



Instrumental Analysis

CHEM 21

Instructor Info



David Punihaole, PhD



Office Hours: 7:00 - 18:00 (W)



Innovation Hall E352



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Course Info



Prereqs: CHEM 21



M/W/F



08:30 - 09:20



VOTEY BLDG 305

Overview

This 3-credit course presents a survey of instrumental methods of chemical analysis. Since this course is 3-credits, students are expected to devote, on average, about 9 hours a week towards working on homework, projects, and studying. Students are expected to draw upon knowledge from previous courses they have taken, including General Chemistry, Quantitative Analysis, Introductory Physics, and Calculus. We will focus on understanding the fundamental principles underlying different methods and their realization in modern instrumentation for chemical analysis. We will focus on the following broad methodological areas:

- Spectroscopy
- Chromatography
- Mass Spectrometry
- Electrochemistry

This is not a "how-to" course. You will not learn how to operate analytical instruments nor will we cover specific analytical "recipes." These change (sometimes quite quickly) with time as the discipline grows, so our focus on principles and concepts of implementation should provide greater insight both into how current instruments work as well as the basis for your understanding how they will work a decade from now. Lastly, we will pay attention to the chemical systems to which these methods are applicable and how best to obtain the chemical information desired using the most appropriate instrumental methods.

Learning Objectives

This course fulfills core competencies in analytical/critical thinking and quantitative reasoning/applied data interpretation. You should develop an understanding of the analytical capabilities of a number of instrumental methods and be able to suggest suitable instrumental methods for particular analytical problems. In order to choose the best instrumental method for addressing an analytical problem, we will consider:

- the property or quantity of the chemical system to be measured
- the physical and chemical principles upon which the measurement is based
- generation of a signal by a suitable detector (transducer) and the processing of the signal to convert it to a form appropriate for a readout device
- the strengths and limitations of each particular instrumental method

In order to make these kinds of assessments, you will need to understand:

- the chemical and/or physical principles exploited during the measurement
- how the instrument actually makes the measurement, and
- some of the techniques used to improve analytical figures of merit (such as accuracy, precision, and sensitivity).

Course Philosophy

Each of us approaches science with a different perspective informed by our personal upbringing, educational background, socioeconomic status, racial identity, ethnicity, and gender. My goal is to create a classroom environment that supports students from a diverse set of backgrounds. I strongly believe that our best path forward to making scientific progress is to promote inclusiveness and equality. It is my expectation that every member of this class will also support diversity and inclusion. As a community, we should strive to uphold the ideals of **Our Common Ground** and welcome any suggestions as to how we can promote a more diverse and inclusive classroom.

Required Textbook

Principles of Instrumental Analysis - 7th Ed. by Douglas A. Skoog, F. James Holler, and Stanley Crouch (ISBN 9781305577213)

Available at the UVM Book Store, Amazon, or the publisher, Cengage.

Grading Scheme

Grading Scale

40%	Exams, 0% each
24%	Homework, 2% each
30%	Projects, 0% each
6%	Attendance/Participation

Grades will follow the standard scale: A+ > 92-100%; A- > 89-92%; B+ > 87-89%; B > 82-86%; B- > 79-82%; C+ > 76-79%; C > 72-76%; C- > 69-72%; D+ > 66-69%; D > 62-66%; D- > 60-62%; F < 60%. Grades will be curved at the discretion of the professor. Grading curves will be different for undergraduate and graduate students.

