UNIVERSITY OF IDAHO
Department of Mechanical Engineering

ME 450/550: Computational Fluid Dynamics
Spring 2018

Course Instructor

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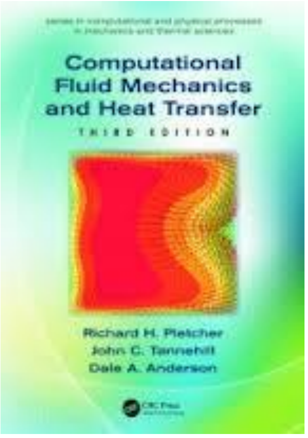
Course Textbook



Richard H. Pletcher, John C. Tannehill, Dale Anderson, Computational Fluid Mechanics and Heat Transfer, 3rd Edition, CRC Press, 2013.

In addition to the course textbook, additional handouts will be made available on the course BlackBoard website.

Course Schedule:

Lecture: 1:30 – 2:20pm MWF at JEB 025
CFD Lab: 1:30 – 2:20pm MWF at JEB 331
Office Hours: 2:30 – 3:30pm MWF or by appointment

Course Description

The growth of computing power in the past decades has led to a dramatic increase of computational fluid dynamics (CFD) utilization within research, teaching, and industry. CFD is an inherently interdisciplinary branch of science with an extremely broad spectrum of applications, such as aerospace, automobile, biomedical devices, chemical processing, renewable energy, hydraulics, marine, nanofluidics, and sports, etc. The objective of this course is to teach the student fundamental governing equations of fluid flow, basic computational methodology and procedures, and how to use CFD to learn flow physics and design aspects of fluid engineering.

The first section of the course reviews governing equations of fluid flow; basic numerical methods for solution of the governing equations; estimation of accuracy and stability of different discretization schemes; verification and validation; boundary and initial conditions; grid generation; fundamentals of turbulence modeling, and CFD post-processing. The second section of the course focuses on applications of CFD to fluid engineering systems. Students will become familiar with the commercial CFD software ANSYS FLUENT through the hands-on CFD Labs that cover both laminar and turbulent viscous pipe flows and external laminar/turbulent flows over a 2D airfoil and a circular cylinder. ME 550 students will be also required to use CFD OpenFoam to complete those labs. In the final project, ME 550 students will develop their own CFD code for a two-dimensional problem (driven cavity) and compare the results with those obtained using FLUENT including quantitative verification and validation.

Prereq.: Engr 335 (Engineering Fluid Mechanics), and **Math 330** (Linear Algebra).

Course Learning Objectives

Students will:

- understand the applications of fundamental and advanced principles of fluid mechanics.
- be familiar with mathematical models for various CFD applications such as Navier-Stokes equations and turbulence models.
- be familiar with the common numerical methods and understand how to estimate the numerical errors (verification), modeling errors (validation), and uncertainties for CFD
- be able to use the commercial CFD software ANSYS FLUENT to set up, solve, and analyze classical internal and external flow problems. ME 550 students will also be able to use CFD OpenFoam to set up, solve, and analyze those problems.
- be able to develop CFD programming skills to solve two-dimensional steady state problems (ME 550 students only).

Course Web Site

All course-related material will be distributed on the course BlackBoard website. If you are a registered student in the class, you will automatically receive an invitation to the class website. Check it frequently. Download any items of interest that you find there!

Reading and Homework Assignments

Reading and homework assignments will be posted on the course website. Homework assignments are due at the beginning of the class period posted on the course website. Homework not submitted by the due time is considered late and will receive a grade of zero.

Software

- <u>Commercial CFD software.</u> All students will use ANSYS Academic Teaching CFD for all the CFD Labs, including **Workbench** for grid generation and **FLUENT** for fluid dynamics simulations. <u>ANSYS Academic Student Version</u> is free and you may need it to complete all the CFD Labs when you don't have access to computers on campus. Instructions on how to download and install ANSYS Academic Student License has been posted on course website. For students on Moscow campus, the software has also been installed on computers in the Mechanical Engineering labs and JEB 331 (up to 50 seats can be checked out at any time).

