UCF CREOL, THE COLLEGE OF OPTICS AND PHOTONICS

Course Syllabus

OSE 4520 LASER ENGINEERING, 3 Credit Hours

Instructor: Peter J. Delfyett
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Office: CREOL, Rm. A-231
Office Hours: Tuesday, Thursday, 3:00pm-4pm
(or by appointment – in person or Zoom)

Term: Spring 2024
Class Meeting Days: Tuesday, Thursday
Class Meeting Time: 12:00-1:15pm
Class Location BA1 - 218
Website:

Additional Notes: I will be in my office at these times, but of course, I will be happy to discuss the material with you anytime. Often, I get questions via e-mail that can be quickly answered.

Course Catalog Description: Laser Engineering
The photon nature of light. Absorption and spontaneous and stimulated emission of light. Fluorescence. Optical amplifiers. Optical resonators. Lasers. Pulsed lasers. Nonlinear optical wave conversion.

Prerequisites: OSE 3052 or PHY 4424 or EEL 4440.

Detailed Course Description and Learning Outcomes:
Detailed Description - Topics to be covered:

I. Laser Fundamentals: Overview, Energy states in atoms, Basic stimulated emission, Power and energy, Monochromaticity, coherency and linewidth, spatial coherence, longitudinal and transverse modes, gain profile.

II. Energy States and Gain: Laser states, multiple-state laser systems, linewidth and the uncertainty principle, broadening of fundamental linewidths; basics of gain, blackbody radiation, gain.

III. The Fabry Perot Etalon: Longitudinal modes in the laser resonator cavity, quantitative analysis of a Fabry Perot etalon, illustrative Fabry Perot etalon calculations.

Mid-Term Exam

IV. Transverse Mode Properties: TEM transverse modes, Gaussian beam propagation, ray matricies, Gaussian beams in resonant cavities, ABCD Law

V. Gain Saturation: Saturation of the exponential gain process, homogeneous and inhomogeneous gain saturation, Rate equations, Laser output power characteristics

VI. Transient Processes: Relaxation oscillations, Q-switching; Mode-locking

VII. Introduction to Nonlinear Frequency Conversion: X^2 processes, e.g., second harmonic generation; X^3 processes

Final Exam (Cumulative)

Learning Outcomes:

A student's grade will also be assessed on their ability to:

1) Analyze the conditions for population inversion and optical amplification in gain media and determine the threshold gain for laser action.

2) Determine the layout of optical components that produce a laser spot of given dimensions at a given distance.

3) Model a stable cavity with prescribed beam characteristics.

Relationship of Course to ABET Criteria

ABET Criteria	Level of Emphasis During Course (Low, Medium, High)
(a) An ability to apply knowledge of mathematics, science, and engineering.	High
(b) An ability to design and conduct experiments, as well as to analyze and interpret data.	Medium
(c) An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.	High
(d) An ability to function on multidisciplinary teams.	Low
(e) An ability to identify, formulate, and solve engineering problems.	High
(f) An understanding of professional and ethical responsibility.	Low
(g) An ability to communicate effectively.	Medium
(h) The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.	Low
(i) A recognition of the need for, and an ability to engage in life-long learning.	Low
(j) A knowledge of contemporary issues.	Low
(k) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.	High

Textbook: Laser Engineering, Kelin J. Kuhn, Prentice Hall, (1998)
ISBN 0-020366921-7

Course Grading and Requirements for Success:

Homework: Required

Exams: Mid-term and Final; Scheduled

Quizzes: In class, randomly scheduled

Participation: Required

Final Exam: Required

Make up Exam Policy: If an emergency arises and a student cannot submit assigned work on or before the scheduled due date or cannot take an exam on the scheduled date, the student **must** give notification to the instructor **no less than 24 hours before** the scheduled date and **no more than 48 hours after the** scheduled.

