

ASEN 5519
Boundary Layers and Convection
Spring 2020

Lectures: Monday/Wednesday 11:30-12:45 AERO N240
Final Exam: Sunday May 3 at 7:30 pm.

Purpose: The Navier-Stokes equations and the boundary layer approximation. Exact solutions and integral methods of incompressible and compressible boundary layers. Convective heat transfer in laminar and turbulent flow. Analytical and computational approaches pursued.

Instructor: Professor Kenneth Jansen Office: AERO 363 Phone: 303-492-4359 jansenke@colorado.edu Office hours: Monday 12:45:2:00		

Text:

Required Textbook:

1) Viscous Fluid Flow, (2nd or 3rd edition), Frank M. White, McGraw-Hill.

Recommended Books:

1) Boundary Layer Analysis, Second Edition, Joseph A. Schetz and Rodney D. Bowersox, AIAA Education Series, ISBN: 978-1600868238.

2) Boundary Layer Theory, 8th Revised and Enlarged Edition, H. Schlichting and K. Gersten, Springer, ISBN: 978-3540662709.

Class Web Site and email List: <http://fluid.colorado.edu/~kjansen/BLandC2020/>. All relevant documents, lab assignments, schedules, supplemental documents will be either emailed to the class list or posted to this site throughout the semester. Please check back to see what has been posted.

Prerequisites: Graduate Fluids (ASEN 5051), B+ or better in Aerodynamics (ASEN 3111) or permission of instructor.

Course Goals / Objectives

The main objective of this course is to introduce the students to the principles of viscous fluid flow and methods for performing engineering calculations of quantities such as skin friction and heat transfer rates in boundary layers. The first portion of the course material will focus on basic principles of fluid mechanics. We will derive the Navier-Stokes equations and discuss some simple solutions to these equations. The second portion of the course will concentrate on the application of these principles to boundary layers. We will derive the boundary layer equations and discuss their approximate and almost exact solutions.

Course Content

- 1) Introduction to viscous flows.
- 2) Concept of a fluid; Kinematics of fluid motion; Properties of a fluid.

- 3) Conservation laws for a continuum: mass, momentum and energy; Navier-Stokes equations.
- 4) Simple viscous solutions of Navier-Stokes equations, for example: Couette flow, Poiseuille flow.
- 5) Boundary layer equations; Incompressible boundary layers: Flow over a flat plate, Falkner-Skan solution, separation, stability, transition to turbulence, approximate solution techniques.
- 6) Thermal boundary layers: uncoupled solution to energy equation.
- 7) Compressible boundary layers: energy integral and Reynolds analogy.
- 8) Computational approaches applied in all topics.

Student Learning Outcomes

1. Understand concept of viscous fluid flows and basic conservation laws (to derive basic governing equations).
2. Be able to find solution to simple viscous flows.
3. Ability to derive boundary layer equations and find their solution (including similarity analysis and integral methods).
4. Develop basic understanding of transition and turbulence as well as compressible boundary layers.

Grading

Grade Breakdown According to Assignments: Your final grade is determined according to the following percentage breakdown:

Spot reading quizzes	10
Midterm Exam	40
Final Exam	40
Homework	10
	100%

Comments on Grades

Our grading scheme is not assigned to reward or punish. It is designed to indicate your level of competency compared to the standard that we set. Do you meet the minimum level of competency? Do you exceed the minimum? Are you below the minimum? This should be indicated by the final grade.

The final grade indicates your readiness to continue to the next level of courses. Meeting the minimum requirements indicates that you are prepared to continue at least at the minimum level required for the next in the sequence of courses. Exceeding the minimum means you are ready to enter the next course and that you have mastery of material beyond the minimum, i.e., you show some level of proficiency.

Important Notes and some Q&A:

1. *Homework assignments are due at the start of class on the due date.* There is a five-minute grace period, 11:30 pm – 11:35 am, during which the homework may be submitted. If you must miss class for an excused absence, you may submit your homework early. Late assignments are graded as follows: 1) before start of next class period (90%), 2) before start of second class period (80%), and 3) before final (50%).
2. Collaboration is permitted on homework. You may discuss the means and methods for formulating and solving problems and even compare answers, but you are not free to copy someone's assignment. ***Copying material from any resource (including solutions manuals) and submitting it as one's own is considered plagiarism and is an Honor Code violation. Remember, the less you think about the problems yourself, the less you actually learn, and the more difficult it will be to succeed on exams.***

Collaboration on quizzes or exams, using another student's work as your own, or allowing another student to use your work as their own is academic misconduct and is not tolerated. If you are caught in any of these activities, you will receive a grade of “F” for the course and a report will be made to the Dean’s office for further punitive action.

3. Attendance to all scheduled lecture/discussion periods is expected. In addition to announced exams, random unit quizzes may be given during any lecture/discussion. Like the scheduled quizzes and exams, there are no make-ups.
4. Some assignments require access to a computer, basic programming skills, and familiarity with some programming languages and/or environments similar to what is covered in introductory computing courses.
5. This class is not graded on a “curve”; there are absolute expectations of performance. However, we reserve the right to normalize the class grades based on the highest performance in the class.

Special Campus Notes

Accommodation For Disabilities

If you qualify for accommodations because of a disability, please submit to your professor a letter from Disability Services in a timely manner (for exam accommodations provide your letter at least one week prior to the exam) so that your needs can be addressed. Disability Services determines accommodations based on documented disabilities. Contact Disability Services at 303-492-8671 or by e-mail at dsinfo@colorado.edu. If you have a temporary medical condition or injury, see [Temporary Injuries guidelines](#) under the Quick Links 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 few weeks of the semester so that we can work with you to make reasonable 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, culture, religion, creed, politics, veteran’s status, sexual orientation, gender, gender identity and gender expression, age, disability, and nationalities. 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 [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 misco

under either policy should contact the Office of Institutional Equity and Compliance (OIEC) at 303-492-2273. 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 [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](#) of the institution. Violations of the policy may include: plagiarism, cheating, fabrication, lying, bribery, threat, unauthorized access, 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>.