Fall 2018 **Advanced Optics (Physics: 6723)**

Instructor: John Prineas, Professor
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Department: Department of Physics and Astronomy
Department Office is in 203 Van Allen
Department Executive Officer is Professor Fred Skiff
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Course location & times: Van Allen 358, MWF 11:00 am - 12:15 pm
Course website: icon.uiowa.edu

Course description: This course includes a combination of material on laser physics, and nonlinear optics. Topics covered include semiclassical theory of absorption and emission; laser theory, threshold, rate equations, saturation, spectral and spatial hole burning; photon statistics, and counting; multimode and pulsed operation; laser resonators and Gaussian beam optics; nonlinear optics, 3-and 4-wave mixing, harmonic generation, parametric amplification, stimulated scattering

Prerequisites: An undergraduate course in electricity and magnetism is necessary; a course in undergraduate quantum mechanics is highly recommended.

Text: Laser Physics, Milonni and Eberly (2010 edition)
Other references: Nonlinear Optics, Boyd; Laser Principles, Svelto

Format: Two lectures will be given a week. Problem sets will be assigned every other week. One midterm and a final exam will be given.

Homework: Problem sets and due dates will be announced in class and on the course website on ICON. Homework solutions will be available via ICON. Homework will be cursorily checked, but will not be graded in detail.

Exams: A two-part midterm is tentatively scheduled for Tu and Th Mar 6 and 8. The final exam date will be announced when known. The final will also be two part. For both exams, the first part will consist of homework problems. The second part will consist of conceptual questions and problems based on homework and lectures.

Grading: Homework 10%; midterm part I 22.5% and part II 22.5%; and final 45%.

Administrative Home

The College of Liberal Arts and Sciences is the administrative home of this course and governs matters such as the add/drop deadlines, the second-grade-only option, and other related issues. Different colleges may have different policies. Questions may be addressed to 120 Schaeffer Hall, or see the CLAS Academic Policies Handbook at https://clas.uiowa.edu/students/handbook.

Electronic Communication

University policy specifies that students are responsible for all official correspondences sent to their University of Iowa e-mail address (@uiowa.edu). Faculty and students should use this account for correspondences (Operations Manual, III.15.2).

Accommodations for Disabilities

The University of Iowa is committed to providing an educational experience that is accessible to all students. A student may request academic accommodations for a disability (which includes but is not limited to mental health, attention, learning, vision, and physical or health-related conditions). A student seeking academic accommodations should first register with Student Disability Services and then meet with the course instructor privately in the instructor's office to make particular arrangements. Reasonable accommodations are established through an interactive process between the student, instructor, and SDS. See https://sds.studentlife.uiowa.edu/ for information.

Nondiscrimination in the Classroom

The University of Iowa is committed to making the classroom a respectful and inclusive space for all people irrespective of their gender, sexual, racial, religious or other identities. Toward this goal, students are invited to optionally share their preferred names and pronouns with their instructors and classmates. The University of Iowa prohibits discrimination and harassment against individuals on the basis of race, class, gender, sexual orientation, national origin, and other identity categories set forth in the University's Human Rights policy. For more information, contact the Office of Equal Opportunity and Diversity, diversity@uiowa.edu, or visit diversity.uiowa.edu.

Academic Honesty

All CLAS students or students taking classes offered by CLAS have, in essence, agreed to the College's Code of Academic Honesty: "I pledge to do my own academic work and to excel to the best of my abilities, upholding the IOWA Challenge. I promise not to lie about my academic work, to cheat, or to steal the words or ideas of others; nor will I help fellow students to violate the Code of Academic Honesty." Any student committing academic misconduct is reported to the College and placed on disciplinary probation or may be suspended or expelled (CLAS Academic Policies Handbook).

CLAS Final Examination Policies

The final examination schedule for each class is announced by the Registrar generally by the fifth week of classes. Final exams are offered only during the official final examination period. No exams of any kind are allowed during the last week of classes. All students should plan on being at the UI through the final examination period. Once the Registrar has announced the date, time, and location of each final exam, the complete schedule will be published on the Registrar's web site and will be shared with instructors and students. It is the student's responsibility to know the date, time, and place of a final exam.

Making a Suggestion or a Complaint

Students with a suggestion or complaint should first visit with the instructor (and the course supervisor), and then with the departmental DEO. Complaints must be made within six months of the incident (CLAS Academic Policies Handbook).

Understanding Sexual Harassment

Sexual harassment subverts the mission of the University and threatens the well-being of students, faculty, and staff. All members of the UI community have a responsibility to uphold this mission and to contribute to a safe environment that enhances learning. Incidents of sexual harassment should be reported immediately. See the UI Office of the Sexual Misconduct Response Coordinator for assistance, definitions, and the full University policy.

Reacting Safely to Severe Weather

In severe weather, class members should seek appropriate shelter immediately, leaving the classroom if necessary. The class will continue if possible when the event is over. For more information on Hawk Alert and the siren warning system, visit the Department of Public Safety website.

Tentative list of course topics, by week:

LP, Ch 1:

1. Introductory laser concepts, Lorentz oscillator and linear dispersion

LP, Ch 3, 9.1-4:

2. Thermal radiation, Einstein's laws of radiation, semiclassical model, density matrix equations, Rabi oscillations, adiabatic following
3. Absorption and stimulated emission rate, transition cross section, gain, line broadening mechanisms

LP, Ch 4

Population rate equations, absorption saturation, rate equations for photons, 3 & 4 level systems

4. Threshold requirements, small signal gain and gain saturation, spatial and spectral hole burning

LP, Ch 5

5. Power out from laser, optimal output coupling, multimode oscillation, single mode selection, laser tuning, laser linewidth

LP, Ch 12, 13.14, 15

Fundamental noise limit, photon statistics for laser and thermal sources

6. Brown-Twiss result, higher order correlation

LP, Ch 6, 8.4

7. Relaxation oscillations, Q switching, mode locking, group velocity dispersion

LP, Ch 7

8. Resonator stability via ray matrices, paraxial equation, Gaussian beams, ABCD Law
9. Gaussian beam resonator modes, diffractive losses by aperture, unstable resonators, Bessel beams

From NLO Ch 1:

10. Nonlinear optical susceptibility; intro to 2nd and 3rd order nonlinearities, nonlinear susceptibility of harmonic and anharmonic classical oscillators, permutation symmetry, Kleinman's symmetry, other symmetries

From NLO Ch 2:

11. Nonlinear wave equation, phase matching, intracavity SHG, spatial dependence of sum frequency generation, Manley-Rowe relations, quasi-phase matching, optical parametric oscillator

From NLO Ch 7:

12. Optical Kerr effect, self focusing, spatial solitons, optical phase conjugation, optical bistability, optical switching, temporal solitons

From NLO Ch 8-10:

13. Introduction to light scattering, Brillouin scattering (spontaneous), Raman scattering (stimulated), coherent anti-stokes Raman scattering (CARS)

From NLO Ch 3:

14. Quantum mechanical calculation of susceptibility, electromagnetically induced transparency