ASEN 5131 – Introduction to Hypersonics
Course Syllabus, Fall 2024

INSTRUCTOR

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TEACHING ASSISTANT

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OFFICE HOURS AND CONTACT INFORMATION

In-Person / Zoom Office Hours: Tuesday 11am – 12pm and Thursday 1pm to 2pm
In-Person Office Location:
Zoom Virtual Office Link:
Email:

Email Policy: It is my intent to make myself as accessible as possible to you during this semester within the bounds of my other responsibilities. In general, I will do my best to accommodate student needs and respond as promptly as possible to emails. In your email, please identify yourself by providing your name and the course number at the start of your message. However, 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 SCHEDULE, LOCATION, and LINKS

- **Schedule:** 2:30 PM – 3:45 PM, Tuesday and Thursday
- **In-Person: ASEN 5131-001 AERO 111** –students enrolled in the class should attend the class synchronously in-person or asynchronously.
- **Remote: ASEN 5131-002 –** students attend class asynchronously by watching recordings of the ASEN 5131-001 lectures on their own time
- **Website:** *(link provided in course)*
- **Slack:** *(link provided in course)*

Slack Policy: To help better facilitate communication a Slack Workspace has been set up for this course. An invitation link will be posted as a Canvas announcement. You must sign in with your CU email address (@colorado.edu) to be successfully added to the workspace. Please note that you are not required to use Slack and all course wide notifications will still be sent out via the course webpage. This tool is primarily to improve communication and collaboration within the course. Please note that while the Instructor and Teaching Assistants aim to regularly monitor the Slack Workspace, you should not expect communication outside of business hours.

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 techniques and computational analyses. This course is designed to be an accessible introduction to hypersonics without prerequisites. However, basic programming experience is required.

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COURSE TEXTBOOK AND WEBSITE

There is no required textbook, but interested students may refer to the following books for further discussion and resources. Reading may be assigned from these books, but they will either be available online through the CU Library or the relevant sections will be provided.

- Bertin, "*Hypersonic Aerothermodynamics*", AIAA, 1994. Full text is available online through the library at http://tinyurl.com/y292lqnt.
- Anderson, "*Hypersonic and High-Temperature Gas Dynamics",* AIAA, 2006. Full text is available online through the library at https://tinyurl.com/yyyxpjvr.
- Hankey, "*Re-entry Aerodynamics*", AIAA, 1988. Full text is available online through the library at http://tinyurl.com/yymhlaw9.
- Heiser and Pratt, "*Hypersonic Airbreathing Propulsion*", AIAA, 1994. Full text is available online through the library at https://tinyurl.com/yybuuvwh.

ASSIGNMENTS, EXAMS, AND GRADING

This course will be assessed through assignments and examinations, with a more detailed breakdown below:

8 assignments, 5% each	40%
1 midterm exam, Tuesday, November 5th	25%
1 final exam, Wednesday, December 18th	35%
Total	100%

Extensions and Late Assignments: The late penalty for assignments is 10% per day, for up to 5 days. Beyond 5 days late, the assignment is worth 0%. Please email me for accommodations due to illness or other extenuating circumstances.

Assignment Policy: 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.

Exam Policy: The time-limited midterm and final examinations will cover all material in the course including lecture, discussions, readings, and assignments. The final examination will be cumulative. **There is no collaboration allowed on exams.** All exams will be administered with an in-person option and will tentatively take place on the days and times provided in the course schedule portion of this syllabus. To allow flexibility for both distance and in-person students but also ensure consistency in the assessments, students will have an option to complete the timed exams (with the same time limit as the in-person exam) remotely within a reasonable (24 – 36 hour) window of the in-person exam date.

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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. For more information, see the classroom behavior policy, the Student Code of Conduct, and the Office of Institutional Equity and Compliance.

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 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. If you have a temporary medical condition or required medical isolation for which you require accommodation, please email the instructor.

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.

CU COMMUNITY OF CARE

CU Boulder is committed to a community of care in which students are supported by faculty and staff throughout their college journey. You don't have to face academic challenges alone – CU and the college are here to help you learn and succeed in your coursework and campus life. Part of this community of care is your connection to faculty and staff across campus. Our college promotes and hopes you will connect with faculty or staff who may reach out during your educational journey at CU.

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 in 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 the Student Conduct & Conflict Resolution as well as be subject to academic sanctions from the faculty member. Visit Honor Code for more information on the academic integrity policy.

SEXUAL MISCONDUCT,DISCRIMINATION,HARRASEMENT,AND/OR RELATED RETALIATION

CU Boulder is committed to fostering an inclusive 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- and off-campus. 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 CUreport@colorado.edu. Information about university policies, reporting options, and support resources including confidential services can be found on the OIEC website. Please know that faculty and graduate instructors must inform OIEC when they are made aware of incidents related to these policies regardless of when or where something occurred. This is to ensure that individuals impacted receive outreach from OIEC about resolution options and support resources. To learn more about reporting and support for a variety of concerns, visit the Don't Ignore It page.

RELIGIOUS HOLIDAYS

Campus policy requires faculty to provide reasonable accommodations for students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. Please communicate the need for a religious accommodation in a timely manner. In this class, please email the instructor if a conflict arises due to religious observance. See the campus policy regarding religious observances for full details.

MENTAL HEALTH AND WELLNESS

The University of Colorado Boulder is committed to the well-being of all students. If you are struggling with personal stressors, mental health or substance use concerns that are impacting academic or daily life, please contact Counseling and Psychiatric Services (CAPS) located in C4C or call (303) 492-2277, 24/7.

Free and unlimited telehealth is also available through Academic Live Care. The Academic Live Care site also provides information about additional wellness services on campus that are available to students.

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COURSE MATERIAL AND OUTLINE

Below is a (tentative) course outline for the class as of the 1st day. The specific schedule is subject to change.

1. Introduction [2 lectures]

- Course outline
- Broad overview of hypersonics

2. Hypersonic flight mechanics [3 lectures]

- Trajectory equations
- Ballistic entry (missile)
- Equilibrium glide (Space Shuttle)
- Air-breathing, powered flight

3. Aerothermodynamics phenomena [6 lectures]

- Review of compressible gas dynamics
- High-temperature gas effects
- Nonequilibrium thermochemical kinetics
- Fluid conservation equations
- Molecular transport processes
- Review of aerodynamics

4. Surface pressure [3 lectures]

- Stagnation point
- Newtonian models
- Sharp cones

5. Boundary layers [3 lectures]

- Self-similar equations
- Solution for a flat plate
- Stagnation-point heating (Fay-Riddell)

6. Heat transfer and skin friction [2 lectures]

- Surface temperature
- Laminar and turbulent boundary layers

7. Hypersonic propulsion [2 lectures]

- Rockets and ramjets
- Scramjets

8. Thermal protection systems [3 lectures]

- Design drivers
- Passive (Space Shuttle, X43)
- Ablative (Stardust)
- Guest lecture: TBD

9. Cutting-edge capabilities (subject to change) [2 lectures]

- Computational tools
- Experimental facilities
- Guest lecture: TBD

10. Conclusions and exam preparation [1 lecture]