Assessments of Graded Work

- Exams: Exams will be primarily conceptual in nature. They will be designed to test mastery and understanding of the material at a deep-level. Calculators are not necessary, but will be allowed. Exams will be open book/open notebook. Exams will typically be 4 or 5 questions, which will require short essay/answer responses.
- Homework: The purpose of homework assignments is to help students learn basic concepts presented in the course. These assignments are not designed to mimic or reflect questions that may be asked on exams. Homework assignments will be graded on a completion or best effort basis. It is entirely acceptable and encouraged to work with your peers on the weekly problem sets. The problem sets will consist of between 10 problems. Homework will be assigned on Mondays and will be due the following Monday. Late assignments will not be accepted unless otherwise excused by me.
- Projects: There will be small projects assigned during the semester. These projects are designed to allow students to study certain topics covered in class in deeper detail and may require rudimentary knowledge of coding. You may use any programming language or numerical computing environment to answer coding-related problems. Please speak to me if you do not have coding experience or require help to answer these or other problems. Late project assignments will not be accepted unless otherwise excused by me. Rubrics specifying grading criteria will be provided to the students on the date that the projects are formally assigned in class.

Course Format

Modality Description

This course will be held in-person unless otherwise specified. Students attending lecture may be required to obey strict social distancing requirements and other UVM policies as stipulated by the university's [Green and Gold Promise](#). We will give students instructions on how to proceed in the event that the course switches to an online-only format due to COVID-19 concerns.

Blackboard and Microsoft Teams

Important course announcements will be posted on Blackboard. In the event that this course switches to an online-only format, we will use Microsoft Teams to conduct the remainder of the course. The use of laptops, Pads, and other mobile devices to follow/make class notes and participate in course activities is highly encouraged. Please speak to me if this is not possible for you. Please refrain from using these devices for anything but activities related to the class.

Course Policies

General Attendance, Participation Policies, and Expectations

Attendance/participation in this course is expected for you to succeed. The [UVM attendance policy](#) outlines expectations for attendance. Students are expected to complete homework and read class notes (which will be posted prior to lecture) before class. Science has never and is not done in isolation. A major part of this course will depend upon class discussion, working in teams, or participating in other group activities. Students are expected to be team players and to maintain a respectful learning environment so that everyone is heard. Racist, sexist, or any other bigoted language will not be tolerated and are grounds for being asked to leave the class. Finally, given the content-heavy nature of this course, it is virtually impossible to cover every topic in the course notes in detail. Course lectures will be reserved for covering what I deem to be the most important or difficult topics. However, any material covered in the course notes are fair game for exams or homework assignments.

Excused Absence Policies

- **Religious Holidays:** Students have the right to practice the religion of their choice. If you need to miss class to observe a religious holiday, please submit the dates of your absence to me in writing by the end of the second full week of classes. You will be permitted to make up work within a mutually agreed-upon time frame. <https://www.uvm.edu/registrar/religious-holidays>
- **Inter-collegiate Athletics:** Members of UVM varsity and junior varsity teams are responsible for documenting in writing any conflicts between their planned athletic schedule and the class schedule by the end of the second full week of classes. You will be permitted to make up work within a mutually agreed-upon time frame.
- **Medical and Emergency Absences:** Absences due to sickness, as well as medical and family emergencies, should be brought to my attention as soon as possible. You will be permitted to make up work within a mutually agreed-upon time frame.
- **Other Absences:** Absences due to extracurricular or other activities not specified above should be brought to my attention as soon as possible so that we can work out an arrangement to make up work.

COVID-specific Policies

The University of Vermont reserves the right to make changes in the course offerings (<http://catalogue.uvm.edu/>), mode of delivery, degree requirements, charges, regulations, and procedures contained herein as educational, financial, and health, safety, and welfare considerations require, or as necessary to be compliant with governmental, accreditation, or public health directives.

Due to COVID-19 concerns, students are expected to maintain a safe atmosphere when attending class. The **Green and Gold Promise** clearly articulates the expectations that UVM has for students, faculty, and staff to remain compliant with all COVID-19 recommendations from the federal CDC, the State of Vermont, and the City of Burlington. This includes following all rules regarding facial coverings and social distancing when attending class. If you do not follow these guidelines, I will ask you to leave the class. If you forget your mask, you cannot enter the class and should go back and retrieve your mask. The **Code of Student Conduct** outlines policies related to violations of the Green and Gold Promise. Sanctions for violations include fines, educational sanctions, parent notification, probation, and suspension.

