

Introduction to Chemical Instrumentation

CHM 5140

Time: Tu & Th 9:45AM - 11:00AM

Location: MCH 0220

Dr. Xiangpeng Li

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Phone: (850) 645-8617

Office Hours: Any time except Thursdays. Stop by my office, call, or email to check for availability.

Description: This course covers the principles, design, operation, and applications of modern chemical instrumentation across analytical chemistry, physical chemistry, biochemistry, biology, and environmental science. Graduate students will learn the theoretical foundations of measurement techniques, the functions of key instrument components, and methods for interpreting data. Topics include measurement fundamentals, atomic spectroscopy, molecular spectroscopy, separation methods, and advanced instrumentation such as microfluidics and genetic sequencing. The course will also incorporate critical discussions of recent literature in chemical instrumentation to highlight current trends and innovations, as well as project-based learning through hands-on instrument design using Arduino platforms or mobile phones. By the end of this course, students will understand how modern chemical instruments are designed, built, and operated, and how their components work together to produce analytical data. This knowledge will enable students to evaluate the strengths and limitations of different techniques and make informed choices in laboratory and research applications.

Learning Objectives: By the end of this course, students will be able to:

- Explain the theoretical principles underlying major categories of chemical instrumentation, including spectroscopic, separation, electrophoretic, and sequencing techniques.
- Describe how chemical instruments are designed, built, and operated, including the functions of key components such as sources, optical elements, detectors, electronics, and data acquisition systems.
- Apply concepts of signals, noise, and Fourier transformation to evaluate measurement quality and instrument performance.
- Operate selected analytical instruments and interpret data from spectroscopic, chromatographic, mass spectrometric, and sequencing platforms.
- Design, construct, and test a simple analytical instrument or sensing system through project-based learning using platforms such as Arduino or mobile devices.
- Compare the advantages, limitations, and appropriate applications of different analytical techniques in chemical, biological, and environmental contexts.

- Design and justify an analytical strategy for a given problem, including instrument selection, method validation, and quality control considerations.

Lecture Topics (The order of the lecture is subject to change):

1. Introduction to instrumental methods
2. Electrical component and circuits
3. Operational amplifier in chemical instrumentation
4. Digital electronics and computers
5. Signals and noise
6. Fourier transform
7. Spectrometric methods
8. Components of optical instruments
9. Ultraviolet-visible molecular absorption spectrometry
10. Fluorescence spectrometry
11. Luminescence spectrometry
12. Infrared spectrometry and Raman spectrometry
13. Microscopy and image analysis
14. Nuclear magnetic resonance spectroscopy
15. Mass spectrometry
16. Chromatographic separation
17. Electrophoresis and Sanger sequencing
18. Microfluidics
19. Next generation sequencing
20. Statistical analysis and analytical method validation

Instrument Design Assignment: Groups of 2–3 students will work together to design an analytical instrument using Arduino platforms or mobile phones. Dr. Li will provide up to 10 Arduino kits, and special electronic components may be requested for purchase. If a group chooses a mobile phone-based project, the group is responsible for providing the phone. Raspberry Pi or other microcontrollers are allowed, but the group must supply the kits. This project will span the entire semester, culminating in a poster presentation of results. Detailed guidance and examples will be provided by Dr. Li during in-class preparation sessions.

- 1) Project design (due by the 3rd week of 2nd month)
 - Submit one paragraph outlining the proposed instrument design.
 - Include the selection of samples and standards for testing.
 - Provide a data analysis plan.
 - Dr. Li will provide feedback and may supply samples as needed..
- 2) Prototype (due by 2st week of 3rd month).
 - Submit a one-page description of the prototype instrument design.
 - Include preliminary data or proof-of-concept results.
 - Dr. Li will provide feedback.
- 3) Presentation (due by 2-3 weeks before the final exam)
 - Each group will prepare a poster.
 - Each member's contribution must be clearly described.
 - Judges outside the class will be invited to provide feedback and judge the projects.
 - Additional details will be provided by Dr. Li during in-class preparation.

4) Resources:

- Arduino Tutorials (<https://docs.arduino.cc/tutorials/>)
- FSU Digital FabLab (<https://www.innovation.fsu.edu/fablab>). The FSU FabLab is equipped with 3D printers, laser cutters, and electronic soldering stations, freely accessible to students.

Grading: The grading will be based on class participation, assignment, project presentation and exam.

Items	Percentage
Class Participation	10%
Mid-term Exam I	15%
Mid-term Exam II	15%
Final Exam	30%
Project & Presentation	30%

Grading Scale:

GRADE	PERCENTAGE
A	95% to 100%
A-	90% to <95%
B+	87% to <90%
B+	84% to <87%
B-	80% to <84%
C+	75% to <80%
C+	70% to <75%
C-	65% to <70%
D	60% to <65%
F	0% to <60%

Class Participation: It is extraordinarily difficult to do well in this class without attending lectures. If you do not plan on attending lectures, please drop the course now. Students are expected to take notes, actively participate in class discussion and group activities.

Exam: There will be two mid-term exams and one final exam during the semester.

- Mid-term Exam I will cover material from the first portion of the course (topics and readings up to that point). (2nd or 3rd week of the 2nd month)
- Mid-term Exam II will cover material from the middle portion of the course. (4nd week of the 3rd month or 1st week of the 4th month)
- The Final Exam will be cumulative, emphasizing conceptual understanding, instrument design, data interpretation, and evaluation of analytical approaches.
- Requests for make-up mid-term exams must be submitted at least one week before the scheduled exam date.

