Boundary Layers and Convection
ASEN-5121-001(B)
Spring Semester 2023

Syllabus

(Revised by: J. Farnsworth - January 16, 2023)

Time: Tue. & Thurs. 2:30pm-3:45pm

Classroom: AERO 232

Instructor: John Farnsworth (Assistant Professor)
Office: AERO 365
Phone:
Email: john.farnsworth@colorado.edu

Office Hours: Tuesday 4:00 - 5:00 PM MT (AERO 365 / Zoom)
Thursday 4:00 - 5:00 PM MT (AERO 365 / Zoom)

principles of uid 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.

Prerequisites: B+ or better in ASEN 3111: Aerodynamics (Undergraduate Level) or equivalent course. Recommended completion of ASEN 5051: Fundamental Fluid Dynamics (Graduate Level), but not required.

Required Text:

F. White and J. Majdalani, *Viscous Fluid Flow*. McGraw-Hill, 4th ed., 2022. Webpage

Note: *The class will be using the latest edition of this book, but students are welcome to*

1. Introduction to viscous ows.
2. Concept of a uid; Kinematics of uid motion; Properties of a uid.
3. Conservation laws for a continuum: mass, momentum and energy; Navier-Stokes equa-

Course Website and Course Communications: There will be a class website on Canvas. All relevant documents and course materials will be posted to this site throughout the semester. Please check it regularly to see what has been posted. All course announcements outside of lecture will be sent as Canvas Announcements, so it is the student's responsibility to make sure their Canvas settings are appropriately con gured to receive these announcements.

Students should only e-mail the teaching team if they have a pressing logistical or health issue (these include personal administrative and academic questions that the student does not feel comfortable asking in front of the class). The teaching team will aim to respond to e-mails within one business day. All general questions on assignments, quizzes, exams, and course content should be asked during lecture, o ce hours, or on the course Slack Workspace in a public forum to ensure that other students with similar questions receive a consistent response and to limit unnecessary redundancy in communication.

Grading: The table below presents the grading structure for the course.

Concept Quizzes	10%
Homework Assignments	15%
Midterm Concept Exams	25%
Final Project	20%
Final Concept Exam	30%
Total	100%

Grades will be posted to the class website (Canvas). This class is not graded on a \curve"; there are absolute expectations of performance. However, the Professor reserves the right to normalize the class grades based on the highest performance in the class.

Concept Quizzes: Weekly concept quizzes will be conducted through the class webpage on Canvas. Concept quizzes will focus on the conceptual content primarily associated with the lecture and readings during the week they are scheduled, but can also include other content covered in prior weeks. The concept quizzes will be released on Monday at 12:00 am and will be due the following Sunday at 11:59 pm. Students will have fteen minutes to complete each quiz, and students will be able to take each concept quiz as many times as they like before it is due. This allows students to retake each quiz to help them identify, practice, and comprehend important concepts until they have mastered the content. The concept quizzes will be closed-book and collaboration is prohibited. There will be no make-up concept quizzes, however the lowest two quiz grades will be dropped.

Homework Assignments: Homework problem sets will be assigned approximately every two weeks during the rst two-thirds of the semester. Homework assignments will always be due by 11:59pm on Thursday. Students will submit their completed homework electronically using Gradescope, which they can access through the class website on Canvas. Late homework assignments can be submitted, but their value will be aged 20% per day (24 hrs) after the deadline up until the release of the solution at which point a student will receive a 0% for

the homework. The lowest homework grade will be dropped from the homework assignment average.

Homework assignments will focus on problem solving to develop and assess a student's ability to implement the prediction and analysis tools discussed in class. Students can expect the homework assignments to have challenging and involved problems that may take over a week of e ort (o and on) to complete with the discussion and assistance from the instructor. 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.

is an Honor Code violation (and will be reported as such). Additionally, each report will be analyzed for plagiarism to ensure that it is the original work of the student. Additional details on the expectations and implementation will be provided when the project is o cially assigned and released to the students around week 10 (the week before spring break).

