ASEN 6519 Aerospace Environments – Upper Atmospheres

Syllabus, Spring 2020

Lecture: AERO 114 T, Th 1:00-2:15 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 (3 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 (4 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 book is:

- Ionospheres: Physics, Plasma Physics, and Chemistry, second edition, Robert Schunk and Andrew Nagy, Cambridge University Press, 2009.

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:

- NRL MSIS , https://www.nrl.navy.mil/ssd/branches/7630/modeling-upper-atmosphere
- 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.spenvis.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

20%	Homework
30%	Take Home Exam
50%	Final Project
100%	Total

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 or injury, see Temporary Medical Conditions under the Students tab on the Disability Services website.

Classroom Behavior

Students and faculty each have responsibility for maintaining an appropriate learning environment. 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.

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 a positive and welcoming learning, working, and living environment. CU Boulder will not tolerate acts of sexual misconduct, intimate partner abuse (including 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, 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, all dates for exams, assignments and presentations are fixed in the course schedule. Please review the course schedule and let us know if certain dates conflict with your religious obligations. See the campus policy regarding religious observances for full details.

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.