

ASEN 6519 Aerospace Environments – Upper Atmospheres

Syllabus, Spring 2022

Lecture: AERO N250 T, Th 11:30-12:45 pm

Web page: Canvas course page

Instructor

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Office Hours: By Appointment

Course Overview

This multidisciplinary course is an advanced-level exposition of those neutral and plasma physical, dynamical, chemical, and electrodynamic processes that determine the evolving states of the upper atmospheres and ionospheres of Earth and other planets. The overall context is the solar-terrestrial system, wherein energy from the Sun (i.e., visible, UV and EUV radiation; solar wind and interplanetary magnetic field) is transformed into various forms that facilitate flow into, and dissipation within, upper atmospheres. In part, specific topics to be covered will be determined by student needs and interests. The CU Space Weather Technology, Research and Education Center (SWx TREC) will also provide resources to assist students in computational labs that expose students to the latest modeling and data developments.

Class Learning Goals

The goals of this course are to expose students to the multidisciplinary field of upper atmosphere research and develop graduate students' research capabilities. Students will improve their analysis skills working with current upper atmosphere data sets, their research acuity by conceptualizing and understanding issues currently under study by the upper atmosphere community, their presentations skills by concisely and coherently presenting their analyses in a research conference format. Students will actively participate in the teaching-learning process through in-depth review of articles in the archival literature, and oral presentations of their analyses in class.

Prerequisites

Level of knowledge of the solar-terrestrial system similar to that of ASEN 5335 Aerospace Environments

Course Content

The class is broken into a number of sections, as follows:

- **Transport Equations for Upper Atmospheres (4 weeks)**
 - Boltzmann equation and velocity moments
 - Transport equations: continuity, momentum, energy, pressure tensor and heat flow
 - Maxwellian velocity distribution and closing the system of transport equations
 - Euler and Navier- Stokes approximations
- **Upper Atmosphere: Thermosphere (4 weeks)**
 - Density and Composition Structure
 - Gas Diffusion and Vertical Structure
 - Eddy and Molecular diffusion
 - Minor versus Major gas diffusion
 - Plasma Diffusion
 - Thermal structure

- Energy sources and sinks
 - Exospheric temperature
 - Temperature profile
 - Collisions
 - Binary elastic collisions
 - Maxwell molecule collisions
 - Momentum transfer collision frequencies
 - Dynamics
 - Internal and External Forces
 - Wind systems
- Upper Atmosphere: Ionosphere (3 weeks)
 - Formation
 - Ionization
 - Chemistry
 - Layering
 - Thermal structure
 - Ion energy sources and sinks
 - Ion temperature profile
 - Electron energy sources and sinks
 - Electron temperature profile
- Upper Atmosphere: Electrodynamics (3 weeks)
 - Earth's magnetic field
 - Currents and Electric fields
 - Conductivities
 - Magnetosphere-Ionosphere Coupling
 - High Latitude Electrodynamics
 - Low Latitude Electrodynamics
- Student Final Report Presentations (1 week)

Texts

There are many books on upper atmospheres that you can access through the Engineering Library to provide a different point of view on the material we will cover in class. We will also be accessing journal articles from Journal of Geophysical Research, Geophysical Research Letters, Journal of Atmospheric and Solar-Terrestrial Physics and others. The primary books are:

- Ionospheres: Physics, Plasma Physics, and Chemistry, second edition, Robert Schunk and Andrew Nagy, Cambridge University Press, 2009.
- Fundamentals of Plasma Physics, third edition, J. A. Bittencourt, Springer Science, 2004.

