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:

T1. **H K Versteeg & W Malalasekara**, "Introduction to Computational Fluid Dynamics: The Finite Volume Method", Pearson Education (Indian Reprint), 2nd Edition, 2007
T2. **Steven C. Chapra and Raymond P. Canale,** "Numerical Methods for Engineers" Sixth Edition, McGraw Hill Education (India) Private Limited, New Delhi

Reference books

R1. Stefan J. Capmann, "Matlab Programming for Engineers", 4th Ed. Cengage Learning
R2. **K Muralidhar & T Sundararajan**, "Computational Fluid Flow and Heat Transfer", Narosa Book Distributors Pvt Ltd, 2nd Edition, 2009.
R3. **S V Patankar**, "Numerical Heat Transfer and Fluid Flow", Taylor & Francis, 1st Edition, 1980.
R4. Debashis Panda and V K Surasani, The Lattice Boltzmann Simulation and its application to drying of porous media.
R5. **John D Anderson,** "Computational Fluid Dynamics", Tata-McGraw Hill Publisher, 1st Edition, 1995.

Course Plan:

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

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	CSTR reactor problem

	ODEs	
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:

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