BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI
INSTRUCTION DIVISION
FIRST SEMESTER 2015-2016
Course Handout (Part II)

Date: 03/08/2015

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: Dr. Ravi Inder Singh

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 nonstationary 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: Pieter Wesseling, Principles of Computational Fluid Dynamics, Spinger International Edition, @2004

4. **Reference Books**:
   R1: J H Ferziger, M Peric, Computational methods for Fluid Dynamics, Springer, 2002, 3rd Edition.
   R2: An introduction to computational fluid dynamics: The finite volume method H.K.Versteeg and W.Malajasekra, Longman

5. Course Plan:

Lect No.	Learning Objectives	Topics to be covered	Ref.Chap in Textbook
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	Particularly Suitable to CFD, Introduction Models of the Flow, Finite Control Volume, Infinitesimal Fluid Element, The Substantial Derivative, The Divergence of the Velocity: Its Physical Meaning, The Continuity Equation, The Momentum Equation, Equation, The Energy Equation, Summary of the Governing Equations for Fluid Dynamics.	Chapt 2, T1
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 Eigen value 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
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	Chap 4 T1
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	Chat 6 T1
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
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: 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
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	1 hr 30 min	30	10/10 10:00 - 11:30 AM	CB
Class Test(2)	50 min	20	12/12 AN	OB
Compre Exam.	3 hrs.	50	12/12	CB

7. **Class test:** Two **c**lass tests will be held in class one before mid sem and one after mid sem.

8. **Chamber consultation hours:** To be announced in the class.

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

* TBA To be announced in Class

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