- Official final exam dates will be announced by the FSU University Registrar and posted on Canvas.

Required Items:

- Computer: Each pair of students will be required to bring one or more devices for in-class activities and projects. Laptop computers, tablets, and even smartphones are functional. I strongly recommend the use of laptops, in lieu of smartphones or tablets.

Resources:

- **Textbook** (not required): Skoog, Holler, Crouch, Principles of Instrumental Analysis 7th ed., (ISBN-10: 1-305-57721-3).
- All other reading materials will be provided via Canvas.

Schedule:

	Date	Day	Topic
1	1/8/2026	Thursday	Introduction to instrumental methods (data domain and instrument components)
2	1/13/2026	Tuesday	Calibration of Instrumental Methods
3	1/15/2026	Thursday	Electrical component and circuits
4	1/20/2026	Tuesday	Operational amplifier in chemical instrumentation
5	1/22/2026	Thursday	Digital electronics and computers
6	1/27/2026	Tuesday	Signals and noise
7	1/29/2026	Thursday	Spectrometric methods
8	2/3/2026	Tuesday	Components of optical instruments
9	2/5/2026	Thursday	Mid-term 1
10	2/10/2026	Tuesday	Ultraviolet-visible molecular absorption spectrometry
11	2/12/2026	Thursday	Fluorescence spectrometry
12	2/17/2026	Tuesday	Fluorescence: FRET
13	2/19/2026	Thursday	Fluorescent: Anisotropy
14	2/24/2026	Tuesday	Fluorescent: life time
15	2/26/2026	Thursday	Luminescence spectrometry
16	3/3/2026	Tuesday	Infrared spectrometry and Raman spectrometry
17	3/5/2026	Thursday	Microscopy and image analysis
18	3/10/2026	Tuesday	Nuclear magnetic resonance spectroscopy
19	3/12/2026	Thursday	Mass spectrometry-1
	3/17/2026	Tuesday	spring break
	3/19/2026	Thursday	spring break
19	3/24/2026	Tuesday	Mass spectrometry-2
20	3/26/2026	Thursday	Mid-term 2
21	3/31/2026	Tuesday	Chromatographic separation
22	4/2/2026	Thursday	In class Project Presentation
23	4/7/2026	Tuesday	In class Project Presentation
24	4/9/2026	Thursday	Electrophoresis and Sanger sequencing

25	4/14/2026	Tuesday	Microfluidics
26	4/16/2026	Thursday	Next generation sequencing
27	4/21/2026	Tuesday	Statistical analysis and analytical method validation
28	4/23/2026	Thursday	Review (Last day of class)
	4/28/2026	Tuesday	final exam 7:30-9:30

University Attendance Policy: Excused absences include documented illness, deaths in the family and other documented crises, call to active military duty or jury duty, religious holy days, and official University activities. These absences will be accommodated in a way that does not arbitrarily penalize students who have a valid excuse. Consideration will also be given to students whose dependent children experience serious illness.

Academic Honor Policy: The Florida State University Academic Honor Policy outlines the University's expectations for the integrity of students' academic work, the procedures for resolving alleged violations of those expectations, and the rights and responsibilities of students and faculty members throughout the process. Students are responsible for reading the Academic Honor Policy and for living up to their pledge to ". . . be honest and truthful and . . . [to] strive for personal and institutional integrity at Florida State University." (Florida State University Academic Honor Policy, found at <http://dof.fsu.edu/honorpolicy.htm>.)

Americans With Disabilities Act: Students with disabilities needing academic accommodation should: (1) register with and provide documentation to the Student Disability Resource Center; and

(2) bring a letter to the instructor indicating the need for accommodation and what type. This should be done during the first week of class.

This syllabus and other class materials are available in alternative format upon request.

For more information about services available to FSU students with disabilities, contact the:

Student Disability Resource Center 874 Traditions Way 108 Student Services Building Florida State University Tallahassee, FL 32306-4167 (850) 644-9566 (voice) (850) 644-8504 (TDD) sdrc@admin.fsu.edu <http://www.disabilitycenter.fsu.edu/>

Free Tutoring from FSU: On-campus tutoring and writing assistance is available for many courses at Florida State University. For more information, visit the Academic Center for Excellence (ACE) Tutoring Services' comprehensive list of on-campus tutoring options – see <https://ace.fsu.edu/tutoring> or contact tutor@fsu.edu. High-quality tutoring is available by appointment and on a walk-in basis. These services are offered by tutors trained to encourage the highest level of individual academic success while upholding personal academic integrity.

Syllabus Change Policy: Except for changes that substantially affect implementation of the evaluation (grading) statement, this syllabus is a guide for the course and is subject to change with advance notice.

Statement on Public Health Protocols: During any adverse event or condition that threatens our university community, please look for specific information on the FSU Alerts page (<https://alerts.fsu.edu/>) to ascertain particulars to the current situation. Please be patient with one another while we navigate any ongoing challenge. Whatever happens, we are committed to helping you learn the material thoroughly and stay on schedule with your degree program.

Please choose only one (1) Class Recording statement from below as appropriate for your course:

Statement for Courses Not Subject to HB233 Recording

In this class, consistent with state law and university policy, you may not make recordings of classroom activities without the permission of the instructor. This policy applies to both audio and video recordings.