

ASEN 5131: INTRODUCTION TO HYPERSONICS

Fall 2026

Time:	Tue./Th. 10:00 – 11:15 AM	Location:	AERO N240/Recordings
Instructor:	Prof. Robyn Macdonald	Email:	robyn.macdonald@colorado.edu

Course Goals: The purpose of this course is to introduce key elements of hypersonic vehicle design, including trajectories, surface heating, propulsion, and thermal protection systems. The course provides the necessary background on fluid dynamics and boundary layers, so students from a variety of disciplines are welcome. We will also cover thermochemical nonequilibrium, turbulence, and experimental facilities. The course includes a mix of empirical and computational analyses. This course is designed to be an accessible introduction to hypersonics without prerequisites. However, basic programming experience is required.

Text: There is no required textbook for this course. Notes will be posted on the course website for each section. Some useful references are listed below which are available digitally or in the course reserves at the Gemmill Library. At the beginning of the notes for each section is a list of sources from which the notes were compiled.

- Bertin, “Hypersonic Aerothermodynamics”, AIAA, 1994. Full text is available online through the library at <https://app-knovel-com.colorado.idm.oclc.org/s.v?oPwRlULz>.
- Anderson, “Hypersonic and High-Temperature Gas Dynamics”, AIAA, 2006. Full text is available online through the library at <https://ucblibraries.skillport.com/skillportfe/main.action?path=summary/BOOKS/15592>.
- Hankey, “Re-entry Aerodynamics”, AIAA, 1988.
- Heiser and Pratt, “Hypersonic Airbreathing Propulsion”, AIAA, 1994. Full text is available online through the library at <https://app-knovel-com.colorado.idm.oclc.org/s.v?H0qgWay2>.

Grading Policy: Homework (20%), Concept Quizzes (10%), Midterm Exam (30%), Final Exam (40%).

Homework: Homework will be assigned periodically as the appropriate material is covered, and will include both handwritten problem sets and programming assignments (most assignments will include some of both). There will be approximately six homework assignments. The due date for each assignment will be announced when the assignment is made. All students will submit assignments through the course Gradescope website. Late work will not be accepted. You may receive help from a classmate or the instructor/TA on homework assignments, but the submitted assignment must be your own work. This includes both handwritten solutions, as well as programming assignments.

Concept Quizzes: Concept quizzes will be made available on Canvas approximately every two weeks. Concept quizzes will test your conceptual understand with true or false, multiple choice, fill in the blank, and other short answer questions. The quizzes will be open for 5 days and you may take the quiz anytime within the 5 day window. Each student will have two attempts on each concept quiz where your grade on that quiz will be the better of your two attempts. There will be approximately six concept quizzes.

Exams: There will be two exams in this course. The first will cover material from the first half of the class (to be specified later) and the second will be cumulative, but focusing on material in the second half of the course. Students registered for the asynchronous remote section will have the option to take the exam remotely with a proctor. You should coordinate a proctor and communicate with Professor Macdonald the details on your proctor at least two weeks before the exams. If you are looking for a proctor local to your area, consider looking at a local community college or public library. For students taking the exams remotely with a proctor, you are expected to take the exam within 24 hours of the rest of the class. The exam dates are as follows:

	Day	Time	Location
Midterm exam	Thursday, October 29	10:00 - 11:15 AM	AERO N240
Final exam	Monday, December 7	1:30 - 4:00 PM	AERO N240

Class format: This class operates in two modalities: in-person and asynchronous remote. All lectures will be recorded via Classroom Capture and will be made available to all students.

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 (including use of paper writing services or technology [such as essay bots]), 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. Understanding the course's syllabus is a vital part of adhering to the Honor Code.

All incidents of academic misconduct will be reported to Student Conduct & Conflict Resolution: StudentConduct@colorado.edu. Students found responsible for violating the Honor Code will be assigned resolution outcomes from Student Conduct & Conflict Resolution and will be subject to academic sanctions from the faculty member. Visit [Honor Code](#) for more information on the academic integrity policy.

Accommodation for Disabilities, Temporary Medical Conditions, and Medical Isolation: 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 <https://www.colorado.edu/disabilityservices>. 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.

If you have a temporary illness, injury or required medical isolation for which you require adjustment due to a missed in-person assessment (exam), please alert Professor Macdonald of your absence via email but do not include specific information about your illness due to privacy laws. Because attendance is not required in this class, if you miss a class you do not need to inform Professor Macdonald but can watch the lecture asynchronously on Canvas.

Students should expect to receive accommodations for a timed assessment (e.g., exam) only if their faculty instructor(s) receive the student's accommodations letter at least 5 business days before the assessment, as a departmental policy, in order to facilitate administering the assessment.

