Chemistry
UNIVERSITY OF TORONTO

CHM414HS: Biosensors and Chemical Sensors

Winter 2025 Course Syllabus

I   TEACHING TEAM

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Office: Lash Miller 139/147
Student hours: Wednesdays (January 15-April 9), 4:10- 5 pm in the Caffeine room, A. D. Allen Chemistry Library or by appointment (subject email: CHM414- office hours)

II   COURSE OVERVIEW

COURSE DESCRIPTION:

Sensors are an integral part of modern technology, ranging from simple devices that measure physical properties like temperature to complex systems incorporating human cells. Their applications span industries, including industrial processing, pharmaceutical analysis, automotive technology, military systems, and environmental monitoring.

This course focuses on the fundamentals of chemical sensors and biosensors, specialized devices designed for detecting chemical and biological species. Topics include the architecture of sensor systems and device types based on electrochemistry, piezoelectricity, acoustic wave physics, and optical science. Emphasis is placed on the interdisciplinary nature of these technologies, exploring their applications in fields such as medicine, biology, materials science, and electronic engineering. By the end of the course, students will gain a comprehensive understanding of the principles and real-world applications of chemical and biosensor technology.

STUDENT LEARNING OUTCOMES:

By the end of this course, students will:

- **Understand Sensor Design and Fabrication**: Gain foundational knowledge of the design and functionality of biosensors and chemical sensors. Develop a detailed understanding of physicochemical principles and transduction mechanisms, enabling comparisons of performance across various sensor types.

- **Apply Knowledge to Real-Life Problems**: Collaboratively propose a chemical sensor or biosensor as a solution to a specific research question or solve a real-world challenge, bridging theoretical concepts with practical applications.

- **Design and Present a Sensor Solution**: Collaboratively create and present a conceptual design for the proposed biosensor or chemical sensor, highlighting its potential applications and ability to address the identified problem.

- **Critically Evaluate Sensor Research**: Collaboratively write a well-structured review article related to their proposed sensor, synthesizing current advancements, evaluating methodologies, and identifying future directions in the field.

- **Foster Interdisciplinary Understanding**: Appreciate the synergy between chemistry, materials science, environmental science, biology, and medicine in sensor development. Develop the interdisciplinary mindset needed for careers in bioanalytical chemistry or related fields.

- **Enhance Communication Skills**: Effectively articulate complex scientific concepts and technical principles through written assignments, presentations, and group discussions. Develop clarity and confidence in presenting ideas to both technical and non-technical audiences.

- **Strengthen Teamwork Abilities**: Collaborate with peers in group assignments to propose and design a chemical or biosensor. Foster a cooperative and respectful team environment, demonstrating skills such as active listening, conflict resolution, and equitable task delegation.

PREREQUISITE COURSE(S):

This course assumes a foundational understanding of analytical and physical chemistry principles, including familiarity with concepts such as spectroscopy, electrochemistry, and chemical kinetics. Basic knowledge of biochemistry, including biomolecular interactions, is helpful but not mandatory. Prior experience with research methods or laboratory techniques in chemistry or related disciplines is recommended to enhance your understanding of the course material.

Prerequisite courses: CHM 217H, (CHM 220H, CHM 222H)/CHM 225Y, however course admission is at the discretion of the instructor.

READINGS:

This course does not have a designated textbook. Instead, an extensive collection of review articles, research papers, and book chapters will be available to students throughout the semester. These materials will be carefully selected to align with the course topics and assignments. Lecture slides and supplemental resources will also be provided. All course materials will be accessible on the course Quercus shell.

III   COURSE ORGANIZATION

This course follows a flipped classroom model, emphasizing active student participation and engagement. Students are expected to review assigned materials before class, including lecture slides, review articles, and research papers provided via the course Quercus shell. During class sessions, the focus will be on discussions, problem-solving activities, and student-led presentations to deepen understanding and apply concepts.

The course is organized into the following key topics:

- **Introduction to Biosensor/Chemical Sensor Architecture**: Overview of sensor types, components, design principles, and requirements.

- **Probe Attachment**: Types of probes, challenges of non-specific adsorption, and methods for probe attachment to surfaces.

- **Surface Characterization**: Information needed about surface characterization and surface analysis techniques.