You may need to isolate or quarantine this semester due to COVID-19 concerns. If this is the case, Student Health Services will inform the Dean's office. I will then contact the Dean's office for confirmation that a student is in quarantine or isolation. Students, especially those who are asymptomatic in quarantine, will be expected to continue their academic work. I will work with students in quarantine and isolation in a mutually agreed-upon format to make-up missed course material. Students are encouraged to **email me** directly to discuss how to proceed in the course during quarantine/isolation.

Email Policy

Students are encouraged to **email me** directly to clarify any questions concerning homework, projects, or materials covered in the course. The subject line of emails should only contain the words "CHEM 21: Instrumental Analysis." Emails will be filtered using this subject line to ensure that they are not mistakenly missed. I will not respond to emails that do not contain these words in the subject line. Unless there is an emergency, I will generally only answer students' emails once a day, at around 8:30. I expect students to respond or acknowledge any emails to them within 24 hours of sending.

Recording Policy

Our class sessions may be audiovisually recorded for students in the class to refer back to, and for enrolled students who are unable to attend class in-person. Students who participate with their camera engaged or utilize a profile image are agreeing to have their video or image recorded. If you are unwilling to consent to have your profile or video image recorded, be sure to keep your camera off and do not use a profile image. Likewise, students who un-mute during class and participate orally are agreeing to have their voices recorded. If you are not willing to consent to have your voice recorded during class, you will need to keep your mute button activated and communicate exclusively using the "chat" feature, which allows students to type questions and comments live.

Important University Policies

Academic Integrity

Offenses against the Code of Academic Integrity are deemed serious and insult the integrity of the entire academic community. Any suspected violations of the code are taken very seriously and will be forwarded to the Center for Student Ethics and Standards for further investigation. Violations of the Code of Academic Integrity—including any inappropriate collaboration, collusion, cheating, corroboration, plagiarism, or any other related offense—will be fully investigated according to the rules set by the UVM Academic Integrity Office and may be punishable with a score of zero for the assignment in question. Details can be found at

<http://www.uvm.edu/policies/student/acadintegrity.pdf>

Grade Appeals

If you would like to contest a grade, please follow the procedures outlined in this policy:

<https://www.uvm.edu/policies/student/gradeappeals.pdf>

[Code of Student Conduct](#)

<http://www.uvm.edu/policies/student/studentcode.pdf>

[FERPA Rights Disclosure](#)

The purpose of this policy is to communicate the rights of students regarding access to, and privacy of their student educational records as provided for in the Family Educational Rights and Privacy Act (FERPA) of 1974.

<http://catalogue.uvm.edu/undergraduate/academicinfo/ferparightsdisclosure/>

[Promoting Health and Safety](#)

The University of Vermont's number one priority is to support a healthy and safe community:

Center for Health and Wellbeing <https://www.uvm.edu/health>

Counseling & Psychiatry Services (CAPS): Please call 802-656-3340 for assistance.

C.A.R.E. If you are concerned about a UVM community member or are concerned about a specific event, we encourage you to contact the Dean of Students Office (802-656-3380). If you would like to remain anonymous, you can report your concerns online by visiting the Dean of Students website at <https://www.uvm.edu/studentaffairs>

[Alcohol and Cannabis Statement](#)

As a faculty member, I want you to get the most you can out of this course. You play a crucial role in your education and in your readiness to learn and fully engage with the course material. It is important to note that alcohol and cannabis have no place in an academic environment. They can seriously impair your ability to learn and retain information not only in the moment you may be using, but up to 48 hours or more afterwards. In addition, alcohol and cannabis can:

- Cause issues with attention, memory and concentration
- Negatively impact the quality of how information is processed and ultimately stored
- Affect sleep patterns, which interferes with long-term memory formation

It is my expectation that you will do everything you can to optimize your learning and to fully participate in this course.

Student Resources

[Technical Support for Students](#)

Students, please read this technology [checklist](#) to make sure you are ready for classes. Students should contact the Helpline (802-656-2604) for support with technical issues.

