ASEN 5051: Fundamentals of Fluid Dynamics

University of Colorado **Boulder**

Fall Semester 2022

Syllabus

Time: Tues. & Thurs. 1:00pm-2:15pm

Physical Classroom: AERO N240

Virtual Classroom/Office:

Instructor: Assistant Professor John Farnsworth
Office: AERO 365
Phone: (303)735-7287
Email: john.farnsworth@colorado.edu
Office Hours: Tuesday 4:00 - 5:00 PM MT (AERO 365 / Zoom)
Wednesday 1:00 - 2:00 PM MT (AERO 365 / Zoom)

Teaching Assistant: Dasha Gloutak
Email: dasha.gloutak@colorado.edu
Office Hours: Monday 1:00 - 2:00 PM MT (AERO 203 / Zoom)
Wednesday 5:30 - 6:30 PM MT (AERO 203 / Zoom)

Website: Canvas (https://canvas.colorado.edu/)

Slack Workspace: To help better facilitate communication the following Slack Workspace has been set-up for this course: Please note that you are not required to use this and all course wide notifications will still be sent out via class wide announcements through the course webpage. This tool is primarily set up to help improve communication and collaboration within the course. Please also note that while the Instructor and Teaching Assistant will aim to regularly monitor the Slack Workspace you should not expect communication outside of regular business hours.

Objective: To establish a fundamental understanding of fluid mechanics with a specific emphasis on incompressible flows.

Description: A rigorous introduction to the fundamentals of fluid dynamics. The course provides a solid foundation for students intending to study fluids at the advanced level, but is sufficiently broad that it serves as a valuable survey for many other students. Topics: Cartesian tensors, kinematics of fluid flows, conservation laws, vorticity dynamics, theory and application of irrotational flows, topics in geophysical fluid dynamics, dynamic similarity and nondimensional parameters, viscous flows, and boundary layers. Intended for students in all engineering majors.

Prerequisites: This class requires undergraduate courses in fluid mechanics, thermodynamics, and ordinary and partial differential equations. It attacks the subject at a graduate mathematics level with extensive use of indicial notation and vector calculus. Students will find the course material much easier to digest by reviewing these topics before the start of class as only a rapid review of the background material will be given.

Required Text:

Fluid Mechanics, Kundu and Cohen (and Dowling). Academic Press, 4th Edition (6th Edition), 2008 (2016). CU Library Online Access

Note: The preferred edition of the textbook is the 4th edition, however any edition of this text should suffice for the course. The CU library provides full online access to each of the editions of the text. The link posted above should take you to the library search page from which you can access the texts. To access you may have to be on the campus network, logged into the campus VPN from off-campus, or may be asked to log in with your campus credentials to access the text.

Supplemental Material:

1. *Incompressible Flow*, Panton, Wiley, 4th Ed., 2013. CU Library Online Access
2. *An Album of Fluid Motion*, Van Dyke, Parabolic Press, 1982. Online Access
3. *National Committee for Fluid Mechanics Films (NCFMF)*, Shapiro.
`http://web.mit.edu/hml/ncfmf.html`
4. *Introduction to Incompressible Fluid Mechanics*, Tilton & Randall, 2021. Online Access
5. *Introduction to Graduate Fluid Mechanics*, Smith, 3rd Ed., 2020. Online Access
6. *Vectors, Tensors and the Basic Equations of Fluid Mechanics*, Aris, Dover, 1989.
CU Library Online Access

Topics:

1. Review of Basic Fluid Dynamic and Thermodynamic Concepts
2. Cartesian Tensors and Vector Calculus
3. Basic Kinematic Concepts
4. Conservation Laws
5. Dimensional Analysis
6. Potential Flows
7. Vorticity Dynamics
8. Waves in Fluids
9. Laminar Flows
10. Boundary Layers
11. Stability and Transition to Turbulence
12. Turbulent Flows

Class Format: The class meets twice a week for one hour and fifteen minutes of formal lecture and discussion. All lectures will be be recorded and posted on the course website for asynchronous viewing after the scheduled lecture period, and all students actively enrolled in the course will have access to the lecture videos. If students are unable to participate in-person or are registered for the distance section then they are encouraged to participate virtually in an asynchronous format by watching the lecture videos and posting questions/discussion on the course Slack Workspace. Office hours will be held in a hybrid format (simultaneously in-person and over zoom) using the Zoom web-link provided above. The format may be adapted through the semester depending upon attendance and demand. All technical questions on course content should be asked during lecture, office hours, or on the course Slack Workspace. One-on-one meetings with the instructor will only be scheduled to address individual administrative or academic issues.

