

# CHM1482: Laser Spectroscopy and Photophysics

## Course Syllabus, Spring 2024:

### Instructors:

Prof. Mark W.B. Wilson, LM 241, [mark.w.b.wilson@utoronto.ca](mailto:mark.w.b.wilson@utoronto.ca)

*Note: E-mail is preferred. Only messages from UofT accounts will garner responses.*

**Classes:** Mondays, 10am–12pm, **AB088** (Astronomy Building Conference Room)

*Lectures will also be streamed synchronously until further notice: See Quercus*

**Minimum Technical Requirements:** A platform capable of running Zoom

**Office Hours:** By Appointment

**Website:** The syllabus, assignments, and any course announcements will be posted on Quercus.

Log in with your UTORid at: [q.utoronto.ca](https://q.utoronto.ca)

**Textbooks:** There are no required textbooks for this course, and we will cover material from a range of sources. However, we highlight a few standard reference texts that are useful for more-thorough discussions, alternative perspectives, and extensions (well!-)beyond the course material.

*Optics, 5th Ed.* – Eugene Hecht ([Reserve copy in Phys. library](#))

*Lasers, 1st Ed.* – Anthony E. Siegman ([Reserve copy in Chem. library](#))

*Optical Properties of Solids* – Mark Fox ([Reserve copy in Phys. library](#)) ([Fancy on-line access](#))

*Quantum Optics* – Mark Fox ([Copies in Phys. library](#)), ([Fancy on-line access](#))

*Nonlinear Optics, 4th Ed.* – Robert Boyd ([Reserve copy in Phys. library](#)) ([Fancy on-line access](#))

*Libretext: Time-Dependent Quantum Mechanics & Spectroscopy* – Andrei Tokmakoff

### Marking Scheme:

4 Assignments	44%
Research Highlight	16%
Final Exam	40%

### Notes on assessment:

- All assignments will be submitted via Quercus, though the form of each submission may vary. This will be specified on each assignment sheet.
  - For the three analytical problem sets (tentatively due February 9th, March 15th, and April 5th.), we recommend uploading a single pdf containing scans of hand-written hard copy. Solutions individually written up in e.g.  $\text{\LaTeX}$  or Word can be acceptable if you strongly prefer, please discuss with Prof. Wilson. In all cases, please indicate your name & student number clearly on the first page.
  - Submission of the Research Highlight assignment (tentatively due February 16th) will be on-line via Quercus. See assignment sheet for details.
  - Submission of the computational problem set (tentatively due January 26th) will be on-line via Quercus. See assignment sheet for details.
- The mark for a problem set submitted after the specified time and date will be reduced by 25% if handed in before the beginning of the first class after its due date (*i.e.* Monday morning), and by 50% if handed in afterwards. However, no marks will be awarded for assignments submitted after 2pm on April 12th.

- There are no make-ups available for the Final Exam *which will be **in-person** if the prevailing public health guidelines at the time permit*. As a result, students are advised to avoid schedule conflicts/travel during the [exam period](#), particularly the week of April 15–19th. Students who miss the exam may contact the course instructor to discuss their situation.

The potential impacts of unforeseen illness or injury will only be considered if the student presents a completed [Verification of Student Illness or Injury Form](#)

- Students with diverse learning styles and needs are welcome in this course—please discuss in-class accommodations and supports with the instructor. 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](#).

However, accommodations involving assessment will generally be made on the advice of a University Disability Counsellor, who may require medical documentation. Accordingly, students are encouraged to register with Accessibility Services as soon as possible, to ensure that there is time to make arrangements.

In a similar spirit, the University provides reasonable accommodation of the needs of students who observe religious holy days other than those already accommodated by statutory holidays. Students have a responsibility to alert members of the teaching staff in a timely fashion to upcoming religious observances and anticipated absences and instructors will make reasonable effort to avoid scheduling synchronous activities at these times.

### Course Expectations:

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

### Equity, Diversity, and Inclusion:

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. The CHM1482 teaching team will neither condone nor tolerate behaviour that undermines the dignity or self-esteem of any individual in this course and we 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](#).

**Copyright & Video Recording:**

Elements of this course, including your participation during lectures, may be recorded on video and made available to students in the course for viewing after each session. For questions about the recording/use of videos in which you appear, please contact the instructor.

Course videos and materials belong to your instructor, the University, and/or other sources depending on the specific facts of each situation and are protected by 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. More information regarding this is available here: <https://teaching.utoronto.ca/resources/recording-of-lectures-and-class-sessions/>

**Academic Integrity:**

Academic integrity is fundamental to learning and scholarship, 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](http://www.academicintegrity.utoronto.ca)).

**Additional Services & Support**

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

- School of Graduate Studies' [Policies and Guidelines](#)
- Full library service and resources on conducting online research through [University of Toronto Libraries](#)
- Resources on academic support from the [Academic Success Centre](#)
- Learner support at the [Writing Centre](#)
- Information for [Technical Support/Quercus Support](#)

**Acknowledgement of Traditional Lands**

The University of Toronto wishes to acknowledge this land on which it 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.

*Continued overleaf...*

**Summary of Course Aims:**

CHM1482 is a tailored course for advanced students with an interest in Experimental Physical Chemistry here in the department. To support your broader research ambitions, we will jointly pursue three aims: 1) develop and demonstrate your knowledge of the fundamentals of optics & light-matter interactions 2) build, or extend, your familiarity with scientific writing and computational data analysis 3) introduce you to selected topics in nonlinear, near-field, ultrafast, and quantum optics as they relate to experimental spectroscopy.

**Syllabus:**

1. *Intermediate classical optics* ( $\sim 5$  weeks)
  - Electromagnetic waves
  - Gaussian Optics
  - Ray optics & Imaging
  - Polarization & Birefringence
  - Waves at interfaces
  - Interference
  - Diffraction & Fourier Optics
2. *Light-Matter Interactions* ( $\sim 4$  weeks)
  - Radiative transitions in atoms: Classical description
  - Semi-classical treatment: Fermi's Golden Rule
  - Molecular Photophysics: Electronic and Vibrational Transitions
  - Molecular Photophysics: Energy and Electron Transfer
3. *Introduction to Nonlinear Optics* ( $\sim 3$  weeks)
  - Series expansion of the polarizability: 2nd- & 3rd-order effects
  - Nonlinear pulse propagation
  - Transient spectroscopies
4. *Introduction to Quantized Optics* (If interest builds and time permits...)
  - Photon Statistics, bunching/anti-bunching