Module (Course Syllabus) Catalogue

2023-2024

College/ Institute	**Erbil Technical Engineering College**	
Department	**Mechanical & Energy Engineering Dept.**	
Module Name	**Computational Fluid Dynamics (CFD)**	
Module Code	**CFD103**	
Degree	**Technical Diploma ☐ Bachler ☐ High Diploma ☐ Master ☐ PhD ■**	
Semester	**1**	
Qualification	**Ph.D.**	
Scientific Title	**Assistant Professor**	
ECTS (Credits)	**6**	
Module type	**Prerequisite ☐ Core ■ Assist. ☐**	
Weekly hours		
Weekly hours (Theory)	**(2)hr Class**	**(8)Total hrs Workload**
Weekly hours (Practical)	**(0)hr Class**	**(0)Total hrs Workload**
Number of Weeks	**15**	
Lecturer (Theory)	**Dr. Banipal N. Yaqob**	
E-Mail & Mobile NO.	**banipal.yaqob@epu.edu.iq**	
Websites	**https://academicstaff.epu.edu.iq/faculty/banipal.yaqob**	

Course Book

Course Description	The course is aimed of giving the fundamental of Computational Fluid Dynamics (CFD) for energy technologies. Computational techniques for solving Navier-Stokes and Energy equations with emphasis on turbulent heat and mass transfer are introduced. Finite Volume Method (FVM) and solution of systems of linear algebraic equations are discussed. Error control, accuracy and stability are discussed and demonstrated. Reynolds-Averaged-Navier-Stokes (RANS) equations and computation of turbulent flows are discussed and demonstrated. Explicit vs. implicit time stepping methods. The course consists of a theoretical only, where it deals with the derivations and properties of the methods and models for CFD.
Course objectives	The course gives a thorough knowledge and understanding of the finite volume method for computational fluid dynamics (CFD).
Student's obligation	1. **Class Attendance, Participation, Punctuality and Cheating:** Attendance at each class session is expected. Students are expected to be on time for class. It is the student's responsibility to familiarize himself or herself with and adhere to the standards set forth in the policies on cheating and plagiarism as defined in the Erbil Polytechnic University website or the appropriate graduate program handbook. **Cheating is absolutely unacceptable in any guise. If you are caught cheating, you will be warned once and you will receive a "0" (zero) on that assignment. The second offense will result in an "Fail" for the course.** Cheating means using the work of others as your own. Copying homework, using papers from the Internet, using solutions from the instructor's solution manual, any talking or looking around during exams and allowing others to look at your exam papers are examples of cheating. Additionally, "recycled" work is not accepted in this course. 2. **Preparation, Deadlines and Late Policy:** Late assignments will not be graded. Please do not wait until the last minute to submit your assignment. 3. **Homework:** Homework is important and represents a key component of your grade. I will not be able to accept homework or assignments emailed to me. You must show all your work (math) step by step. Simply supplying an answer or excluding logical steps will result in points being taken off your grade. Incorrect calculations with correct answers may be given a 0 for that problem. Late homework will not be graded. The following checklist is strongly recommended while presenting the solutions in the homework. ▪ Sketch of problem and discussion of the problem solving procedure.

	▪ Equation(s) stated in general form ▪ Necessary assumptions stated ▪ Substitutions or simultaneous solutions labeled ▪ Units converted properly ▪ Final answers clearly indicated 4. **Review Paper:** There will be an individual reviewing paper. A handout on requirements and report format will be provided. The paper may involve experimental design and analysis or numerical methods. 5. **Exams:** There will be two exams. The exams will include materials covered in class. The last exam will be given during finals week. It is suggested that you obtain a calculator which has trig functions. No laptops, computers, or phones with calculators will be allowed during exams (only calculators specifically). You may not share a calculator with another classmate during an exam. You must show all your work (math) step by step. Simply supplying an answer or excluding steps will result in points being taken off your grade. 6. **Phones:** As a courtesy to classmates and faculty, phones should be turned off during class.
Required Learning Materials	Undergraduate numerical analysis. Graduate-level fluid mechanics and heat transfer. Basic computer skills

Evaluation

Task		Weight (Marks)	Due Week	Relevant Learning Outcome
Paper Review		20	12	
Assignments	Homework			
	Class Activity			
	Report			
	Seminar	10	8	
	Essay			
	Project			
Quiz		05		
Lab.				
Midterm Exam		15	11	
Final Exam		50	15	
Total		100		

Specific learning outcome:

Students will be familiar with the following at the end of this class:

- Basics of computational fluid dynamics
- Governing Equations in computational fluid dynamics
- Discretization methods and numerical solutions:
  - o FDM: Finite Difference Method
  - o FEM: Finite Element method
  - o FVM: Finite Volume Method

