

Modeling of Air and Pollutant Flows in Buildings

ARE 383, ARE 372, CE 397 Fall 2009

The University of Texas at Austin

Department of Civil, Architectural, and Environmental Engineering

Course Numbers and credits: ARE 383(15380), ARE 372(15335), CE 397(15990) 3 credits

Course Website: <http://www.ce.utexas.edu/prof/Novoselac/classes/ARE372>

Classroom and Time: CPE 2.206, Tuesday and Thursday 2:00 PM -3:30 PM

Prerequisites: Graduate standing students. A limited number of advanced undergraduate students will be admitted; they need to have taken the Building Environmental Systems (ARE 346N) and Elementary Mechanics of Fluids (CE 319F) courses and permission of instructor.

Professor: Dr. Atila Novoselac

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<http://www.ce.utexas.edu/prof/Novoselac>

Office Hours: Tuesday and Thursday, 12:30 PM - 1:30 PM or by appointment. I have an open door policy – if my office door is open, I will see students without an appointment. If I am busy, we will schedule a convenient time for both of us.

Course Catalog Description: Fundamentals of indoor airflow modeling, use of Computational Fluid Dynamics (CFD) for air quality and thermal comfort analyses, application of CFD for analysis of air velocity, temperature, humidity, and contaminant distributions with different ventilation systems.

Course Objectives:

- 1) Recognize the physics behind various numerical tools used for solving airflow problems.
- 2) Employ basic numerical methods for solving Navier-Stokes Equations.
- 3) Apply CFD for airflow simulations in buildings and use this tool in various design and/or research problems.
- 4) Evaluate thermal comfort and indoor air quality (IAQ) with different ventilation systems.
- 5) Assess human exposure to different pollutant types.
- 6) Critically analyze and evaluate CFD simulation results.

Textbook:

Versteeg, H.K. and Malalasekera, W. 1996. *An Introduction to Computational Fluid Dynamics*, Prentice Hall, ISBN: 0582218845

References: (optional – on 2 hour reserve at Engineering Library)

Anderson 1995. *Computational Fluid Dynamics –The Basics With Applications*, McGraw-Hill
Malkawi, Ali, and Godfried Augenbroe, eds., 2003, *Advanced Building Simulation*, New York, Spon Press, eBook ISBN 0203073673.
Wilcox, D.C. 1998. *Turbulence Modeling for CFD*, DCW Industries, Inc.

Topics:

1. Course Introduction and Background	1 wk
2. Fundamentals of fluid dynamics	2 wks
3. Turbulence and turbulence models	1 wk
4. Numerical methods and parameters	2 wks
5. CFD simulation programs	1 wk
6. Introduction to Fluent-Airpak software	1 wk
7. Application of CFD for building airflows	2 wks
8. Simulation of IAQ parameters	1 wk
9. Simulation of thermal comfort parameters	1 wk
10. Air and pollutant flows in the vicinity of occupants	1 wk
11. Accuracy and validation of building airflow simulations	<u>1 wk</u>

Total 14 wks

<u>Grading:</u>	Midterm Test	25%
	Classroom Participation	5%
	Homework Assignments	30%
	Midterm Project	10%
	Final Project & Presentation	<u>30%</u>
		100%

Course Letter Grades: (Numerical Grades for graduate and **undergraduate** students)

90-93; 94-100	A-, A
80-83; 84-86; 87-89	B-, B, B+
70-73; 74-76; 77-79	C-, C, C+
60-63; 64-66; 67-69	D-, D, D+
< 60	F

Personal Problems:

If you have illness or personal problems that will affect your performance during the course of the semester, please let me know as soon as possible. “After the fact” provides little protection unless there are extreme circumstances. I have an answering machine and an e-mail address if you need to get in touch with me after hours. Do not hesitate to use them.

Academic Honesty:

Students who violate University rules on scholastic dishonesty are subject to disciplinary penalties, including the possibility of failure in the course and/or dismissal from the University. Since such dishonesty harms the individual, all students, and the integrity of the University,

policies on scholastic dishonesty will be strictly enforced. For further information, visit the Student Judicial Services web site <http://www.utexas.edu/depts/dos/sjs/>.