- **Acoustic Wave Devices:** The phenomenon of piezoelectricity; operation of devices in the air; bulk acoustic wave devices as sensors; the Sauerbrey response equation; propagation of acoustic waves in fluids.

- **Electrochemical Sensors:** Overview of potentiometry, amperometry, voltammetry, ion-selective electrodes, and electrochemical impedance spectroscopy for sensor development.

- **Optical and Electromagnetic Devices:** Sources of radiation and laser technologies for sensors, optical components, and fiber-optic sensing systems.

- **Surface Plasmon Resonance:** The phenomenon of surface plasmon resonance (SPR) and design of the SPR experiment for bio-sensing.

Introduction to Databases and AI Tools for Literature Reviews, Research, and Writing: This course includes a dedicated session on effectively utilizing databases and AI tools to support literature reviews, research, and academic writing.

Student Presentations:

- **Project Presentation:** Students collaboratively will present their conceptual design for a novel biosensor or chemical sensor, highlighting its applications and addressing a specific research question or real-world problem.

Course Schedule: The detailed course schedule, including lecture topics, deadlines, and presentation dates, will be posted on the Quercus course shell for easy access.

Note: This course does not include separate tutorials or laboratory sessions.

IV   EVALUATION/GRADING SCHEME

OVERVIEW & MARK BREAKDOWN:

- First Assignment (including a group presentation): 40% of the total grade
- Second Assignment (review article): 50% of total grade
- Online and In-Class Activities:10% of total grade

Details about assignments are available on the course Quercus shell.

ASSESSMENT DATES

- **First Assignment**:
  - Documents (proposal and slides) to be handed out: **Monday, February 24, 8:00 AM**
  - Submission and presentation details will be provided in the assignment brief.
- **Second Assignment**:
  - Due: **Sunday, April 4, 11:59 PM**

Note: if an unexpected technical issue occurs with a university system (e.g., Quercus services, network outage) that affects availability or functionality, it may be necessary to revise the timing or weighting of the assessments.

Note: A penalty of 5% of the total mark for the assignment will be applied per day (including weekends and holidays) for late submission.

V   COURSE POLICIES

- Each member of this course is expected to maintain a:

  (i)   professional and respectful attitude during all course activities, including classes, laboratories, tutorials, and other online activities.
  (ii) personal calendar/schedule/organizer to ensure that all course activities are completed, and due dates are met.
  (iii) collection of notes recorded independently based on concepts covered in course activities (students registered with Accessibility Services requiring a class note-taker will have access to this accommodation)
  (iv) familiarity with the university policy on Academic Integrity

- The University of Toronto is committed to equity, human rights, and respect for diversity. All members of the learning environment in this course should strive to create an atmosphere of mutual respect where all members of our community can express themselves, engage with each other, and respect one another's differences. As a Course Instructor, I will neither condone nor tolerate behaviour that undermines the dignity or self-esteem of any individual in this course and wish to be alerted to any attempt to create an intimidating or hostile environment. It is our collective responsibility to create a space that is inclusive

and welcomes discussion. Discrimination, harassment and hate speech will not be tolerated. If you have any questions, comments, or concerns, we encourage you to reach out to the staff in our [Equity Offices](#).

- If you are absent from your studies due to illness or other reasons and unable to complete an assignment then a piece of written documentation is required. The following four items are the recognized forms of documentation:

  1. [Absence Declaration via ACORN](#) (please note the circumstances under which an absence declaration can and cannot be submitted)
  2. [U of T Verification of Illness or Injury Form](#)
  3. College Registrar's letter
  4. Letter of Academic Accommodation from Accessibility Services

- Students who complete the ACORN Absence Declaration form must additionally contact me at soha.ahmadi@mail.utoronto.ca (subject email: CHM414- Absence) to discuss their situation within five business days of the missed piece of work. This is an essential action for any consideration to be granted.

- Please note that assignments in this course are group assignments completed with your classmates. Your absence may impact the entire group. It is your responsibility to discuss the situation with your groupmates and ensure clear communication to minimize any disruptions to the group's work.

- For extended absences and for absences due to non-medical reasons, make sure to contact your [College Registrar's Office](#). They can help you decide between a request for an extension or other types of academic consideration.

- If you suspect or know that you have a disability that is affecting your studies, [learn about the services and supports available through Accessibility Services](#). A disability can be physical disability, sensory disability, a learning disability, mental health disorder or a short-term disability like an injury. If you are not sure whether you have a disability, you can confidentially contact [Accessibility Services](#) with your questions.

