Use with Low-Speed Inviscid Flow , Aspects of Numerical Dissipation and Dispersion; Artificial Viscosity, The Alternating-Direction-Implicit (ADI) Technique, The Pressure Correction Technique: Application, Computer Graphic Techniques Used in CFD	Chapt 6 T1 Chapt 6, T2
30-33	Numerical Solutions of Quasi-One-Dimensional Nozzle Flows	Introduction to the Physical Problem: Subsonic-Supersonic Insentropic Flow, CFD Solution of Subsonic-Supersonic Isentropic Nozzle Flow: MacCormack's Technique.	Chap 7 T1
34-36	Incompressible Couette Flow: Numerical Solutions by Means of an Implicit Method and the Pressure correction Method	The Physical Problem and Its Exact Analytical Solution, The Numerical Approach: Implicit Crank-Nicholson Technique, The Pressure Correction Method	Chap 9 T1 Chap. 12, R3
37-38	Supersonic Flow over a Flat Plate: Numerical Solution by Solving the Complete Navier-Stokes Equations	Introduction, The Physical Problem, The Numerical Approach: Explicit Finite-Difference, Solution of the Two-Dimensional Complete Navier-Stokes Equations: The Governing Flow Equations, The Setup, The Finite-Difference Equations, Calculation of Step Sizes in Space and Time, Initial and Boundary Conditions	Chap 10 T1 Chapt.12, R3
39-40	Future of CFD	The Importance of CFD Revisited, Computer Graphics in CFD, The Future of CFD: Enhancing the Design Process	Chap 12 T1

6. Evaluation Schedule:

Component	Duration	Weightage(%)	Date & Time	Remarks
Mid Sem CB	1 hr 30 min	30	4/10 8:00 - 9:30 AM	
Assignment/ Project Work (1)		30	TBA	OB
Compre Exam.	3 hrs.	40	3/12 AN	CB

7. **Assignment/Project Work:** Assignment/Project work submission date will be announced in class.

8. Chamber consultation hours: Any time

9. Notices: Notices pertaining to this course will be displayed on Mechanical Engineering notice board.

* TBA: To be announced in Class
CB: Closed book
OB: Open book

Instructor-In-Charge
ME G515