Syllabus:
ASEN 6050 – Space Instrumentation

Instructor: Prof. Zoltan Sternovsky, (303) 819-2783, Zoltan.Sternovsky@colorado.edu
Lecture Time: Tuesday/Thursday 11:30 am – 12:45 pm
Location: AERO 114 for Section -001, Lecture capture for Section -002
Office Hour: remote over zoom on Wednesdays 5-6 pm (both sections) – *may be updated based on student needs*
Class Zoom (OHs, exams, all other communications): https://cuboulder.zoom.us/j/95347034587 (Meeting ID: 953 4703 4587, Passcode: 6050)
Webpage: Canvas: https://canvas.colorado.edu/
Reading material: There is no required textbook, reading material will be posted for each lecture

Overview

Developing scientific instruments for space applications requires close collaboration between scientists and engineers. The process begins with identifying a compelling scientific question, followed by deriving the measurement requirements, and culminates in designing and constructing a unique instrument capable of collecting the data needed to address the original question. Such instruments typically operate based on physical principles or phenomena that must be understood in detail. An additional challenge lies in understanding and mitigating the effects of the space environment on instrument performance and longevity.

The hardware must be designed and developed within a complex framework of constraints, including cost, mass, power consumption, and data rate limitations, as well as restrictions imposed by mission design and operations.

This course provides an introductory overview of space instrumentation from the perspective of an *instrument scientist*—the individual who links science goals to measurement requirements, selects the appropriate measurement method and detector, defines the key characteristics of the instrument, and evaluates all aspects of its operation in the relevant environment. Building space instruments involves three core elements:

1. Understanding the space environment and its impact on instrument design and performance.
2. Familiarity with basic detector types, their operating principles, capabilities, and limitations.
3. The knowledge of measurement techniques and the performance of past or existing instruments.

The course reviews fundamental concepts and surveys common types of instruments used in a variety of planetary and heliophysics missions. Emphasis is placed on *in situ* instrumentation, as remote-sensing concepts and hardware are covered in greater detail in other available courses.

Course Outline

Space environment

- Vacuum (from surface to space, and the laboratory)
- Thermal environment and basic thermal design concepts
- Solar radiation (solar spectrum and effects on measurements/instruments)

- Other sources of radiation
- Galactic rays
- Radiation environment and its effect on measurements/instruments
- Plasma and charged particle environment
- Space debris and micrometeoroid environment

Review of relevant elementary physical processes:

- Secondary electron emission (SEE), ion-surface interactions, photoemission, ionization, particle and photon scattering.

Materials for space instruments:

- CTE, outgassing, mass loss, radiation damage, various properties and limitations

Detectors:

- Photon detectors
- Particle detectors

Electronics:

- Front-end electronics basics. Voltage, current and charge measurements and their sensitivities, bandwidth characteristics.

Space Instruments *, **

- Dust detectors and analyzers
- Magnetometers
- UV spectrometers
- IR instruments (thermal imaging, spectrometers)
- Imaging/cameras
- Neutral/ion mass spectrometers
- Plasma instruments (Faraday cups, solar wind analyzers, energetic particle detectors
- Neutral particles (high and low energy)

** For each instrument type, we will review the relevant scientific questions it can address, the underlying physical principles of the measurement, the key performance parameters, and the designs of past instruments as well as those currently in development.*

*** Space instrumentation and its capabilities are advancing rapidly, driven by new technologies, improved materials, and innovative measurement techniques. Every effort is made to keep the course material current, reflecting recent developments and emerging trends in the field. Nevertheless, the focus remains on the*

fundamental principles and core concepts that provide the foundation for understanding and designing any space instrument.

Prerequisites

ASEN 5335 Space Environment.

Homework, exams and grades

Component	Notes	Percentage
Homework (weekly/biweekly)	Due one week after the assignment	20%
Mid-term paper	Short paper describing the measurement principle of documented instrument of your choosing.	10%
Mid-term oral exam*	Covered topics: the space environment and detector types.	30%
Final oral exam*	Covered topics: measurement principles and instrument types.	40%
Final grade	Weighted average from above	

** The oral exams are 'closed book' one-on-one with the instructor. The questions will be assigned at random and there will be time (~30 minutes) to prepare for the discussion. The oral exam is to assess the conceptual understanding of the topic or measurement principle.*

The final grade will be calculated as weighted average from the table above. The default grading scheme (in canvas) will be used for the final letter grade.

Artificial Intelligence (AI) policy

You may use gen AI tools in this course however you see fit, including the homework and mid-term paper assignments. However: (1) Keep in mind your own and others' privacy implications and security risks when using gen AI tools, (2) **If you use gen AI tools on assignments in this class, you *must* document your usage following the *Chicago Manual of Style* or appropriate citation guidelines for this course**, and (3) Remember that AI can (and will) make mistakes.

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 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 illness, injury or required medical isolation for which you require adjustment, please contact the instructor as soon as possible.

Accommodation for Religious Obligations

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, attendance is not required. See the campus policy regarding religious observances for full details.

Preferred Student Names and Pronouns

CU Boulder recognizes that students' legal information does not always align with how they identify. If you wish to have your preferred name (rather than your legal name) and/or your preferred pronouns 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.
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Sexual Misconduct, Discrimination, Harassment 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 OIEC@colorado.edu. Information about university policies, reporting options, and OIEC support resources including confidential services can be found on the OIEC website.

Please know that faculty and graduate instructors are required to inform OIEC when they are made aware of incidents related to these concerns regardless of when or where something occurred. This is to ensure the person impacted receives outreach from OIEC about resolution options and support resources. To learn more about reporting and support a variety of concerns, visit the Don't Ignore It page.