- <u>CFD OpenFoam.</u> ME 550 students will learn how to use CFD OpenFoam mainly through self-study. Instructions will also be provided.

- <u>Software to develop your own CFD code (graduate students ONLY).</u> All graduate students are required to develop their own CFD code for the final project (Driven Cavity). They can use any computer programs/languages that they are familiar with, such as FORTRAN, C, C++, EES, MATHEMATICS, and MATLAB. Please note you may need a separate software to post-process your results, including XY plots (residuals versus iteration number, velocity profile, center of vortices versus grid resolution) and 2D plot (velocity vectors, contours of pressure & velocity, streamlines).

Course Grading

Your total course percentage will be made up of the following,

Homework	20%
CFD Lab 1	15%
CFD Lab 2	15%
CFD Lab 3	15%
CFD Lab 4	15%
Final Project	20%

Course grades will be assigned on the following scale: 90-100% = A, 80-89% = B, 70-79% = C, 60-69% = D, <60% = F. The instructor reserves the right to adjust the scale according to overall class performance.

Academic Honesty

As a student enrolled at the University of Idaho, you are bound by the UI Student Code of Conduct. Article II, Section 1 of this code addresses academic honesty. This code states …

> *Cheating on classroom or outside assignments, examinations, or tests is a violation of this code. Plagiarism, falsification of academic records, and the acquisition or use of test materials without faculty authorization are considered forms of academic dishonesty and, as such, are violations of this code. Because academic honesty and integrity are core values at a university, the faculty finds that even one incident of academic dishonesty seriously and critically endangers the essential operation of the university and may merit expulsion.*

Violation of this code will not be tolerated in this course and will be reported immediately to the Office of the Dean of Students for review.

Professionalism

You are training yourself, through formal education, for a career in engineering or a related field. Professional integrity is expected in the workplace, and it is also expected in the classroom. This includes, but is not limited to,

- On-time class attendance. In your professional career, you will no-doubt be involved in many things requiring your on-time attendance (meetings, conferences, etc.). Entering a meeting, presentation, or a class lecture late is a distraction for everyone. It can completely derail the proceedings. Distractions like this can cause those who are trying to focus to lose their concentration.
- Attention during class. It is my sincere hope that you never will have to deal with people talking, whispering, laughing, eating, internet-surfing, or doing other distracting things while you are giving a presentation. For the presenter, this is not a pleasant experience at all. It causes one to lose his/her train of thought very quickly. Activity that distracts the presenter also distracts those in the room who *want* to hear the material in more ways than one. Causing a presenter to stumble because of distractions degrades the quality of the presentation. Distracting activity directly affects those around you who are interested in the subject material and *want* to hear the presentation.

Respecting the individual presenting the information and respecting your peers that surround you in the room by refraining from distracting activity is truly professional in every sense of the word.

- Cell phones. This falls under the previous category, but it warrants a separate bullet. Hearing a cell phone ring during a presentation is a huge distraction for everyone. Sending and receiving text messages or surfing the internet is distracting you from the material being presented. I respectfully request that you **turn your cell phone off** during the class period.
- Courtesy and respect. These represent the pinnacle of professional integrity. Exhibiting courtesy and respect to others is absolutely essential for effective communication.

Class Schedule is in the next page!!

