

ASEN 6011: Experimental Fluid Mechanics

University of Colorado Boulder

Fall Semester 2020

Syllabus

Time: Tue. & Thurs. 02:50 PM - 04:05 PM

Physical Classroom: AERO 232

Virtual Classroom/Office:

Instructor: Assistant Professor John Farnsworth

Physical Office: AERO 365

Office Phone: (303)735-7287

Email: john.farnsworth@colorado.edu

Office Hours: Mon. 11:00 AM - 12:00 PM

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

Slack Workspace: To help better facilitate online communication this semester we will also be using the following Slack Workspace: Please note that you are not required to use this and all course wide notifications will still be sent out also via notifications through the course webpage, but we believe this application will help improve communication and collaboration within the course.

Objective: To establish a fundamental understanding of the theory and practice of performing experimental measurements in fluid mechanics.

Description: This course presents an intermediate level introduction into the theory and practice of performing experimental measurements in fluid mechanics. The fundamental principles and definitions associated with instrumentation, measurement procedures, data analysis, and uncertainty quantification will be discussed. A specific focus will be placed on the application of a variety of measurement techniques in low-speed aerodynamic environments. A selection of measurement techniques will be extensively studied and applied including: classical pressure and temperature measurements, thermal (hot-wire) anemometry, laser doppler anemometry, particle image velocimetry, surface and field flow visualization techniques, schlieren and shadowgraph photography techniques.

Prerequisites: Undergraduate level courses dedicated to the fundamentals of fluid mechanics, thermodynamics, and aerodynamics are recommended for this course. A basic background in optics, simple electronics, system dynamics, and signal processing will also be beneficial.

Required Text:

S. Tavoularis, *Measurements in Fluid Mechanics*. Cambridge University Press, 1st ed., 2005.

Note: There is no official online access to this text through the CU Library.

Supplemental References:

Note: The CU library provides full online access to many of these texts. The links posted below 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.

1. C. Tropea, A. Yarin, J.F. Foss, *Springer Handbook of Experimental Fluid Mechanics*. Springer, 1st ed., 2007. [CU Library Online Access](#)
2. R. J. Goldstein, *Fluid Mechanics Measurements*. Taylor & Francis, 2nd ed., 1996. [CU Library Online Access](#)
3. E. Rathakrishnan, *Instrumentation, Measurements, and Experiments in Fluids*. CRC Press, 1st ed., 2007. [CU Library Online Access](#)
4. H. W. Coleman and W. G. Steele, *Experimentation, Validation, and Uncertainty Analysis for Engineers*. Wiley, 3rd ed., 2009. [CU Library Online Access](#)
5. J. R. Taylor, *An Introduction to Error Analysis*. University Science Books, 2nd ed., 1997. [CU Library Online Access](#)
6. J. B. Barlow, W. H. Rae, A. Pope, *Low-Speed Wind Tunnel Testing*. Wiley, 3rd ed. 1999.
7. M. Raffel, C. Willert, S. Wereley, J. Kompenhans, *Particle Image Velocimetry*. Springer, 2nd ed., 2007. [CU Library Online Access](#)
8. R. J. Adrian and J. Westerweel, *Particle Image Velocimetry*. Cambridge University Press, 1st ed., 2010.
9. G. S. Settles, *Schlieren and Shadowgraph Techniques*. Springer, 1st. ed., 2001. [CU Library Online Access](#)

Grading: The following presents the planned grading structure for the course. Be aware, that this is subject to change, however the class will be thoroughly notified and polled for agreement.

60% Homework Assignments (approximately 6 during first half of semester)

40% Lab Assignments (approximately 4 during second half of semester)

-Grades are posted to the class website (Canvas).

Class Format: The class meets in-person twice a week for an hour and fifteen minutes of formal lecture and discussion. If students are unable to participate in-person, students are encouraged to participate in lectures virtually in a synchronous format using the Zoom web-link above. All lectures will 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. All office hours and other one-on-one meetings associated with this course will take place in a virtual format using the Zoom web-link provided above, same as that used for lectures.

