CHM1482: Laser Spectroscopy and Photophysics

Course Syllabus, Fall 2021:

Instructors:
Prof. Mark W.B. Wilson, LM 241, mark.w.b.wilson@utoronto.ca
Prof. Gilbert C. Walker, LM 145, gilbert.walker@utoronto.ca
Note: E-mail is preferred. Only messages from UofT accounts will garner responses.

Classes: Mondays, 2–4pm, Wednesdays 10–11am ***All lectures on Zoom: 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`

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) *Access to 4th Ed. via HathiTrust*
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)

Marking Scheme:

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

Notes on assessment:

- The method of submission for each assignment will vary, and will be specified on the assignment sheet.
  - For the three analytical problem sets (Tentatively due October 11th, November 29th, and December 13th.), work can either be submitted in hand-written hard-copy, or a suitable equivalent (*e.g.* scanned pages, or individually written up in e.g. Word or LaTeX if you prefer) uploaded via Quercus. In all cases, please indicate your name & student number clearly on the first page.
  - Submission of the Research Highlight assignment (tentatively due November 12th) will be on-line via Quercus.
  - Submission of the computational problem set (tentatively due October 1st) will be on-line via Quercus.
- 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, and by 50% if handed in afterwards. However, no marks will be awarded for assignments submitted after 2pm on April 8th.
- 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. Students who miss the exam may contact the course instructors 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, signed by an appropriate medical professional.

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

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. U of T does not condone discrimination or harassment against any persons or communities.

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.

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. Please do not copy or share any course or student materials/videos without the explicit permission of the instructor.

For questions about the recording/use of videos in which you appear, please contact us.

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. Students are expected to be familiar with the University's Code of Behaviour on Academic Matters—particularly Section B.i.1., which gives examples of student actions considered an offence against the Code. I also recommend consulting the 'Smart Strategies' regarding recording lectures, group work, and time management.

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 routine computational techniques 3) introduce you to selected topics in nonlinear, near-field, ultrafast, and quantum optics.

Syllabus:

1. *Intermediate classical optics* (∼4 weeks, Prof. Wilson)
    - Electromagnetic waves
    - Gaussian Optics
    - Polarization & Birefringence
    - Waves at interfaces
    - Diffraction & Fourier Optics
    - Interference
2. *Light-Matter Interactions* (∼6 weeks, Prof. Walker)
    - Radiative transitions in atoms: Classical description
    - Semi-classical treatment: Fermi's Golden Rule
    - Molecular photophysics: Electronic and Vibrational Spectroscopy
    - Nano-optics
    - Optics in Solids
3. *Introduction to Nonlinear Optics* (∼2 weeks, Prof. Wilson)
    - Series expansion of the polarizability: 2nd- & 3rd-order effects
    - Nonlinear pulse propagation
    - Applications of nonlinear optics
    - Pump-probe spectroscopies
4. *Introduction to Quantized Optics* (If interest builds and time permits. . . , Prof. Wilson)
    - Photon Statistics, bunching/anti-bunching