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 configured 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, office 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:

15% Homework Assignments
15% Concept Quizzes
30% Mid-Term Exam
40% Final Exam

Grades are posted to the class website on Canvas.

Reading: Readings are assigned frequently 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, they should either raise them during the lecture or post the question to the course Slack Workspace.

Homework Policy: Homework problems are assigned every two weeks on Thursdays so that students can implement and practice the theory and concepts discussed in class through traditional engineering problem solving. Eight homework assignments are tentatively planned throughout the fifteen week semester.

Homework assignments are provided as a learning tool to help students internalize the theories and methods discussed in class and are not used as detailed assessment of the learning. Credit will be given for homework assignments based on completion. Students will receive full credit if they attempt each problem and display sufficient work for each problem. Detailed problem solutions will be provided by the instructor and teaching assistant including basic grading rubrics. Students are expected to evaluate their own work and assess their equivalent numerical grade. The process of critically evaluating ones own work, represents an additional learning opportunity, as it will force each student to dissect their work and understand any missteps they may have made.

Students will have two weeks to complete the assignment and will submit a scanned copy to the course website by 11:59pm on the Thursday of the week that the homework is due. The homework solutions, including a basic breakdown of points will be provided immediately following each deadline (i.e. on Friday) and students will be given one week to "self assess" their assignment and re-upload a graded copy of the homework assignment to the course website based upon the provided solutions/scoring. Students will receive credit for BOTH their original submission of the homework (10%) and the their own self-assessment of the homework (5%) based upon the effort that they make (and not whether they get the assignment right or wrong). If a student submits either a blank problem/assessment or only provides information given to them in the assignment document (i.e. the problem statement) then they will receive

no credit for attempting the specific problem in question. No extensions or make-ups will be offered for homework assignments, however the lowest (one) homework assignment grade (combined original and self-assessment) will be dropped from the overall homework average to provide students some flexibility and recovery throughout the course.

Students are asked to complete their homework assignments on standard plain white or engineering paper, however this is not a requirement. That said students should keep individual problems separated on different pages. In other words, page breaks should be inserted between problems to simplify the uploading to the website and identification of individual problems. Students should make an effort to turn in assignments that are organized, professional looking, and they must be legible.

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 assignments from other students/sources. The work that a student turns in must be their own – copying is not allowed for any assignment and will not be tolerated. Students who are caught copying (or providing their assignment to another) will receive an "F" for the course and reported to the Dean's office for further punitive action.

Concept Quizzes: Short, timed quizzes which cover basic concepts, will be administered every week throughout the semester except for the first and last week of class and during the midterm exam week. These concept quizzes will be administered as Canvas quizzes, and each quiz will be released on a Monday at 12:00 AM and due on the Sunday at 11:59 PM. Students will have fifteen minutes to complete each quiz, and students will be able to take the concept quizzes as many times as they like before they are due. The concept quizzes will cover material assigned in readings during the week they are assigned, and are intended to help students identify, practice, and comprehend important concepts. Minimal mathematical problem solving will be required for the quizzes. The concept quizzes will be closed-book, collaboration is not permitted, and there will be no make-up concept quizzes. The lowest two concept quiz grades will be dropped from the overall quiz average to provide students some flexibility and recovery throughout the course.

Exam Policy: The midterm and final examinations will cover all material in the course including lecture, discussions, homework, and quizzes. The final examination will be cumulative and will be time limited.