	• General CFD simulation process • Geometry modeling • Mesh generation • Various solution methods and their suitability for different engineering applications • CFD Simulation of: o Basic fluid flows o 2D modeling o 3D Modeling o Heat transfer o Heat exchanger modeling o Turbulent modeling o Transient flows o User Defined Functions o Post Processing
Course References:	• S. V. Patankar, ***Numerical Heat Transfer and Fluid Flow***, McGraw-Hill, NY, 1980. • T. J. Chung, ***Computational Fluid Dynamics***, Cambridge University Press, UK, 2002. • H. K. Versteeg & W. Malalasekera, ***An Introduction to Computational Fluid Dynamics: the finite volume method***, Longman Group, England, 1996. • John C. Tannehill, Dale A. Anderson and Richard H. Pletcher, ***Computational Fluid Mechanics and Heat Transfer***, Taylor &Francis. • John D. Anderson Jr, ***Computational Fluid Dynamics***, McGraw Hill Book Company. • J. Blazek, ***Computational Fluid Dynamics: Principles and Applications***, Elsevier. • K.A. Hoffmann, ***Computational fluid dynamics for engineers***, Engineering Education System, Austin-Texas, 1989.

Course topics (Theory)	**Week**	**Learning Outcome**
Introduction: Definition of CFD, Application of CFD Technique, Main elements of a CFD code: 1-Pre-processor, 2-Solver, 3-Post-processor, Types of Fluids, Types of Fluid Motion, General Transport Equation of Fluid Flow, Examples.	1	
Steady State Diffusion: Introduction, 1D steady state diffusion (Cartesian Coordinates): 1-Grid generation, 2- Discretization: Diffusion Coefficient, Gradient (Flux), Source term, 3-Solution of Discretized Equations – TDMA, Solved Examples: 1D steady state diffusion: Examples 1, 2 & 3, 2D steady state diffusion (Cartesian Coordinates), 3D steady state diffusion (Cartesian Coordinates), Solved Example 4, 1D steady state diffusion (Polar Coordinates), Home Work, 1D steady state diffusion (Spherical Coordinates), Projects.	2-3	

Transient Diffusion: 1D unsteady Heat Conduction (Cartesian Coordinates): 1- Fully Explicit, 2- Crank-Nickalson, 3- Fully Implicit, Solved Example 1, Fully implicit time scheme for 2D and 3D unsteady Heat Conduction (Cartesian Coordinates), 1D Unsteady Heat Conduction (Polar Coordinates), Home Work 1, 1D Unsteady Heat Conduction (spherical Coordinates), Home Work 2, Projects.	4-5	
Steady State Convection-Diffusion: Introduction, 1D steady state convection-diffusion, the central differencing scheme, Example 1, Properties of discretization schemes: 1-Conservativeness, 2-Boundedness, 3-Transportiveness, Assessment of the central differencing scheme, the upwind differencing scheme, Example 2, Assessment of the upwind differencing scheme, the hybrid differencing scheme, Example 3, Assessment of the hybrid differencing scheme, Hybrid differencing scheme for multidimensional convection-diffusion, The power-law scheme, Higher order differencing schemes for convection-diffusion problems: 1-Quadratic upwind differencing scheme (QUICK scheme), Example 4, Assessment of the QUICK scheme, stability of the QUICK scheme, Projects.	6-8	
Transient Convection-Diffusion: Discretization of Transient Convection-Diffusion problems, Solved Example of Transient Convection-Diffusion using QUICK scheme: Examples 1, Projects.	9	
Pressure-Velocity Coupling: Introduction, SIMPLE Algorithm for Pressure-Velocity Coupling in Steady State Flow, Flow chart for Steady State SIMPLE, Example 1, SIMPLE Algorithm for Pressure-Velocity Coupling in Transient flow, Flow chart for Transient SIMPLE. Projects.	10	
Mid-Term Exam.	11	
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	12-13	
Accuracy of a Flow Simulation	14	
Final Examination	15	

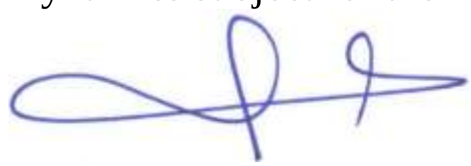
Practical Topics	**Week**	**Learning Outcome**

Questions Example Design

Extra notes:

External Evaluator

I confirm that the contents of this syllabus are sufficient and cover all the requirements of the Computational Fluid Dynamics subject for the Ph.D. level.



Prof. Dr. Ahmed Mohammed Adham

01/10/2023