Supplementary material will come from other references:

- The Earth's Ionosphere, Plasma Physics and Electrodynamics, Michael Kelley, Academic Press.
- Introduction to Ionospheric Physics, Henry Rishbeth and Owen Garriott, Academic Press.
- Aeronomy, Part A and B, Peter Banks and G. Kockarts, Academic Press.
- Aeronomy of the Middle Atmosphere, Guy Brasseur and Susan Solomon, D. Reidel Publishing Company.
- Physics of the Upper Polar Atmosphere, Asgeir Brekke, John Wiley and Sons.
- Partially Ionized Gases, M. Mitchner and C. H. Kruger, JR., Wiley series in plasma physics, 1973.
- Understanding Space Weather and the Physics Behind It, Delores Knipp, McGraw Hill.
- Atmospheres and Ionospheres of the Outer Planets and their Satellites, Sushil Atreya, Springer-Verlag.
- Physics of Solar System Plasmas, Thomas Cravens, Cambridge University Press.
- Physics of the Earth's Space Environment, Gerd Prolss, Springer publishing.
- The High-Latitude Ionosphere and its Effects on radio Propagation, R. Hunsucker and J.K. Hargreaves, Cambridge University Press.
- The Upper Atmosphere and Solar-Terrestrial Relations, J.K. Hargreaves, Van Nostrand Reinhold Company.

- Physics of the Space Environment, Tamas Gombosi, Cambridge University Press.

Web resource material can be found at:

- Space Weather Technology, Research, and Education Center (SWx TREC)
<https://www.colorado.edu/spaceweather/>
- SWx TREC Data Portal, <https://lasp.colorado.edu/space-weather-portal/home>
- SWx TREC Model-Staging Platform
<https://www.colorado.edu/spaceweather/applications-data/space-weather-model-staging-platform>
- NRL MSIS , <https://map.nrl.navy.mil/map/pub/nrl/NRLMSIS/NRLMSIS2.0/>
- NASA IRI, <http://iri.gsfc.nasa.gov/>
- NCAR TIEGCM, <http://www.hao.ucar.edu/modeling/tgcm/>
- NASA CCMC, <http://ccmc.gsfc.nasa.gov/>
- SPENVIS, <http://www.spennis.oma.be/announcement.php>
- OMNIWEB, <http://omniweb.gsfc.nasa.gov/>

Class Format

The course will involve weekly lectures on topical material outlined above in the course content. These lectures will be provided by the instructors and invited speakers. Homework and a mid-term take home exam will be issued. A student project will be required. The class will conclude with final oral and written reports of each student's project. Student presentations will involve research, analysis, and demonstrated understanding of theory. Students will be evaluated by their peers and instructors. Students will participate in both the oral presentations and written reports by providing peer reviews of the work presented.

Course Grading

50% Homework (3 HW assignments: #1-20%, #2-15%, and #3-15%)

50% Final Project (Oral report – 15%, Written report- 30%, Report review-5%)

100% Total

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. 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 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.

CU Boulder currently requires masks in classrooms and laboratories regardless of vaccination status. This requirement is a precaution to supplement CU Boulder's COVID-19 vaccine requirement. Exemptions include individuals who cannot medically tolerate a face covering, as well as those who are hearing-impaired or otherwise disabled or who are communicating with someone who is hearing-impaired or otherwise disabled and where the ability to see the mouth is essential to communication. If you qualify for a mask-related accommodation, please follow the steps in the “Accommodation for Disabilities” statement on this syllabus. In addition, vaccinated instructional faculty who are engaged in an indoor instructional activity and are separated by at least 6 feet from the nearest person are exempt from wearing masks if they so choose.

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 \(contacttracing@colorado.edu\)](#). Please provide an email notification indicating you are ill and it is interfering with your ability to complete course work. You are not required to inform the instructor of the nature of your illness, and you are not required to submit a doctor's note.

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.

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 Conduct & Conflict Resolution policies](#).

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 academic integrity policy. 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 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 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. The university 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 or against 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 email cureport@colorado.edu. Information about university policies, [reporting options](#), and the 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 incidents of sexual misconduct, dating and domestic violence, stalking, discrimination, harassment and/or related retaliation, to ensure that individuals impacted receive information about their rights, support resources, and reporting 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.

Plagiarism

This course includes a research project and final written report. In constructing the research paper it is expected that ideas and concepts will come from specific reference material. It must be demonstrated that this material supports the original premise of your research project and is properly referenced.

Other Policies

Please be respectful of others during class time. This includes turning off your cell phone before class and not talking during class unless you have the floor.