ME 448/548 Applied Computational Fluid Dynamics Winter 2008

Mechanical and Materials Engineering Department
Portland State University

Description

Applied Computational Fluid Dynamics (CFD) is a core course in the graduate Thermal and Fluid Sciences Curriculum. It provides an introduction to the use of commercial CFD codes to analyze flow and heat transfer in problems of practical engineering interest. The course begins with a study of simple finite-difference and finite volume models of one-dimensional partial differential equations. These equations contain important features of more complex CFD models. The SIMPLE model for solution to incompressible flow problems is described.

The bulk of the course involves using a commercial CFD code. Models of simple pipe geometries are developed and studied with the aim of developing intuition of basic flow features. The simple models also are used to demonstrate proper application of boundary conditions, and the use of post-processing for flow field visualization.

A brief overview of turbulence and turbulence modeling is given. Students then use the standard k–ε model to simulate turbulent flow fields. Following that, the modeling of convective heat transfer is introduced.

At the end of the course students will understand the process of developing a geometrical model of the flow, applying appropriate boundary conditions, specifying solution parameters, and visualizing the results. They will also have an appreciation for the factors limiting the accuracy of CFD solutions.

Time and Place

Mondays and Wednesdays, 2:00 PM – 3:50 PM, Lectures in EB Room 510, StarCCM+ demonstrations in EB 420

Instructor

Gerald Recktenwald, Associate Professor & Chair, Mechanical and Materials Engineering Department
Engineering Building, Room 402K, 725-4290, `gerry@me.pdx.edu`
Web sites for the course:

`http://www.me.pdx.edu/~gerry/class/ME448`
`http://www.samla.pdx.edu/`

Reading Material

Required Textbook	Jiyuan Tu, Guan Heng Yeoh, and Chaoqun Liu, *Computational Methods for Fluid Dynamics: a Practical Approach*, 2008, Butterworth-Heinemann, Burlington, MA, ISBN 978-0-7506-8563-4
Lecture Notes	Copies of lecture notes will be made available. On-line documentation for Star-CD will be used. Supplemental references are listed on the last page.

Learning Objectives

The Learning Objectives are what I expect that you will be able to do at the end of Quarter. If you can do each of the following activities very well, then you will get an "A" grade.

- Be able to derive the BTCS and FTCS formulation for the one-dimensional heat equation, and perform meaningful computational experiments with sample codes that implement these methods.
- Be able to interpret exact and numerical solutions to the one-dimensional convection-diffusion equation. Be able to explain the relative merits of numerical solutions to this equation obtained with the upwind difference scheme and the central difference scheme.
- Starting with a rough sketch of a flow problem, identify all physical data necessary to set up and the solve the velocity, pressure, and temperature fields using a CFD package.
- Use Star-CD to solve three-dimensional laminar, and turbulent flow problems.
- Identify whether and when a run of Star-CD has converged.
- Describe the key features of a three-dimensional flow field represented by a vector plot of the velocities, and a contour plot of the pressure field.
- Describe the qualitative differences between a physical flow that is turbulent, and the flow field predicted by a numerical solution to the Reynolds Averaged Navier-Stokes equations.

Evaluation

Learning of the course material will be evaluated by grading of homework, exams, and an independent project. The midterm will have an in-class component and a take-home component. The final exam will be comprehensive. Both exams are mandatory. Discuss any potential conflicts *well before the exam dates*. Make-up exams will not be given.

The independent project, and each homework assignment and exam will be given a numerical grade that is combined to form a cumulative score. The cumulative score is based on the following weights

35%	Homework
20%	Midterm
25%	Project
20%	Final Exam

Project

One quarter of the course grade will be based on a project, which involves a detailed simulation of a particular flow problem. You may chose from a list of projects that have already been identified, or, with instructor approval, you may create your own project. Each student will submit a report and give a brief presentation on their project to the entire class.

Supplemental References

The following textbooks are useful references for CFD.

Anderson, Dale A., Tannehill, John C., and Pletcher, Richard H. *Computational Fluid Mechanics and Heat Transfer*, 1984, Hemisphere, Washington D.C.

Date, A.N., *Introduction to Computational Fluid Dynamics*, 2005, Cambridge University Press, New York.

Ferziger, Joel H. and Perić, Milovan, *Computational Methods for Fluid Dynamics*, third ed., 2001, Springer-Verlag, Berlin.

Lomax, H., Pulliam T.H. and Zingg, D.W., *Fundamentals of Computational Fluid Dynamics*, 2001, Springer-Verlag, New York.

Patankar, Suhas V., *Numerical Heat Transfer and Fluid Flow*, 1980, Hemisphere, Washington D.C.

The following textbooks provide useful background for the study of fluid mechanics.

Acheson, D.J., *Elementary Fluid Dynamics*, 1990, Clarendon Press, Oxford.

Panton, R.L., *Incompressible Flow*, third edition, 2005, Wiley, New York.

Schey, H.M., *Div, Grad, Curl, and All That*, 1973, Norton, New York.

Tritton, D.J., *Physical Fluid Dynamics*, second edition, 1988, Clarendon Press, Oxford.