Privacy – Web Based Class Sites:

Web-based, password-protected class sites may be associated with all academic courses taught at the University. Syllabi, handouts, assignments and other resources are types of information that may be available within these sites. Site activities could include exchanging email, engaging in class discussions and chats, and exchanging files. In addition, electronic class rosters will be a component of the sites. Students who do not want their names included in these electronic class rosters must restrict their directory information in the Office of the Registrar, Main Building, Room 1. For information on restricting directory information, see: <http://www.utexas.edu/student/registrar/catalogs/gi00-01/app/appc09.html> .

Students with Disabilities:

The University of Texas at Austin provides, upon request, appropriate academic adjustments for qualified students with disabilities. Any student with a documented disability (physical or cognitive) who requires academic accommodations should contact the Services for Students with Disabilities area of the Office of the Dean of Students at 471-6259 as soon as possible to request an official letter outlining authorized accommodations. For more information, contact that Office, or TTY at 471-4641, or the College of Engineering Director of Students with Disabilities at 471-4321.

Dropping the Course:

Undergraduate Students: From the 1st through the 12th class day, an undergraduate student can drop a course via the web and receive a refund. From the 13th through the 20th class day, an automatic Q is assigned, no refund; approval from the Dean and departmental advisor is required. From the 21st class day through the mid-semester deadline, approval is required from the Dean, instructor of the course and departmental advisor.

Graduate Students: From the 1st through the 4th class day, graduate students can drop a course via the web and receive a refund. During the 5th through 12th class day, graduate students must initiate drops in the department that offers the course and receive a refund. After the 12th class day, no refund is given. No class can be added after the 12th class day. From the 13th through the 20th class day, an automatic Q is assigned with approval from the graduate advisor and the Graduate Dean. From the 21st class day through the last class day, graduate students can drop a class with permission from the instructor, graduate advisor, and the Graduate Dean.

Course Evaluations:

Each student will be given the opportunity to evaluate the course using the standard course/instructor evaluation form at the end of semester.

Computer Usage:

Basic knowledge of any programming language (Fortran, C, Matlab, Matcad, etc.) is beneficial. Some homework assignments and the term projects will require extensive use of computers. The students will use the energy simulation software Fluent-Airpak for projects and homework assignments.

Projects:

There will be two projects assigned. The midterm projects will account for 10% and final for 30% of your final grade. The final project will include student project presentations during the final week of classes. Exact time and place for the project presentations will be determined later in the semester.

Important Dates:

Test: October 27

Midterm Project Due: November 3

Final Project Due: December 1

TENTATIVE COURSE SCHEDULE

Date	Topics	Due date for
08/27	Course introduction and terminology	
09/01	Fluid dynamics review	HW0
09/03	Conservation Equations	
09/08	Turbulence	
09/10	Reynolds-averaged Navier-Stokes equations	
09/15	No class: Healthy Building Conference	
09/17	Turbulence models	HW1
09/22	k-ε turbulence models	
09/24	Finite volume method	
09/29	Domain discretization	
10/01	No class: Trip to Washington DC	HW2
10/06	Boundary conditions	
10/08	Introduction to CFD software - Airpak (FLUENT)	
10/13	Advanced Discretization Methods and Numerical Schemes	
10/15	System of equations - SIMPLE Algorithm	HW3
10/20	Differencing Scheme, Relaxation, Convergence	
10/22	Review & Midterm project assignment	
10/27	Wall functions and Diffuser modeling	Test
10/29	Modeling of diffusers and surface boundary conditions	
11/03	Simulation of thermal comfort parameters	Midterm Project
11/05	Final project assignment	
11/10	Simulation of indoor air quality (IAQ) parameters	
11/13	Analysis of natural ventilation using CFD	
11/17	Unsteady-state flow	FP prelim. Res.
11/19	Modeling of particle transport using CFD	
11/24	Evaluation of CFD results	
12/01	Use of CFD simulations in various engineering and research problems	Final Project
12/03	Course review	