Attendance:

Criteria	Grade Weighting
Homework & Quizzes	10%
Participation	required
Midterm Exam	45%
Final Exam	45%
Total	100%

Final Exam Date: See published schedule by UCF

Financial Aid and Attendance: As of Fall 2014, all faculty members are required to document students' academic activity at the beginning of each course. In order to document that you began this course, please complete the following academic activity by the end of the first week of classes, or as soon as possible after adding the course, but no later than August 27. Failure to do so will result in a delay in the disbursement of your financial aid.

Grading Scale (%)	Rubric Description
100 ≥ A > 90	Excellent, has a strong understanding of all concepts and is able to apply the concepts in all and novel situations. Has full mastery of the content of the course.
90 > B ≥ 80	Good, has a strong understanding of most or all of the concepts and is able to apply them to stated and defined situations.
80 > C ≥ 70	Average, has a basic understanding of the major concepts of the course and is able to apply to basic situations.
70 > D ≥ 65	Below average, has a basic understanding of only the simple concepts and is able to apply to only a limited number of the most basic situtations.
65 > F ≥ 0	Demonstrates no understanding of the course content.

Grade Objections:
All objections to grades should be made **in writing within one week** of the work in question.
Objections made after this period has elapsed will **not** be considered – NO EXCEPTIONS.

Academic Integrity
Students should familiarize themselves with UCF's Rules of Conduct at
http://osc.sdes.ucf.edu/process/roc According to Section 1, "Academic Misconduct," students are prohibited from engaging in

1. Unauthorized assistance: Using or attempting to use unauthorized materials, information or study aids in any academic exercise unless specifically authorized by the instructor of record. The unauthorized possession of examination or course-related material also constitutes cheating.
2. Communication to another through written, visual, electronic, or oral means: The presentation of material which has not been studied or learned, but rather was obtained through someone else's efforts and used as part of an examination, course assignment, or project.
3. Commercial Use of Academic Material: Selling of course material to another person, student, and/or uploading course material to a third-party vendor without authorization or without the express written permission of the university and the instructor. Course materials include but are not limited to class notes, Instructor's PowerPoints, course syllabi, tests, quizzes, labs, instruction sheets, homework, study guides, handouts, etc.
4. Falsifying or misrepresenting the student's own academic work.

5. Plagiarism: Using or appropriating another's work without any indication of the source, thereby attempting to convey the impression that such work is the student's own.
6. Multiple Submissions: Submitting the same academic work for credit more than once without the express written permission of the instructor.
7. Helping another violate academic behavior standards.

For more information about Academic Integrity, consult the International Center for Academic Integrity http://academicintegrity.org.

For more information about plagiarism and misuse of sources, see "Defining and Avoiding Plagiarism: The WPA Statement on Best Practices" http://wpacouncil.org/node/9 .

Responses to Academic Dishonesty, Plagiarism, or Cheating

Students should also familiarize themselves with the procedures for academic misconduct in UCF's student handbook, The Golden Rule <http://goldenrule.sdes.ucf.edu/docs/goldenrule.pdf>. UCF faculty members have a responsibility for students' education and the value of a UCF degree, and so seek to prevent unethical behavior and when necessary respond to academic misconduct. Penalties can include a failing grade in an assignment or in the course, suspension or expulsion from the university, and/or a "Z Designation" on a student's official transcript indicating academic dishonesty, where the final grade for this course will be preceded by the letter Z. For more information about the Z Designation, see http://goldenrule.sdes.ucf.edu/zgrade

Students with Special Testing/Learning Needs:

The University of Central Florida is committed to providing access and inclusion for all persons with disabilities. Students with disabilities who need access to course content due to course design limitations should contact the professor as soon as possible. Students should also connect with Student Accessibility Services (SAS) http://sas.sdes.ucf.edu/ (Ferrell Commons 185, sas@ucf.edu, phone 407-823-2371). For students connected with SAS, a Course Accessibility Letter may be created and sent to professors, which informs faculty of potential course access and accommodations that might be necessary and reasonable. Determining reasonable access and accommodations requires consideration of the course design, course learning objectives and the individual academic and course barriers experienced by the student. Further conversation with SAS, faculty and the student may be warranted to ensure an accessible course experience.

