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**FIRST SEMESTER 2019-2020**

# Course Handout Part II

Date: 01-08-2019

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.* : ***CHE G554***

## Course Title : **Computational Fluid Dynamics**

## Instructor-in-Charge : **Dr. Vikranth Kumar Surasani**

**Scope and Objective of the Course:**

Computational Fluid Dynamics (CFD) is conventionally is an analysis of fluid flow by means of numerical techniques. With the advent of computation capabilities, CFD techniques become an integrated tool in the Design and R&D of many industries. Areas of application include Aerospace, Chemical Process Engineering, Hydrology and Oceanography, Biomedical engineering, environmental hazards (air pollution, transport of contaminants), Renewable energy systems and etc.

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

**Learning Outcomes:**

1. Understanding the Mechanistic modeling of Fluid Flow.
2. Ability to write programs in MATLAB for simulating the fluid flow.
3. ANSYS CFD using FLUENT
4. Course is the basic foundation to advanced Computation Fluid Dynamics

**Textbooks:**

1. **H K Versteeg & W Malalasekara**, “Introduction to Computational Fluid Dynamics: The Finite Volume Method”, Pearson Education (Indian Reprint), 2nd Edition, 2007
2. **Steven C. Chapra and Raymond P. Canale,** “Numerical Methods for Engineers” Sixth Edition, McGraw Hill Education (India) Private Limited, New Delhi

**Reference books**

* 1. Stefan J. Capmann, “Matlab Programming for Engineers”, 4th Ed. Cengage Learning
  2. **K Muralidhar & T Sundararajan**, “Computational Fluid Flow and Heat Transfer”, Narosa Book Distributors Pvt Ltd, 2nd Edition, 2009.
  3. **S V Patankar**, “Numerical Heat Transfer and Fluid Flow”, Taylor & Francis, 1st Edition, 1980.
  4. Debashis Panda and V K Surasani, The Lattice Boltzmann Simulation and its application to drying of porous media.
  5. **John D Anderson,** “Computational Fluid Dynamics”, Tata-McGraw Hill Publisher, 1st Edition, 1995.

**Course Plan:**

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| --- | --- | --- | --- | --- |
| **Lecture** | **Learning objectives** | **Topics to be covered** | **Chapter in the Text Book** | |
| L. 1 | Introduction to Computation Fluid Dynamics | Introduction to the course; Role of CFD in Engineering Design and Analysis, Scope of the Course work. | T1: Ch. 1 |
| L. 2-3 | Conservation Laws for Fluid Motion | Mass, Momentum and Energy Conservation Equations and Boundary Conditions | T1: Ch. 2 |
| L. 4 | Classification of Partial Differential Equations(PDEs) | Parabolic, elliptic and hyperbolic equations; Well posed and ill posed problems; Initial and boundary conditions | T2:  PART VIII |
| L. 5-6 | Finite difference methods | Taylor’s series: Finite difference formulation, 1D & 2D steady state heat transfer problems; Boundary conditions; Unsteady state heat conduction | T2: Ch. 23 |
| L. 7-8 | Errors associated with FDM; Explicit method; Stability criteria; Implicit method; Crank Nicolson method; ADI |
| L. 9-10 | Finite volume method | Basic rules for control volume approach; Steady and unsteady heat conduction: 1-D, Extension to 2D & 3D problems | T1: Ch. 4 |
| L. 11-13 | FVM based discretization of convection and diffusion equations | 1D convection diffusion, Discretization schemes and their assessment, Treatment of boundary conditions | T1: Ch. 5 |
| L. 14-16 | 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: Ch. 6 |
| L. 17-20 | Turbulent flows | Basics; DNS, LES and RANS models | T1: Ch. 3 |
| Compressible flows, Pressure, velocity and density coupling |  |
| L. 21-25 | Special Topics and Solutions | Lattice Boltzmann Modeling | WorkBook. |

**Practical Plan**

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| **Lecture/Practical No.** | **Learning objectives** | **Topics to be covered** |
| P. 1 | Matlab Programming | Variable Types; Built in functions; Managing variables; Matrix operations; Plot tools; |
| P. 2 | Matlab Programming | Writing functions; Control structures; |
| P. 3 | Solution to Linear Algebraic Equations | 1D and 2D Heat conduction problems |
| P. 4 | Solution to System of ODEs | CSTR reactor problem |
| P. 8-9 | ANSYS Fluent | Creating Geometry, Design Modeler |
| P. 10-11 | ANSYS Fluent | Creating Mesh, Design Modeler |
| P. 12-17 | ANSYS Fluent | Example simulations using Fluent |
| P. 13-23 | Lattice Boltzmann Simulations | Basic LBM Algorithm |
| Simple Flow through a pipe |
| Capillary effect |
| Contact Angle Test |

**Evaluation Scheme:**

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| --- | --- | --- | --- | --- |
| **Component** | **Duration** | **Weightage (%)** | **Date & Time** | **Nature of Component** |
| Midterm | 90 min | 15 |  | CB & Require MATLAB & ANSYS |
| Comprehensive Theoretical Exam | 2hrs. | 20 | 01/10 | OB |
| Practical Tests (P) |  | 25 |  | OB & Require MATLAB |
| Comprehensive Practical Exam | 4hrs | 25 | Dates and Time  by IC | OB & Require MATLAB & ANSYS |
| Project |  | 15 |  |  |

**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.

**Chamber Consultation Hour:** Announced in the class

**Notices:** Display will be on the Chemical Engineering Group notice board and CMS.

**Make-up Policy:** Granted for genuine cases only. Certificate from authenticated doctor from the Medical Center must accompany make-up application (*only prescription or vouchers for medicines will not be sufficient*). Prior permission of IC is compulsory.

**INSTRUCTOR-IN-CHARGE**

**CHE G523**