

THE UNIVERSITY OF COLORADO BOULDER

**ASEN 5037 / MCEN 7221: Turbulent Flows / Turbulence
Spring 2018**

SYLLABUS

Instructor: Assistant Professor John Evans
Office: ECAE 159
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Office Hours: Tuesday/Thursday, 12:30 pm – 2:00 pm

Time: Tuesday/Thursday, 11:00 am – 12:15 pm

Location: ECCR 131

Web Page: Desire2Learn (learn.colorado.edu)

Course Objective:

To establish a fundamental understanding of the mathematics and physics of turbulent flows and to introduce the concepts and analytical tools needed in developing turbulence models and turbulence simulation methods.

Prerequisites:

This class requires a graduate course in fluid mechanics such as ASEN 5051 / MCEN 5021. Topics covered should include kinematics of fluid flows, conservation laws, vorticity dynamics, theory and application of irrotational flows, dynamic similarity, viscous flows, and boundary layers. A working knowledge of vector calculus, Cartesian tensors, and Fourier transforms is also required.

Required Textbook:

Turbulent Flows, Pope, Cambridge University Press, 2000.

Reference and Supplemental Textbooks:

Statistical Theory and Modeling for Turbulent Flows, Durbin and Pettersson Reif, Wiley, Third Edition, 2001.

Turbulence: An Introduction for Scientists and Engineers, Davidson, Oxford Press, Second Edition, 2015.

A First Course in Turbulence, Tennekes and Lumley, MIT Press, 1972.

Turbulence: The Legacy of A.N. Kolmogorov, Frisch, Cambridge Press, 1995.

Topics:

1. Turbulence Theory

- a. Statistical Description of Turbulence
- b. Mean Flow Equations
- c. Free Shear Flows
- d. Wall-Bounded Flows
- e. The Scales of Turbulent Motion

2. Turbulence Modeling and Simulation

- a. Direct Numerical Simulation (DNS)
- b. Reynolds Averaged Navier-Stokes (RANS) Models
 - i. Turbulent Viscosity Models
 - ii. Reynolds Stress Transport Models
- c. Large Eddy Simulation (LES)

Class Format:

The class meets twice a week for an hour and fifteen minutes of formal lecture and discussion.

Grading:

40% Homework Assignments
20% Midterm Exam
15% Literature Review Project
25% CFD Project

Grades will be posted to the class website on Desire2Learn.

Reading Assignments:

Reading assignments are assigned frequently through the course website and are to be completed before lecture. The lecture should help to clarify and supplement what students have read. If a student has any questions on the reading material, he or she should contact the instructor by e-mail who will address the question during lecture.

Homework Policy:

There will be six homework assignments throughout the semester, and students will have approximately two weeks to complete each assignment, with the exception of the final assignment. Students should make an effort to turn in assignments that are organized, professional looking, and legible. Students must staple their work (no paperclips or dog-ears). Very messy work will be returned to a student ungraded and a score of zero will be recorded. Final answers should be indicated with an arrow, underline, or box. Multiple answers (when only one is required) will be counted as incorrect.

Homework is due at the start of class on the due date. Late assignments will not be accepted, though there will be a five-minute grace period. If a student will be unable to attend class, he or she may submit his or her homework early by slipping it under the instructor's door.

Collaboration is permitted on homework. This means students may discuss the means and methods for solving problems and even compare answers, but students are not free to copy someone's assignment. The work that a student turns in must be his or her own – copying is not allowed for any assignment and will not be tolerated. Students who are caught copying (or providing his or her assignment to another) will receive an "F" for the course and reported to the Dean's office for further punitive action.

Examination Policy:

The midterm examination will cover all "Turbulence Theory" material in the course including lecture, discussions, and homework. The midterm examination will be take-home and open-book.

Collaboration on the midterm examination will not be tolerated. Students who are caught in these activities will receive an "F" for the course and reported to the Dean's office for further punitive action. Students are free to ask the instructor any clarification questions.

Literature Review Project:

A literature review project will be assigned during the fourth week of the semester. For this project, students will review a highly-cited journal article on either turbulence theory or turbulence modeling and simulation. The deliverable of the project will consist of a review paper which summarizes the main results of the article, reflects on the impact of the article, and identifies what new questions the article raises.

CFD Project:

A CFD project will be assigned before the spring break. For this project, students will explore the utility and effectiveness of turbulence modeling and simulation using either commercial or open-source CFD software. The deliverables of the project will consist of both a paper and an in-class presentation. A list of possible topics will be given out, but students may also elect to propose their own topic.

Accommodation for Disabilities:

If you qualify for accommodations because of a disability, please submit your accommodation letter from Disability Services to your faculty member in a timely manner so that your needs can be addressed. Disability Services determines accommodations based on documented disabilities in the academic environment. Information on requesting accommodations is located on the [Disability Services website \(www.colorado.edu/disabilityservices/students\)](http://www.colorado.edu/disabilityservices/students). Contact Disability Services at 303-492-8671 or dsinfo@colorado.edu for further assistance. If you have a temporary medical condition or injury, see [Temporary Medical Conditions](#) under the Students tab on the Disability Services website and discuss your needs with your professor.

Religious Holidays:

Campus policy regarding religious observances requires that faculty make every effort to deal reasonably and fairly with all students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. In this class, you must let the instructors know of any such conflicts within the first two weeks of the semester so that we can work with you to make arrangements. See [campus policy regarding religious observances](#) for full details.

Classroom and On-Campus Behavior:

Students and faculty each have responsibility for maintaining an appropriate learning environment, not only while in class, but *also while working outside of class such as in labs and study areas*. Those who fail to adhere to such behavioral standards may be subject to discipline. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with differences of race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, veteran status, political affiliation, or political philosophy. Class rosters are provided to the instructor with the student's legal name. We will gladly honor your request to address you by an alternate name or gender pronoun. Please advise us of this preference early in the semester so that we may make appropriate changes to our records. For more information, see the [policies on classroom behavior](#) and [the student code](#).

Discrimination and Harassment:

The University of Colorado Boulder (CU Boulder) is committed to maintaining a positive learning, working, and living environment. CU Boulder will not tolerate, both in-class and outside of class, acts of sexual misconduct, discrimination, harassment, or related retaliation against or by any employee or student. CU's Sexual Misconduct Policy prohibits sexual assault, sexual exploitation, sexual harassment, intimate partner abuse (dating or domestic violence), stalking, or related retaliation. CU Boulder's Discrimination and Harassment Policy prohibits discrimination, harassment, or related retaliation based on race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, veteran status, political affiliation, or political philosophy. Individuals who believe they have been subject to misconduct under either policy should contact the Office of Institutional Equity and Compliance (OIEC) at 303-492-2127. Information about the OIEC, the above referenced policies, and the campus resources available to assist individuals regarding sexual misconduct, discrimination, harassment, or related retaliation can be found at the [OIEC website](#).

Honor Code:

All students enrolled in a University of Colorado Boulder course are responsible for knowing and adhering to [the academic integrity policy](#). Violations of the policy may include: plagiarism, cheating, fabrication, lying, bribery, threat, unauthorized access to academic materials, clicker fraud, resubmission, and aiding academic dishonesty. All incidents of academic misconduct will be reported to the Honor Code Council (honor@colorado.edu; 303-735-2273). Students who are found responsible of violating the academic integrity policy will be subject to nonacademic sanctions from the Honor Code Council as well as academic sanctions from the faculty member. Additional information regarding the academic integrity policy can be found at <http://honorcode.colorado.edu>.

Prepared by: John Evans

Date: December 27, 2017