- I will respond to emails within 24 hrs. on weekdays.

- Policy for late assignment submissions: A penalty of 5% of the total mark for the assignment will be applied per day (including weekends and holidays).

- **Use of AI Tools in this Course:** Students are encouraged to leverage technology, including generative artificial intelligence (AI) tools, to enhance their understanding of course materials and assist in completing assignments. These tools can serve as valuable learning aids, helping students conceptualize ideas, draft content, and refine their work. Students may use AI tools, including generative AI, to support their learning and assignment preparation. While AI tools can aid in the creation of assignments, students remain fully responsible for the integrity and originality of their submitted work. All submissions must meet the course's academic standards. Specific guidelines on acceptable use will be posted on the Quercus course shell.

- Privacy language and appropriate use of course materials: For additional information, see the syllabus "Copyright" section.

VI   TECHNOLOGY REQUIREMENTS

- Specific guidance from the U of T Vice-Provost, Students regarding student technology requirements is available here:
https://www.viceprovoststudents.utoronto.ca/student-policies-guidelines/tech-requirements-online-learning/

- This course requires the use of computers, and technical issues are possible. When working on a piece of academic work, students are responsible for scheduling enough time to allow for reasonable delays due to technical difficulties to be overcome, so such issues will not be acceptable grounds for deadline extension. Particularly, maintaining an up-to-date independent backup copy of your work is strongly recommended to guard against hard-drive failures, corrupted files, lost computers, etc.

VII   INSTITUTIONAL POLICIES & SUPPORT

ACADEMIC INTEGRITY

Academic integrity is essential to the pursuit of learning and scholarship in a university, and to ensuring that a degree from the University of Toronto is a strong signal of each student's individual academic achievement. As a result, the University treats cases of cheating and plagiarism very seriously. The University of Toronto's Code of Behaviour on Academic Matters outlines the behaviours that constitute academic dishonesty and the processes for addressing academic offences.

All suspected cases of academic dishonesty will be investigated following procedures outlined in the Code of Behaviour on Academic Matters. If you have questions or concerns about what constitutes appropriate academic behaviour or appropriate research and citation methods, you are expected to seek out additional information on academic integrity from your instructor or from other institutional resources (see www.academicintegrity.utoronto.ca/)

Plagiarism Detection

Students will be required to submit their course essays to the University's plagiarism detection tool for a review of textual similarity and detection of possible plagiarism. In doing so, students will allow their essays to be included as source documents in the tool's reference database, where they will be used solely for the purpose of detecting plagiarism. The terms that apply to the University's use of this tool are described on the Centre for Teaching Support & Innovation website (https://uoft.me/pdt-faq)".

COPYRIGHT

If a student wishes to copy or reproduce class presentations, course notes or other similar materials provided by instructors, he or she must obtain the instructor's written consent beforehand. Otherwise, all such reproduction is an infringement of copyright and is absolutely prohibited.

ACCESSIBILITY NEEDS

Students with diverse learning styles and needs are extremely welcome in this course. The University of Toronto is committed to accessibility: if you require accommodations for a disability, or have any other accessibility concerns about the course, please contact [Accessibility Services](#) as soon as possible.

ACCOMMODATIONS FOR RELIGIOUS OBSERVANCES

Following the University's policies, reasonable accommodations will be made for students who observe religious holy days that coincide with the due date/time of an assignment, tutorial, class or laboratory session. Students must inform the instructor **before** the session/assignment date to arrange accommodations.

ADDITIONAL SERVICES & SUPPORT

The following are some important links to help you with academic and/or technical service and support:

- General student services and resources at [Student Life](#)
- Full library service through [University of Toronto Libraries](#)
- Resources on conducting online research through [University Libraries Research](#)
- Resources on academic support from the [Academic Success Centre](#)
- Learner support at the [Writing Centre](#)
- Information for [Quercus Support](#)

ACKNOWLEDGEMENT OF TRADITIONAL LANDS

We wish to acknowledge this land on which the University of Toronto operates. For thousands of years, it has been the traditional land of the Huron-Wendat, the Seneca and, most recently, the Mississaugas of the Credit River. Today, this meeting place is still the home to many Indigenous people from across Turtle Island and we are grateful to have the opportunity to work on this land.