Collaboration on exams will not be tolerated. The exam will be composed of two parts: Part 1) a closed book concept exam portion and Part 2) an open crib/note sheet problem solving portion. For Part 2, a one-sided (two-sided) 8.5 in. $\times$ 11 in. crib sheet is allowed for the midterm (final) exam. No calculators or other electronic devices are permitted. Students who are caught in violation of these policies will receive an "F" for the course and reported to the Dean's office for further punitive action. Additionally students should be aware of the university's final exam policies which can be found on the registrar's website at https://www.colorado.edu/policies/final-examination-policy.

All exams will be administered in-person and will tentatively take place at the days and times provided below. If a student is enrolled in the distance section of the course they are encouraged to take the exams with the in-person section, if they are local and available at the designated times, otherwise they will be asked to identify a proctor, or proctoring service, to oversee administration of the timed exam and facilitate communication with the course instructor. To allow flexibility but also ensure consistency in the assessments, distance

students will be required to take the exams within 24 hrs of the in-person exam time. The exact time may be chosen by the distance student, based upon their best availability, but must be provided to the instructor at least two weeks prior to the exam in written form via email.

Midterm Exam: Tuesday October 04, 2022 from 1:00pm MT - 2:15pm MT
Final Exam: Sunday December 11, 2022 from 4:30pm MT - 7:00pm MT

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 orientation, gender identity, gender expression, veteran status, political affiliation or political philosophy. For more information, see the classroom behavior policy, the Student Code of Conduct, and the Office of Institutional Equity and Compliance.

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, staff and students. Students, faculty and staff must upload proof of vaccination and boosters or file 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 Conflict 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 from fulfilling these safety measures, please follow the steps in the "Accommodation for Disabilities" statement on this syllabus.

If you feel ill and think you might have COVID-19, if you have tested positive for COVID-19, or if you are unvaccinated or partially vaccinated and have been in close contact with someone who has COVID-19, you should stay home and follow the further guidance of the Public Health Office (contacttracing@colorado.edu). If you are fully vaccinated and have been in close contact with someone who has COVID-19, you do not need to stay home; rather, you should self-monitor for symptoms and follow the further guidance of the Public Health Office (contacttracing@colorado.edu).

In this class, if you are sick or quarantined, please notify the instructor of your absence from in-person activities and continue in a completely remote mode until you are able and allowed to return to campus. Please note that for health privacy reasons you are not required to disclose to the instructor the nature of your illness, however you are welcome to share information you feel necessary to protect the health and safety of others in the course.

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. Contact Disability Services at 303-492-8671 or dsinfo@colorado.edu for further assistance. If you have a temporary medical condition, see Temporary Medical Conditions on the Disability Services website.

Preferred Student Names and Pronouns: CU Boulder recognizes that students' legal information doesn't always align with how they identify. Students may update their preferred names and pronouns via the student portal; those preferred names and pronouns are listed on instructors' class rosters. In the absence of such updates, the name that appears on the class roster is the student's legal name.

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 & Conflict Resolution (honor@colorado.edu); 303-492-5550). Students found responsible for violating the Honor Code will be assigned resolution outcomes from the Student Conduct & Conflict 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.

Sexual Misconduct, Discrimination, Harassment and/or Related Retaliation: CU Boulder is committed to fostering an inclusive and welcoming learning, working, and living environment. University policy prohibits sexual misconduct (harassment, exploitation, and assault), intimate partner violence (dating or domestic violence), stalking, protected-class discrimination and harassment, and related retaliation by or against members of our community on- and off-campus. These behaviors harm individuals and our community. The Office of Institutional Equity and Compliance (OIEC) addresses these policies, and individuals who believe they have been subjected to misconduct can contact OIEC at 303-492-2127 or email cureport@colorado.edu. Information about university policies, reporting options, and support resources can be found on the OIEC website.

Please know that faculty and graduate instructors have a responsibility to inform OIEC when they are made aware of any issues related to these policies regardless of when or where they occurred to ensure that individuals impacted receive information about their rights, support resources, and resolution options. To learn more about reporting and support options for a variety of concerns, visit Don't Ignore It.

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 reasonable arrangements.

See the campus policy regarding religious observances for full details.

Prepared By (Date): John A. N. Farnsworth (August 19, 2022)