Tentative Schedule

Lec	Date	Day	Topic	Reading
	8-Jan	M		
1	10-Jan	W	Introduction to CFD I	1.1-1.3
2	12-Jan	F	Introduction to CFD II	1.1-1.3
	15-Jan	M	MARTIN LUTHER KING DAY - UI CLOSED	
3	17-Jan	W	Modeling for CFD	Lecture notes
4	19-Jan	F	Governing Equations (continuity, momentum, energy)	5.1
5	22-Jan	M	Exact Solution for Navier-Stokes Equations and laminar pipe	lecture notes
6	24-Jan	W	Turbulent Pipe Flow	lecture notes
7	26-Jan	F	Flow past Immersed Bodies I	lecture notes
8	29-Jan	M	Flow past Immersed Bodies II	lecture notes
9	31-Jan	W	Turbulence Modeling in CFD I	5.4; lecture notes
10	2-Feb	F	Turbulence Modeling in CFD II	5.4; lecture notes
11	5-Feb	M	Mathematical Behavior of PDE	2.1-2.6
12	7-Feb	W	Impact of PDE on CFD	2.1-2.6
13	9-Feb	F	Basics of Numerics I	3.1-3.7; 4.1-4.3
14	12-Feb	M	Basics of Numerics II	3.1-3.7; 4.1-4.3
15	14-Feb	W	Basics of Numerics III	3.1-3.7; 4.1-4.3
16	16-Feb	F	Basics of Numerics IV	3.1-3.7; 4.1-4.3
	19-Feb	M	PRESIDENTS' DAY - UI CLOSED	
17	21-Feb	W	Verification & Validation I	Lecture notes
18	23-Feb	F	Verification & Validation II	Lecture notes
19	26-Feb	M	Verification & Validation III	Lecture notes
20	28-Feb	W	Introduction to CFD Labs and Final Project	lecture notes
21	2-Mar	F	Introduction to CFD OpenFoam	Lecture notes
	5-Mar	M	CFD Lab 1 (Laminar pipe Flow)	Lecture/Lab Notes
	7-Mar	W	CFD Lab 1 (Laminar pipe Flow)	Lab notes
	9-Mar	F	CFD Lab 1 (Laminar pipe Flow); **Final project assigned**	Lab notes
	12-Mar	M	Spring recess	
	14-Mar	W	Spring recess	
	16-Mar	F	Spring recess	
	19-Mar	M	CFD Lab 2 (Turbulent Pipe Flow)	Lab notes
	21-Mar	W	CFD Lab 2 (Turbulent Pipe Flow)	Lab notes
	23-Mar	F	CFD Lab 2 (Turbulent Pipe Flow)	Lab notes
22	26-Mar	M	Grids with Appropriate Transformations (Lab 2 report due)	Lecture notes
23	28-Mar	W	Grid Generation	10.1-10.7
24	30-Mar	F	Boundary Conditions	6.7; lecture notes
25	2-Apr	M	Some CFD Techniques	Lecture notes
26	4-Apr	W	Numerical Dissipation and Dispersion	Lecture notes
27	6-Apr	F	ADI Technique and the Needs for Pressure Correction Method	4.2
28	9-Apr	M	The Pressure Correction Method	9.3.2
29	11-Apr	W	Post-processing for CFD and Introduction to Tecplot 360	Lecture notes
30	13-Apr	F	Recent Development and Future of CFD	Lecture notes
	16-Apr	M	CFD Lab 3 (2D Clark-Y airfoil)	Lab notes
	18-Apr	W	CFD Lab 3 (2D Clark-Y airfoil)	Lab notes
	20-Apr	F	CFD Lab 3 (2D Clark-Y airfoil)	Lab notes
	23-Apr	M	CFD Lab 4 (2D circular Cylinder); due date for Lab 3 report	Lab notes
	25-Apr	W	CFD Lab 4 (2D circular Cylinder)	Lab notes
	27-Apr	F	CFD Lab 4 (2D circular Cylinder)	Lab notes
	30-Apr	M	CFD Final Project (Driven Cavity); due date for Lab 4 report	Lab notes
	2-May	W	CFD Final Project	Lab notes
	4-May	F	CFD Final Project	Lab notes
	10-May	TH	**FINAL Project Report due by 2:30pm**	