Accommodation for Religious Obligations: Instructional faculty members must make every reasonable effort to accommodate all students who have conflicts with scheduled exams, assignment deadlines or required attendance due to a religious observance. Whenever possible, students must notify the instructional faculty member at least two weeks in advance of the expected exam, assignment deadline, or attendance conflict to request an accommodation for religious observance. If the start date of the course is less than two weeks before the date of requested accommodation, students must notify the instructional faculty member on the start date of the course. See the [Student Academic Accommodations for Religious Observances Policy](#) for more information.

In this class, if you must miss an in-class assessment (exam) due to a religious obligation, please contact Professor Macdonald at least two weeks prior to coordinate an accommodation.

Student Names and Pronouns: CU Boulder recognizes that students' legal information does not always align with how they identify. If you wish to have a name other than your legal name appear on your instructors' class rosters and in Canvas, or if you wish to choose pronouns to appear on your instructors' class rosters and in Canvas, visit the [Registrar's website](#) for instructions on how to change your personal information in university systems.

Classroom Behavior: Students and faculty are responsible for maintaining an appropriate learning environment in all instructional settings, whether in person, remote, or online. Failure 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, marital status, political affiliation, or political philosophy.

Additional classroom behavior information

- [Student Classroom and Course-Related Behavior Policy](#).
- [Student Code of Conduct](#).
- [Office of Institutional Equity and Compliance](#).

Sexual Misconduct, Discrimination, Harassment and/or Related Retaliation: CU Boulder is committed to fostering a productive and welcoming learning, working, and living environment. University policy prohibits [protected-class](#) discrimination and harassment, sexual misconduct (harassment, exploitation, and assault), intimate partner abuse (dating or domestic violence), stalking, and related

retaliation by or against members of our community on- or off-campus. Denial of an approved accommodation for disability, religious observance, or pregnancy or pregnancy related medical conditions may be discriminatory.

The [Office of Institutional Equity and Compliance \(OIEC\)](#) addresses these concerns, and individuals who have been subjected to misconduct can contact OIEC at 303-492-2127 or email OIEC@colorado.edu. Information about university policies, [OIEC reporting options](#), and [OIEC support resources](#) including confidential services can be found on the [OIEC website](#)

Faculty and graduate instructors are required to inform OIEC when someone discloses misconduct regardless of when or where it occurred. This is to ensure that those impacted receive outreach from OIEC about resolution options and support resources. To learn more about reporting and support options for a variety of concerns, visit the [Don't Ignore It page](#).

Mental Health and Wellness: The University of Colorado Boulder is committed to supporting students' mental health and overall wellbeing. If personal, academic, or emotional challenges are affecting your wellbeing or success, [Counseling and Psychiatric Services \(CAPS\)](#), is here to help. CAPS offers counseling, referrals, psychiatric care, crisis support, and much more. Visit CAPS in the C4C, or call (303) 492-2277, 24/7.

Acceptable Use of AI in This Class: You may **NOT** use generative AI tools on any assignments in this course. Generative AI use in this course will not enhance student learning, nor serve the topic at hand. If generative AI use is suspected on an assignment, I will consult with you and ask that you redo the assignment using no generative AI within 1 week of our meeting. In the case of subsequent infractions of this policy, you will receive a zero on the assignment(s) in question.

Course Outline:

1. Introduction
2. Hypersonic flight mechanics
 - I. Trajectory equations
 - II. Ballistic entry (missile)
 - III. Equilibrium glide (Space Shuttle)
 - IV. Air-breathing, powered flight
3. Aerothermodynamics phenomena
 - I. Review of compressible gas dynamics
 - II. High-temperature gas effects
 - III. Nonequilibrium thermochemical kinetics
 - IV. Fluid conservation equations
 - V. Molecular transport processes
 - VI. Review of aerodynamics
4. Surface pressure
 - I. Stagnation point
 - II. Newtonian models
 - III. Sharp cones
5. Boundary layers
 - I. Self-similar equations
 - II. Solution for a flat plate
 - III. Stagnation-point heating (Fay-Riddell)
6. Heat transfer and skin friction
 - I. Surface temperature
 - II. Laminar and turbulent boundary layers
7. Hypersonic propulsion
 - I. Rockets and ramjets
 - II. Scramjets
8. Thermal protection systems
 - I. Design drivers
 - II. Passive (Space Shuttle, X43)
 - III. Ablative (Stardust)
9. Cutting-edge capabilities (subject to change)
 - I. Computational tools
 - II. Experimental facilities
10. Conclusions and exam preparation