ES 206: Instrumental and Spectroscopic Methods in Environmental Systems
Fall 2021 (3 credits)

Instructor: Peggy O'Day (poday@ucmerced.edu), office SRE 457; (209) 228-4338
Weekly meeting time: Tues. & Thurs., 3:00 – 4:15 pm, GLCR 165
Lab sessions: By individual and group arrangement
Office Hours: By appointment

Course Description: This course is a survey of the principles and application of commonly used instrumental and spectroscopic methods applied to the analysis of environmentally related materials, including inorganic, organic, and biological samples. Course content will cover the basic theory of different instrumental and spectroscopic methods, and their associated advantages, limitations, and errors. Discussion/laboratory sessions will give students practical exposure to instruments and methods, and their application to different types of environmental samples. Students will complete an individual project over the course of the semester using one or two of the methods surveyed that will aid in their dissertation or thesis research.

This course is intended for graduate students in science, engineering, or other areas who are interested in learning both the basic principles and practical application of analysis methods for environmental materials.

Prerequisite: Graduate standing; environmental or analytical chemistry, materials chemistry, or equivalent courses suggested.

Format: Scheduled class time will be used for a mixture of lecture, discussion, and lab demonstrations and exercises. Additional flexible laboratory time will be scheduled for student training and data collection on instruments of their choice for their semester project.

Course content will focus on basic theory, principles, and applications of different instrumental, analytical, and spectroscopic methods, and discuss practical aspects such as sample preparation, sample compatibility, and error analysis. Laboratory sessions and assignments will survey different instrumentation, develop skills in analytical and statistical methods, and provide students with practical experience.

Each student will select one or two instruments or methods for their semester research project and carry out detailed analyses. *Everyone is encouraged to develop a project that benefits your dissertation or thesis research.* You will gain experience in preparing a brief research proposal on your project, and results will be presented to the class in oral presentations. Students will prepare a final report on their project in the style of a manuscript for peer-reviewed publication.

Reading: Book chapters, review articles, and supplemental reading for the different methods surveyed in the course will be provided electronically on the Catcourses site.

Grading (Letter grade only[1]): The majority of work in this course will be associated with your individual term project. Additional assignments, class exercises, and a mid-term exam are aimed at development of analytical skills and knowledge. Final grades will be assigned based on:

Research project proposal and written final report: 50%
In-class oral presentations: 15%
Mid-term exam (take-home): 20%
Assignments and class participation: 15%

Development and execution of your semester project will be based the following elements:

- Written proposal explaining the justification and scope of your term project (3 pages), and instrument budget and justification (1 page)
- Written standard operation procedure (SOP) for your instrumental method
- Short oral presentations on your proposed project and preliminary results
- Final oral presentation of project results in the style of a professional meeting
- Final written project report (10 page maximum)

Campus Resources, Policy, and Student Expectations
See the "Resources & Policy" page on the Catcourses site for campus-wide policies and links to campus resources, including student accommodations.

Course policies: Students are expected to come to all classes, be prepared to engage fully in class activities, and to work independently outside of class time. Given the ongoing challenges of Covid-19, prepare to be flexible with changes in class schedule and instrument availability. I realize that each of you faces different personal and home situations. Please contact me as soon as possible if you are unable to attend class or experience difficulties in meeting the expectations of this course for whatever reason.

Your attendance and participation in class activities are important parts of this course. You are expected to come to all classes prepared to engage in activities, to work on assignments and your term project outside of class, and to carry out independent research. Please be considerate of your classmates. *All cell phones, electronic devices, and other noisemakers should be off during class.* Please do not disrupt class by arriving late or leaving early. Students are expected to complete all laboratory and instrument safety training before using any instruments, and all safety protocols must be strictly followed.

