Çankaya University
Faculty of Engineering Mechanical Engineering Department
ME 654 COMPUTATIONAL FLUID DYNAMICS

Instructor: Prof. Dr. Haşmet TÜRKOĞLU

Course content: Advantages and disadvantages of numerical methods. Classification of fluid flow phenomena. Fundamental flow equations. Basic steps of numerical solutions. Discretization methods. Solution of linear algebraic equation systems. Solution of convection-diffusion problems using control volume formulation. Computational methods for incompressible Navier-Stokes equations: Primitive and vorticity-based methods, SIMPLE, SIMPLER, SIMPLEC and PISO algorithms. Application of finite difference method to boundary layer type flows. Finite element method and its application to flow problems.

Textbook:
S. V. Patankar, 1980, Numerical Heat Transfer and Fluid Flow, Hemisphere Publishing Corporation.
Reference Books:
1) H. K. Versteeg and W. Malalasekera, 1995, An Introduction to Computational Fluid Dynamics, Prentice Hall.
2) D. A. Anderson, J. C. Tannehill, Richard H. Plecther, 1984, Computational Fluid Mechanics and Heat Transfer.

Course Objective: To introduce the basic features and importance of numerical methods used for the flow analysis. Implement these methods for simulation of simple flow problems.

Course Outcomes: At the end of the course, students will be able to know basic steps of the numerical solution procedures, able to set up the governing equations, discretize the basic equations and boundary conditions, able to solve algebraic equation sets, able to choose and apply proper numerical methods for flow problems.

COURSE PLAN

Week	Topics
1	**INTRODUCTION**: Basic Definitions, Methods for the Analysis of Flows, Classification of Flows, Basic Laws and Basic Equations.
2	**INTRODUCTION**: Equation of Conservation of Mass, Momentum (Navier-Stokes Equation) and Energy.
3	**DISCRITIZATION METHODS**: Finite Difference, Control Volume, Finite Element Methods.
4	**SOLUTION METHODS FOR LINEAR SET OF ALGEBRAIC EQUATIONS**: Direct methods: Gauss Elimination Method, Gauss-Jordan Elimination Method (TDMA). Iterative Methods: Point by Point Solution, Gauss-Seidel Method, Jacobi Method; Block Method.
5	**HEAT CONDUCTION**: Solution of One-Dimensional Steady Heat Equation Using Control Volume Method, Explicit Formulation, Crank-Nicolson Formulation, Fully Implicit Formulation.
6	**UNSTEADY HEAT CONDUCTION**: Explicit Formulation, Crank-Nicolson Formulation, Fully Implicit Formulation.
7	**HEAT CONDUCTION**: Solution of Two- and Three-Dimensional Heat Conduction Equations.
8	**HEAT CONDUCTION**: Solution of Algebraic Equations, Overrelaxation and Underrelaxation.
9	**CONVECTION AND DIFFUSION**: Steady One-Dimensional Convection and Diffusion, A Preliminary Derivation, Exact Solution, Exponential, Upwind, Hybrid, and Power-Law Formulations.
10	**CONVECTION AND DIFFUSION**: General Formulation and Comparison of Different Methods.
11	**CONVECTION AND DIFFUSION:** Two- and Three-Dimensional Convection Diffusion Equations.
12	**SOLUTION OF TWO- AND THREE-DIMENSIONAL NAVIER-STOKES EQUATIONS**: Primitive Variables Method: SIMPLE algorithm.
13	**SOLUTION OF TWO- AND THREE-DIMENSIONAL NAVIER-STOKES EQUATIONS**: Primitive Variables Method: SIMPLER algorithm.
14	**SOLUTION OF TWO- AND THREE-DIMENSIONAL NAVIER-STOKES EQUATIONS**: Vorticity Based Methods.

Assessment Criteria:

Midterm Exam: 25% (1 exams)
Term Project: 15%
Homework: 20%
Final Exam: 40%

NOTES:

1. Class notes will be uploaded on the course webonline page. Every student should print the class notes and have it ready during the lectures.
2. Regulations about the exams will be announced before the exams.