Select class meetings will be held in the Experimental Aerodynamics Laboratory which is

part of the Sustainability Energy and Environment Complex (SEEC) on the CU Boulder East Campus. During these class periods hands-on experimental laboratory experiments will be conducted.

Homework Assignments: Approximately six sets of homework problems will be assigned during the first half of the semester so that students can implement and practice the theory and concepts discussed in class through traditional engineering problem solving. Students will have approximately one week to complete the assignment and will submit a scanned copy to the course website on Canvas or Gradescope. Students should make an effort to turn in assignments that are organized, professional looking, and 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.

Laboratory Assignments: Approximately four laboratory assignments are planned to provide a practical experience with the the measurement techniques and the their data analysis. Due to the limitations on in-person activities participation in the experimental setup and data collection will be limited and not required. Data sets, with clear directions will be posted to the course website to allow all individuals to participate. Students will submit individual laboratory reports. These reports will be limited to a three page single spaced document with a minimum 1 in margin and 10 pt font. This page limit is inclusive of all discussion, figures, and references. The lab reports will be uploaded as a pdf document to the drop-box folder on the course website.

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 policies on [classroom behavior](#) and the [Student Code of Conduct](#).

Requirements for COVID-19: As a matter of public health and safety due to the pandemic, all members of the CU Boulder community and all visitors to campus must follow university, department and building requirements, and public health orders in place to reduce the risk of spreading infectious disease. Required safety measures at CU Boulder relevant to the classroom setting include:

- maintain 6-foot distancing when possible,
- wear a face covering in public indoor spaces and outdoors while on campus consistent with state and county health orders,

- clean local work area,
- practice hand hygiene,
- follow public health orders, and
- if sick and you live off campus, do not come onto campus (unless instructed by a CU Healthcare professional), or if you live on-campus, please alert [CU Boulder Medical Services](#).

Students who fail to adhere to these 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 policies on [COVID-19 Health and Safety](#) and [classroom behavior](#) and the [Student Code of Conduct](#). If you require accommodation because a disability prevents you from fulfilling these safety measures, please see the "Accommodation for Disabilities" statement on this syllabus.

Before returning to campus, all students must complete the [COVID-19 Student Health and Expectations Course](#). Before coming on to campus each day, all students are required to complete a [Daily Health Form](#). In this class, you may be reminded of the responsibility to complete the [Daily Health Form](#) and given time during class to complete it.

Students who have tested positive for COVID-19, have symptoms of COVID-19, or have had close contact with someone who has tested positive for or had symptoms of COVID-19 must stay home and complete the [Health Questionnaire and Illness Reporting Form](#) remotely. 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 policy may include: 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 the Honor Code (honor@colorado.edu); 303-492-5550). Students found responsible for violating the academic integrity policy will be subject to nonacademic sanctions from the Honor Code as well as academic sanctions from the faculty member. Additional information regarding the Honor Code academic integrity policy can be found at the [Honor Code Office website](#).

Sexual Misconduct, Discrimination, Harassment and/or Related Retaliation: The University of Colorado Boulder (CU Boulder) is committed to fostering an inclusive and welcoming learning, working, and living environment. CU Boulder will not tolerate acts of sexual misconduct (harassment, exploitation, and assault), intimate partner violence (dating or domestic violence), stalking, or protected-class discrimination or harassment by members of our community. Individuals who believe they have been subject to misconduct or retaliatory actions for reporting a concern should contact the Office of Institutional Equity and Compliance (OIEC) at 303-492-2127 or cureport@colorado.edu. Information about the OIEC, university policies, [anonymous reporting](#), and the campus resources can be found on the [OIEC website](#).

Please know that faculty and instructors have a responsibility to inform OIEC when made aware of incidents of sexual misconduct, dating and domestic violence, stalking, discrimination, harassment and/or related retaliation, to ensure that individuals impacted receive information about options for reporting and support resources.

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 (September 4, 2020)