NORTHERN ARIZONA UNIVERSITY

Department of Astronomy and Planetary Science

AST 550: Spectroscopy

Semester: Fall 2024
Prerequisites: None
Location: Physical Sciences (Building 19), Room 218
Meeting Time: Monday & Wednesday 12:45-2:00 pm
Course Credit: 3 credits, Letter Grade Only
Instructors: Dr. Christopher Edwards, christopher.edwards@nau.edu, (928) 523-7234
Dr. Cristina Thomas, cristina.thomas@nau.edu, (928) 523-0294
Office Hours: By appointment

Course Purpose

This course will discuss the fundamental principles of spectroscopy in the context of laboratory work, observational astronomy, and planetary science. The course will take a quantitative perspective on spectroscopy using foundational wave equations, light interactions with materials, details of instrumentation and spectroscopic methods, as well as applications to laboratory studies and planetary science.

Course Description

This course is a lecture-based course that meets for three hours per week to discuss the fundamental principles outlined above and to develop the analytical tools to apply these principles to various scientific problems. These topics will be introduced in class and supplemented with assigned readings that support the course lectures. These readings will be assigned weekly from outside materials. Homework sets will be assigned to explore spectroscopic principles and to provide practice in their application. In the first half of the semester, students will develop a short proposal on a topic of their choice that is relevant to spectroscopy. In the latter half of the course, students will examine how to apply spectroscopic instruments to current research questions and will develop a spectrometer instrument concept proposal. Students will work with the instructors to develop a topic suitable for the proposals.

Course Objectives & Learning Outcomes

The primary objectives of this course are to develop a quantitative understanding of the governing fundamental principles of spectroscopy and to develop the tools to apply these principles to particular problems of scientific interest. This course will be broken out into several topics. In general, this course will move from a more theoretical discussion to measurement techniques and applications.

By the end of the semester, students will be able to:

- Quantitatively describe the interaction of electromagnetic waves with materials and Maxwell's equations

- Understand how spectroscopy works and how it can be used over the electromagnetic spectrum (e.g. gamma, x-ray, visible, infrared)
- Discuss the limitations and applications of spectroscopic modeling (Hapke, unmixing, etc.)
- Describe (at a high level) the basic functions of and differences in instrumentation and spectroscopy methods (FTIR, grating, Raman, etc.)
- Discuss applications of spectroscopy in the lab, across the solar system, and through telescopic observations (e.g. spectroscopy of planetary surfaces, interpretation, etc.)
- Develop proposals from conception to completion

Assessment

Course assessment will include homework, class participation, the research proposal components (outline, proposal), instrument proposal (outline, proposal, presentation)

Homework (3 assignments, 50 pts each)	150	90% and above	A
Class Participation	50	80 - 89%	B
Research Proposal Outline	50	70 - 79%	C
Research Proposal	100	60 - 69%	D
Research Proposal Peer Review	50	59% and below	F
Instrument Concept Proposal Outline	50		
Instrument Concept Proposal	200		
Instrument Concept Proposal Presentations	50		
	700 Total		

Homework: The homework assigned in this course will primarily cover the applications of spectroscopic methods. These homework assignments are focused on theory and application of spectroscopic methods. The application focused homework can be completed in the programming language of the student's choice but all code must be submitted with the assignments.

Class Participation: Active class participation (engaged in discussions, examples from reading and research, spectroscopy in the news, etc.) will be used to assess this portion of the student's grade.

Research Proposal: A short proposal focusing on a scientific topic of your choice (telescope/spacecraft/lab, solar system/stars/galaxies) where you will conceive of a research topic, describe its scientific importance, methodology and expected outcomes. The proposal is not intended to focus on your specific ongoing research projects. This proposal will start with an outline developed with feedback from the instructors. Research proposals will also be peer reviewed (~2-3 reviews per proposal) with a provided review template.

Instrument Concept Proposal: An instrument concept focusing on developing an instrument that would be useful for your area of research interest. In this proposal, you will conceive of an instrument to make needed measurements to address specific scientific questions. The proposal must justify the scientific basis, instrument performance details, and feasibility. Like the research proposal, an outline will be developed first. The concepts will be presented to the class (~10 minutes) at the end of the semester.

Reading Assignments: Reading assignments will be given out prior to the start of each topic, as necessary. There will generally be one or two readings per topic that will be taken from an outside source (i.e., journal article) that will be provided. These readings are designed to augment the discussion in class and as such should be completed prior to the day in which the material will be covered.

Course effort: At a minimum, you should plan on spending an additional 5-10 hours per week on this class outside of our scheduled meeting times. In addition to formal assignments you should also review what we have covered previously and look ahead to what is coming.

Suggested Materials & Technology

These materials are available in the NAU library.

- Suggested: Mineralogical Applications of Crystal Field Theory, by Burns
- Suggested: Symmetry and Spectroscopy, by Harris and Bertolucci

Class Schedule

The most up to date class schedule and materials can be found under the Shared Google Drive Folder: https://drive.google.com/drive/folders/1uqtkOppW1YNwCOSskGro5849lrdakq9v?usp=sharing

Class, Departmental, & University Policies

- As a courtesy to the instructors and to your fellow students, please come to class on time.
- All assignments are due at 5pm MST on the specified date. Students are expected to complete all assignments on time. Any requests for additional time need to be submitted to both instructors at least 2 days in advance and need to be adequately justified.
- Please refrain from any other "electronic distractions" (e.g., answering emails, text messaging, browsing social media) during class. If you are anticipating disruptions during class for any personal or professional reasons, please notify the professors prior to class.
- Please disclose any disabilities or special requirements to the NAU Disabilities Resources Office (DR.Registration@nau.edu, (928) 523-8773), who will contact the instructors privately regarding any accommodations.
- Neither audio or video recording will be permitted except under special circumstances prescribed by the NAU Disability Resources Office or discussed with the professor prior to class.

NACE Career Readiness Competencies: The National Association of Colleges and Employers (NACE), the leading source of information on the employment of the college educated, have identified eight Career Readiness Competencies (CRC), a foundation from which to demonstrate requisite core competencies that broadly prepare the college educated for success in the workplace and lifelong career management. The CRCs are identified to be aligned to the assignments:

1. Career & Self-Development: Proactively develop oneself and one's career through continual personal and professional learning; awareness of one's strengths and weaknesses.
2. Communication: Clearly and effectively exchange information, ideas, facts, and perspectives with personals inside and outside of an organization
3. Critical Thinking: Identify and respond to needs based upon an understanding of situational context and logical analysis of relevant information
4. Equity & Inclusion: Demonstrate the awareness, attitude, knowledge, and skills required to equitably engage and include people from different local and global cultures.
5. Professionalism: Knowing work environments differ greatly understand and demonstrate effective work habits, and act in the interest of the larger community and workplace
6. Teamwork: Build and maintain collaborative relationships to work effectively toward common goals, while appreciating diverse viewpoints and shared responsibilities
7. Technology: Understand and leverage technologies ethically to enhance efficiencies, complete tasks, and accomplish goals

Career Ready Resources:

LinkedIn:

CEFNS Career Development
www.linkedin.com/in/cefns-career-development-072715233
NAU Career Development
https://www.linkedin.com/company/nau-career-development/

Handshake:

https://nau.joinhandshake.com/login

Udemy: Online courses and career searching advice

https://in.nau.edu/its/udemy/
Log in with your NAU email account and search 'NAU Career Steps'

O*net Online: Occupation exploration reports

https://www.onetonline.org/