Opti 541: Laser Physics

https://policy.arizona.edu/faculty-affairs-and-academics/course-syllabus-policy-graduate

Semester and Year this Document Covers
Fall 2021

Course Number and Title
OPTI 541: Laser Physics

Instructor Information
R. Jason Jones, Professor
Email: rjjones@optics.arizona.edu
Phone: 520-626-4634
Wyant College of Optical Sciences
Office Hours: By appointment, Regular hours TBA

Course Description
Introduction to physical principals of laser operation, including: semiclassical laser theory, optical resonators, Gaussian beam propagation, steady-state and transient dynamics of laser oscillation, aspects of CW and pulsed operation. Ultrafast laser systems, linear and nonlinear pulse propagation, pulse measurement and characterization of noise in these systems will be emphasized. Examples of commonly used lasers, including solid-state, fiber, and semiconductor systems, as well as related topics such as femtosecond frequency combs, laser stabilization, ultrafast nonlinear optics, and spectroscopy will be discussed.

Course Prerequisites or Co-requisites
It is strongly recommended students have a prior graduate level understanding of optical physics and semiclassical light-matter interactions, as covered in OPTI 511R (Optical Physics and Lasers) or OPTI 544 (Quantum Optics).

Course Format and Teaching Methods
Lecture only. Flex in person, Distance Learning

Course Objectives
Course objectives:

1. Provide students with a basic understanding of laser operation.
2. Develop framework for understanding stable laser cavities, predicting lasing threshold levels, and predicting performance of various laser systems for cw and pulsed operation (e.g. single frequency operation, laser linewidth, minimum possible pulse duration, etc...).
3. Explore theoretical models describing ultrashort pulse operation and propagation, as well as fundamentals of pulse characterization techniques.
4. Provide overview of commonly used laser systems and their applications (e.g. fs frequency combs, laser stabilization, ultrafast nonlinear optics).

Expected Learning Outcomes
Students will be conversant with basics of laser operation, key concepts of ultrafast optics, and various types of laser systems. Students will be able to design stable optical laser cavities and predict performance, including lasing threshold, relaxation oscillation frequency of the system, and pulsed performance including Fourier-limited pulse durations. It is expected that students will be able to calculate laser beam propagation through linear systems as well as some nonlinear elements. Students will also be able to predict ultrashort pulse performance for a given gain medium as well as propagation of ultrashort pulses through linear and limited nonlinear systems.

400/500 Co-convened Course Information
Not Applicable.

Required Texts and Materials
Portions of the textbook "Laser Physics" by Peter Milonni and Joseph Eberly will be utilized in this course and is freely available as an e-book through the UA libraries. Supplementary notes and other readings will be provided.
Schedule of Topics and Activities
Topics to be covered include:
1. Overview of light-matter interactions and semi-classical laser theory.
2. Characterization of laser gain media (homogeneous vs. inhomogeneous, 3-level vs 4-level systems).
3. Optical resonator theory and Gaussian beam propagation.
5. Transient laser dynamics and Q-switched operation.
6. Mode-locked laser operation and techniques (e.g. passive versus active)
7. Ultrashort pulse descriptions and characterization.
8. Ultrashort pulse propagation and dispersion compensation.
12. Laser stabilization
13. Femtosecond frequency combs and applications
14. Miscellaneous laser topics (spectroscopy, precision measurements, high-harmonic generation...)

Assessments
Homework 30%, Exams 30%, Course Projects 40%

Grading Scale and Policies
90-100% = A, 75-90% = B, 60-75% = C, 40-60% = D, <40% = E.

Requests for incomplete (I) or withdrawal (W) must be made in accordance with University policies, which are available at [http://catalog.arizona.edu/policy/grades-and-grading-system#incomplete](http://catalog.arizona.edu/policy/grades-and-grading-system#incomplete) and [http://catalog.arizona.edu/policy/grades-and-grading-system#Withdrawal](http://catalog.arizona.edu/policy/grades-and-grading-system#Withdrawal) respectively.

Nondiscrimination and Anti-harassment Policy
The University of Arizona is committed to creating and maintaining an environment free of discrimination. In support of this commitment, the University prohibits discrimination, including harassment and retaliation, based on a protected classification, including race, color, religion, sex, national origin, age, disability, veteran status, sexual orientation, gender identity, or genetic information. For more information, including how to report a concern, please see: [http://policy.arizona.edu/human-resources/nondiscrimination-and-anti-harassment-policy](http://policy.arizona.edu/human-resources/nondiscrimination-and-anti-harassment-policy)

University Policies
All university policies related to this syllabus are available at: [https://academicaffairs.arizona.edu/syllabus-policies](https://academicaffairs.arizona.edu/syllabus-policies).

Subject to Change Notice
Information contained in the course syllabus, other than the grade and absence policies, may be subject to change with reasonable advance notice, as deemed appropriate by the instructor of this course.

Graduate Student Resources
University of Arizona’s Basic Needs Resources page: [http://basicneeds.arizona.edu/index.html](http://basicneeds.arizona.edu/index.html)

Accessibility and Accommodations
At the University of Arizona we strive to make learning experiences as accessible as possible. If you anticipate or experience physical or academic barriers based on disability or pregnancy, you are welcome to let me know so that we can discuss options. You are also encouraged to contact Disability Resources (520-621-3268) to explore reasonable accommodation.

If our class meets at a campus location: Please be aware that the accessible table and chairs in this room should remain available for students who find that standard classroom seating is not usable.

Code of Academic Integrity
Students are encouraged to share intellectual views and discuss freely the principles and applications of course materials. However, graded work/exercises must be the product of independent effort unless otherwise instructed. Students are expected to adhere to the UA Code of Academic Integrity as described in the UA General Catalog. See: [http://deanofstudents.arizona.edu/academic-integrity/students/academic-integrity](http://deanofstudents.arizona.edu/academic-integrity/students/academic-integrity).

The University Libraries have some excellent tips for avoiding plagiarism, available at [http://new.library.arizona.edu/research/citing/plagiarism](http://new.library.arizona.edu/research/citing/plagiarism).
Selling class notes and/or other course materials to other students or to a third party for resale is not permitted without the instructor’s express written consent. Violations to this and other course rules are subject to the Code of Academic Integrity and may result in course sanctions. Additionally, students who use D2L or UA e-mail to sell or buy these copyrighted materials are subject to Code of Conduct Violations for misuse of student e-mail addresses. This conduct may also constitute copyright infringement.