PHYS-4140/6140: Principles of Lasers Spring 2025

Credit hours: 3
Prerequisites: PHYS 3202 and PHYS 3401
Instructor: Dr. A.T. Le, GS 313G, E-mail: thu.le@uconn.edu
Class time & place: 3:30-4:45pm Tu/Th, CHM T112
Office hours: E-mail requests for appointments are encouraged

Main textbook: 1. P. Milonni and J. Eberly, *Laser Physics*, https://onlinelibrary.wiley.com/doi/book/10.1002/9780470409718
Additional textbooks: 2. O. Svelto, *Principles of Lasers*, Springer; 5th ed, 2010
3. A. Yariv, *Quantum Electronics*, 2nd ed, 1975

Description: The physics of lasers, including optical pumping and stimulated emission, laser rate equations, optical resonators, Gaussian beam propagation, Q-switching, mode-locking and nonlinear optics. Applications to gas, solid-state and tunable laser systems.

Course Grade: Final grade will be based on a scale of 1,000 points from homework, exams, and project/presentation. Graduate students will have additional questions/problems for homework and exams, as compared to undergraduate students.

Attendance & in-class participation:	15%
Homework:	40%
Two midterm exams:	15% each
Project & in-class presentation:	15%

Attendance: The course will not always follow the textbooks. Class attendance is important (150 points). Students who anticipate being away from a class for a legitimate reason should inform the instructor ***by e-mail*** ahead of class and give the reason for absence.

Homework: Homework assignments will be given approximately once a week (Thursday, to be posted on HuskyCT) and are due after one week (to be submitted on HuskyCT by Thursday at 1pm). ***Late assignments will not be accepted***. There will be about 9 homework assignments, each will be worth 50 points. The lowest score will be dropped so a total of 400 points may be earned from the homework. ***Guidelines for homework:***

- Discussions among the students are strongly encouraged.
- Students should document the intermediate steps so that partial credit can be given.
- Try to always check your final answer to see if it makes sense.
- Each student should write his/her own report. Report will **not** be accepted after the due date.

Exams: There will be two mid-semester open-book exams (150 points each).

Project & Presentation: The project will be worth 150 points. This will involve reading research papers or book chapters or performing mathematical/computational/data analysis. You will be able to choose from several topics. You can also propose a project on the topic of your own interest (an approval by the instructor and possible adjustment will be needed). The project will require a written report and a ~12-minute presentation during the last week of the semester. The grade will be based on the clarity of the discussion, the coverage of essential elements that will be determined by the student's choice of presentation topic, and the legibility and clarity of the PowerPoint file.

Make-up policy: There is no make-up for homework assignments, exams, or final projects.

Topics to be covered (chapters refer to the main textbook):

1. **Chapter 1**: Introduction, laser properties, cavities, Einstein theory of light-matter interaction
2. **Chapter 3**: Electron Oscillator Model, Absorption, Emission, Dispersion, Collisions and Doppler broadening
3. **Chapter 4**: Gain and threshold; rate equations; three-level and four-level laser schemes
4. **Chapter 5**: Laser output intensity; Measuring gain and optimal output coupling; frequency pulling; single-mode oscillation; laser linewidth
5. **Chapter 6**: Rate equation for intensity & populations; Relaxation oscillations; Q-switching; Mode locking; short pulse
6. **Chapter 7**: The Ray Matrix; Resonator stability; Paraxial wave equation; Gaussian beams & transverse modes
7. **Chapter 8**: The Wave Equation for the Electric Field; Group Velocity; Group Velocity dispersion; Chirping.
8. **Chapter 9**: Time-Dependent Schrodinger Equation; Two-state atoms & Rabi oscillation; Density matrix; Optical Bloch equations and Maxwell-Bloch equations
9. **Chapter 11**: Some Specific Lasers: He-Ne, CO2, Excimer lasers, Dye lasers, Solid state lasers
10. **Chapter 14**: Some Applications of Lasers – **final projects & presentations in the final week**

Some final words from the University of Connecticut

- General University policies can be found at: http://provost.uconn.edu/syllabi-references/

The Center for Students with Disabilities (CSD) at UConn provides accommodation and services for qualified students with disabilities. If you have a documented disability for which you wish to request academic accommodation and have not contacted the CSD, please do so as soon as possible. The CSD is located in Wilbur Cross, Room 204 and can be reached at (860) 486-2020 or at csd@uconn.edu. Detailed information regarding the accommodations process is also available on their website at www.csd.uconn.edu.

Students are required to be available for their exam and/or complete an assessment during the time stated in the Registrar's Office Schedule. If you have a conflict with this time, you must visit the Office of Student Services and Advocacy to discuss the possibility of rescheduling this assessment. The OSSA now *requires* that students who have a conflict about which they have or should have had advanced notice (bunched finals, religious obligation, legal/medical appointments…) *must* seek permission to reschedule their assessment.

Please note that vacations, previously purchased tickets or reservations, graduations, social events, misreading the assessment schedule and over-sleeping are not viable excuses for missing a final assessment. If you think that your situation warrants permission to reschedule, please contact the Office of Student Services and Advocacy (2nd floor Wilbur Cross) to meet with a staff member.