Academic Integrity: Working collaboratively with your classmates and outside colleagues is encouraged! We will do group activities in class, and share expertise and knowledge. Some assignments will be peer-reviewed by class members. Any assignments submitted for grading should be your own work. Any information or material taken from published sources (in print or electronic) should be properly attributed. Discussions about ideas and approaches are not cheating; the exchange of finished, written answers is cheating. Direct copying from other

[1] Per university policy for graduate degree programs, a letter grade of B or higher must be achieved in this course in order to receive credit towards your degree.

sources, either published or from individuals, is plagiarism. Cheating and plagiarism will be subject to disciplinary action by University policies. Further information about campus policies on academic integrity is detailed in the "Resources & Policy" page on the Catcourses site.

Course Learning Outcomes: By the end of this course, students should have attained the following:

- Basic understanding of different instrumental, analytical, and spectroscopic methods commonly used for the analysis of environmental samples.
- Working knowledge of the information obtained from an analysis using a particular method, and the ability to recognize which instruments or methods are most appropriate for a particular type of sample or desired chemical or physical information.
- Knowledge of different types of errors associated with each method and ability to perform appropriate error analysis.
- Ability to formulate a research question and hypothesis related to the student's dissertation or thesis research, and to design a tractable sample analysis approach for a testing the hypothesis.
- Ability to effectively communicate scientific research results in oral presentations.
- Ability to prepare a manuscript reporting scientific research results in the format and style of a paper for peer-reviewed publication.

Program Learning Outcomes: This course supports the following ES program learning outcomes:

- **Core Knowledge** - Graduates will be knowledgeable, skillful and self-directed in the observation and analysis of environments systems in terms of their capacity to independently identify important research questions, formulate experimental plans, analyze data, and formulate conclusions in the context of a doctoral dissertation
- **Communication Skills** - Graduates will be conversant in at least two areas of environmental systems, and be adept at oral, written and visual communication of research results to peers and non-technical decision makers
- **Career Placement and Advancement** - Graduates will find suitable career placement and achieve advancement in government agencies, non-government organizations, private industry, and/or academic teaching and research institutions

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Course Schedule (subject to change): Topics and in-class activities will be refined further based on student research and project-related interests.

Week 1 (8/26)	No class.
Week 2 (8/31, 9/2)	Introduction: Course objectives, format, and expectations Overview of analytical methods, principles, and quantification Discussion: Introductions and research interests
Week 3 (9/7, 9/9)	Analysis of error and uncertainty Assignment: Errors and statistics Principles of spectrometry and spectroscopy Discussion: Developing student projects
Week 4 (9/14, 9/16)	Principles of spectrometry and spectroscopy Thurs -- Tour of the Environmental Analytical Lab (EAL)
Week 5 (9/21, 9/23)	Basic principles of electron microscopy Thurs -- Tour of the Imaging and Microscopy Facility (IMF)
Week 6 (9/28, 9/30)	Procedure development and standard operating procedure (SOP) Assignment: Writing a SOP Thurs: Student presentations: 5-minute project aims and approach
Week 7 (10/5, 10/7)	Sampling methods; sample handling, storage, preparation SOP peer-review and discussion
Week 8 (10/12, 10/14)	Studying surfaces and interfaces Lab exercise: BET surface area
Week 9 (10/19, 10/21)	Absorption and emission of energy Lab exercise: Spectrophotometry
Week 10 (10/26, 10/28)	X-ray absorption, excitation, and diffraction Discussion: Progress on research projects
Week 11 (11/2, 11/4)	Review **Take-home Midterm**
Week 12 (11/9)	Preparing research papers and oral presentations **11/11: Veteran's Day Holiday (no class)**

Week 13 (11/16, 11/18)	Topical lecture Thurs: Student presentations -- Project updates
Week 14 (11/23, 11/25)	Thanksgiving Week (no class)
Week 15 (11/30, 12/2)	Topical lecture Progress on research reports
Week 16 (12/7, 12/9)	**Final student project oral presentations** **Final Project Reports due (Thursday, Dec. 16)**