Concept Exams: Two concept exams, one midterm and one nal, will be utilized to asses the students aptitude in the course material. The exams will be closed-book and collaboration will not be permitted. The exams will focus on conceptual assessment of understanding of the content discussed in the class. Much of the content covered in these exams will build-o of the questions in the concept quizzes, however in addition to true/false, multiple choice, and ll in the blank questions students should also expect short answer questions that require them to explain, drawn, and annotate important theories and concepts covered throughout the course. Exams will be timed appropriately for the material covered (1 hr. for the midterm exam and 2 hrs for the nal) and students must either attend the exam period in-person in the assigned classroom on the de ned exam days or identify an exam proctor and time to take the exam (if they are participating in the class in an asynchronous remote mode).

Collaboration on 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 as an Honor Code Violation for further review and action. The Final Concept Exam will administered during the assigned nal exam period for the course and will be cumulative for the semester. Additionally students should be aware of the university's Final Exam Policy.

Exam Schedule:

Midterm \Concept" Exam:
Date: Thursday 23 March 2023
Time: 2:30pm - 3:45pm
Location: AERO 232

Final \Concept" Exam (Cumulative):
Date: Sunday 07 May 2023
Time: 4:30pm - 7:00pm
Location: AERO 232 (tentative)

Classroom Behavior: Both students and faculty are responsible for maintaining an appropriate learning environment in all instructional settings, whether in person, remote or online. 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 race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual

Requirements for COVID-19: As a matter of public health and safety, all members of the CU Boulder community and all visitors to campus must follow university, department and building requirements and all public health orders in place to reduce the risk of spreading infectious disease. CU Boulder currently requires COVID-19 vaccination and boosters for all faculty, sta and students. Students, faculty and sta must upload proof of vaccination and boosters or le for an exemption based on medical, ethical or moral grounds through the MyCUHealth portal.

The CU Boulder campus is currently mask-optional. However, if public health conditions change and masks are again required in classrooms, students who fail to adhere to masking requirements will be asked to leave class, and students who do not leave class when asked or who refuse to comply with these requirements will be referred to Student Conduct and Con ict Resolution. For more information, see the policy on classroom behavior and the Student Code of Conduct. If you require accommodation because a disability prevents you

Honor Code: All students enrolled in a University of Colorado Boulder course are responsible for knowing and adhering to the Honor Code. Violations of the Honor Code may include, but are not limited to: plagiarism, cheating, fabrication, lying, bribery, threat, unauthorized access to academic materials, clicker fraud, submitting the same or similar work in more than one course without permission from all course instructors involved, and aiding academic dishonesty. All incidents of academic misconduct will be reported to Student Conduct & Con ict Resolution (honor@colorado.edu; 303-492-5550). Students found responsible for violating the Honor Code will be assigned resolution outcomes from the Student Conduct & Con ict Resolution as well as be subject to academic sanctions from the faculty member. Additional information regarding the Honor Code academic integrity policy can be found on the Honor Code website.

Schedule

Week	*Dates*	*Tuesday*	*Thursday*	*Readings*
1	Jan. 17 & 19	Syllabus & Preliminary Concepts	Properties of a Fluid	**RR:** 1-1 { 1-3
2	Jan. 24 & 26	Cons. of Mass Cons. of Momentum	Cons. of Energy Boundary Conditions	**RR:** 1-4, 2-1 { 2-6
3	Jan. 31 & Feb. 2	Mathematical Character & Nondimensional Forms	Vorticity Streamfunction	**RR:** 2-8 { 2-11 **SR:** 2-7, 2-12
4	Feb. 7 & 9	Control Volume Formulations	Couette & Poiseuille Flow	**RR:** 2-13, 3-1 { 3-3 **SR:** 2-12, 3-4, 3-5
5	Feb. 14 & 16	Similarity Solutions	Plane Stagnation Flow	**RR:** 3-8 **SR:** 3-6 { 3-9
6	Feb. 21 & 23	Laminar Boundary Layer Equations	BL Sim. Solutions (Blasius Soln.)	**RR:** 4-1 { 4-3.1-2
7	Feb. 28 & Mar. 2	BL Sim. Solutions (Falkner-Skan Soln.)	Free Shear Flows (Planar Jets & Wakes)	**RR:** 4-3.3 { 4-4 **SR:** 4-5
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