[Research and Citation Help](#)

For help selecting research topics, finding information, citing sources, and more, ask a librarian. Although they are working remotely, librarians are always eager to help. You may ask questions by phone, e-mail, chat, or text, or make an appointment for an individual consultation with a librarian.

- Howe Library: <https://library.uvm.edu/askhowe>
- Dana Medical Library: <https://dana.uvm.edu/help/ask>
- Silver Special Collections Library: <https://specialcollections.uvm.edu/help/ask>

[Student Learning Accommodations](#)

In keeping with University policy, any student with a documented disability interested in utilizing accommodations should contact SAS, the Office of Disability Services on campus. SAS works with students and faculty in an interactive process to explore reasonable and appropriate accommodations, which are communicated to faculty in an accommodation letter. All students are strongly encouraged to meet with their faculty to discuss the accommodations they plan to use in each course.

Contact SAS:

A170 Living/Learning Center

802-656-7753

access@uvm.edu

<https://www.uvm.edu/access>

Diversity, Equity, and Inclusion Resources

The Division of Diversity, Equity, and Inclusion Center believes excellence should be inclusive of the entire University of Vermont (UVM) community and is steadfastly committed to this belief. Every day, our Division strives to make our work accessible, affirming, and action-oriented to help ensure excellence is inclusive of everyone.

<https://www.uvm.edu/diversity>

UVM Prism Center

The Prism Center serves the diverse queer and trans communities at the University of Vermont. We support and empower lesbian, gay, bisexual, transgender and queer students, as well as students whose identities fall in-between or expand beyond those categories, and work to create a campus community where people of all sexual and gender identities can thrive.

<https://www.uvm.edu/prism>

Interfaith Center

Each of us engages those questions differently, perhaps through a religious tradition, philosophy, or spiritual practice. No matter how you make meaning of your life, you are welcome at the Interfaith Center for reflection, spiritual practice, education, and community building.

<https://www.uvm.edu/interfaithcenter>

Mosaic Center for Students of Color

The Mosaic Center for Students of Color (MCSC) vision is to create a diverse and rich community of empowered, engaged, and enthusiastic students of color at UVM. We fully support the holistic development of self-identified students of color so that they can obtain their goals for academic achievement, personal growth, identity formation, and cultural development.

<https://www.uvm.edu/mcsc>

Women & Gender Equity Center

The UVM Women & Gender Equity Center cultivates joyful community while advancing gender equity across identities. We envision a brave, diverse, and equitable learning environment for all members of the UVM community. We provide advocacy services for those in our community who have experienced sexual or intimate partner violence, and strive to provide programming, education, and events that ask our community to explore the intersections of their gender and other identities.

<https://www.uvm.edu/wagecenter>

Tips for Success

Students are encouraged to attend class, do homework, come to office hours, work with peers, and ask questions to help them succeed in class. In case the course goes fully online, there are a few resources for students on remote/online learning:

- Checklist for success in <https://learn.uvm.edu/about/support-for-students/checklist-online-credit-courses/>
- Academic support for online courses: <https://www.uvm.edu/academicsuccess/online-learning-student-resources-remote-instruction>

Helpful resources other than the instructor include the Undergraduate/Graduate Writing Center, Supplemental Instruction, Learning Co-op tutors, and supplemental course materials.)

Course Schedule (Subject to Change)

Electronic Circuits, Signal and Noise

Jan 9	Lecture 1	Syllabus/Introduction
Jan 21	Lecture 2	Quantitative Analysis/Review
Jan 24	Lecture 3	Series & Parallel Circuits (HW: 2-1, 2-2, 2-5, 2-6, 2-8, 2-9)
Jan 26	Lecture 4	Voltmeters, Ammeters, Capacitors
Jan 28	Lecture 5	RC Circuits (Part 1)
Jan 31	Lecture 6	RC Circuits (Part 2) (HW: 2-11, 2-13, 2-14, 2-16)
Feb 2	Lecture 7	RC Circuits (Part 3)
Feb 4	Lecture 8	Operational Amplifiers
Feb 7	Lecture 9	Signal and Noise (Part 1), Project Due (HW: 3-1, 3-4, 3-5, 3-6, 3-8, 3-3, 3-4, 3-8, 3-9)
Feb 9	Lecture 10	Signal and Noise (Part 2)
Feb 11	Lecture 11	Lock-in Amplification

(Molecular) Optical Spectroscopy

Feb 14	Lecture 12	Introduction to Spectroscopy, Exam (HW: 7-2, 7-7, 7-10, 7-11, 7-12, 7-15, 7-17)
Feb 16	Lecture 13	Components of Optical Instruments (Part 1)
Feb 18	Lecture 14	Components of Optical Instruments (Part 2)
Feb 21		President's Day (no class) (HW: 13-1, 13-5, 13-11, 13-14, 14-1, 14-4, 14-6, 14-11)
Feb 23	Lecture 15	Components of Optical Instruments (Part 3)
Feb 25	Lecture 16	UV-Visible Absorption Spectroscopy
Feb 28	Lecture 17	Fluorescence Spectroscopy
Mar 2	Lecture 18	UV-Vis/Fluorescence Applications
Mar 4	Lecture 19	Infrared Absorption Spectroscopy
Mar 7		Spring Recess
Mar 9		Spring Recess
Mar 11		Spring Recess
Mar 14	Lecture 20	Raman Spectroscopy (Part 1) (HW: 16-1, 16-3, 16-8, 16-15, 18-5, 18-6, 18-7, 18-9)
Mar 16	Lecture 21	Raman Spectroscopy (Part 2)
Mar 18	Lecture 22	IR/Raman Applications

Nuclear Magnetic Resonance Spectroscopy & (Molecular) Mass Spectrometry

Mar 21	Lecture 23 Nuclear Magnetic Resonance (Part 1), Exam (HW: 9-11, 9-12, 9-18, 9-19, 9-38)
Mar 23	Lecture 24 Nuclear Magnetic Resonance (Part 2)
Mar 25	Lecture 25 Nuclear Magnetic Resonance (Part 3)

Mar 28	Lecture 26 Magnetic Resonance Applications, Project due
Mar 30	Lecture 27 Molecular Mass Spectrometry (Part 1)
Apr 1	Lecture 28 Magnetic Resonance/Raman Field Trip

Apr 4	Lecture 29 Molecular Mass Spectrometry (Part 2) (HW: 20-1, 20-2, 20-3, 20-4, 20-5, 20-11)
Apr 6	Lecture 30 Molecular Mass Spectrometry (Part 3)
Apr 8	Lecture 31 Mass Spectrometry Applications

Separations & Electroanalytical Chemistry Methods

Apr 11	Lecture 32 Introduction to Separations (Part 1), Exam (HW: 26-1, 26-3, 26-6, 26-9, 26-14, 26-16)
Apr 13	Lecture 33 Introduction to Separations (Part 2)
Apr 15	Lecture 34 Introduction to Separations (Part 3)

Apr 18	Lecture 35 Gas Chromatography, Project due (HW: 27-5, 27-6, 27-7, 28-2, 28-4, 28-10)
Apr 20	Lecture 36 HPLC Chromatography
Apr 22	Lecture 37 Chromatographic Applications

Apr 25	Lecture 38 Introduction to Electrochemistry (Part 1) (HW: 22-1, 22-2, 22-7, 22-13)
Apr 27	Lecture 39 Introduction to Electrochemistry (Part 2)
Apr 29	Lecture 40 Introduction to Electrochemistry (Part 3)

May 2	Lecture 41 Potentiometry (Part 1) (HW: 23-1, 23-2, 23-4, 23-20, 23-24)
May 4	Lecture 42 Potentiometry (Part 2)
May 6	Lecture 43 Potentiometry (Part 3)

Note: Exams TBD.