Religious Observances

Students must notify their instructor in advance if they intend to miss class for a religious observance. For more information, see the UCF policy at http://regulations.ucf.edu/chapter5/documents/5.020ReligiousObservancesFINALJan19.pdf

Deployed Active Duty Military Students

Students who are deployed active duty military and/or National Guard personnel and require accommodation should contact their instructors as soon as possible after the semester begins and/or after they receive notification of deployment to make related arrangements.

Campus Safety Statement

Emergencies on campus are rare, but if one should arise during class, everyone needs to work together. Students should be aware of their surroundings and familiar with some basic safety and security concepts.

- In case of an emergency, dial 911 for assistance.

- Every UCF classroom contains an emergency procedure guide posted on a wall near the door. Students should make a note of the guide's physical location and review the online version at http://emergency.ucf.edu/emergency_guide.html.
- Students should know the evacuation routes from each of their classrooms and have a plan for finding safety in case of an emergency.
- If there is a medical emergency during class, students may need to access a first-aid kit or AED (Automated External Defibrillator). To learn where those are located, see http://www.ehs.ucf.edu/AEDlocations-UCF (click on link from menu on left).
- To stay informed about emergency situations, students can sign up to receive UCF text alerts by going to https://my.ucf.edu and logging in. Click on "Student Self Service" located on the left side of the screen in the toolbar, scroll down to the blue "Personal Information" heading on the Student Center screen, click on "UCF Alert", fill out the information, including e-mail address, cell phone number, and cell phone provider, click "Apply" to save the changes, and then click "OK."
- Students with special needs related to emergency situations should speak with their instructors outside of class.

To learn about how to manage an active-shooter situation on campus or elsewhere, consider viewing this video (https://youtu.be/NIKYajEx4pk).

Dates:

First Day of Class	Jan. 9
Last Day to Drop Classes, Withdrawal	Jan. 12, Mar 29
Last Day to Add Classes:	Jan. 12
Last Day of Class:	Apr. 18
Final Exam:	April 25; 10:00am – 12:50pm

COURSE, TERM, INSTRUCTOR **Daily Schedule (subject to change)**			
Week	Date	Concepts Presented:	Textbook chapter
1	Jan 9, 11	Overview, Energy states in atoms, Basic stimulated emission, Power and energy, Monochromaticity	
2	16, 18	Coherency and linewidth, spatial coherence, longitudinal and transverse modes, gain profile.	
3	23, 25	Laser states, multiple-state laser systems, linewidth and the uncertainty principle	
4	Jan 30, Feb 1	Broadening of fundamental linewidths; basics of gain, blackbody radiation, gain	
5	6, 8	Longitudinal modes in the laser resonator cavity, quantitative analysis of a Fabry Perot etalon, illustrative Fabry Perot etalon calculations	
6	13, 15	Review, Midterm	
7	20, 22	TEM transverse modes, Gaussian beam propagation, ray matricies	
8	Feb 27, Feb 29	Gaussian beams in resonant cavities, ABCD Law	
9	Mar 5, 7	Saturation of the exponential gain process	
10	19 21	Homogeneous and inhomogeneous gain saturation	
11	19, 21	Spring Break	
12	26, 28	Rate equations, Laser output power characteristics	
13	Apr 2, 4	Optical Amplification	

14	9, 11	Transient Processes: Relaxation Oscillations, Q-switching & Mode-locking	
15	16, 18 (Last day)	Nonlinear processes, e.g., second harmonic generation; Raman scattering, Semiconductor Lasers (if time permits), Semester Review	
	Thursday, Apr. 27, 2023 10:00 AM – 12:50 PM	Final Exam (Thursday, April 27th)	

Short Bio

Peter Delfyett received the B.E.(E.E.) degree from The City University of New York (1981), the M.S. degree in EE from The University of Rochester (1983), the M. Phil and Ph.D. degrees from The City University of New York (1988). He did his PhD work under the supervision of Prof. Robert Alfano, where his thesis focused on developing and utilizing a real time ultrafast spectroscopic probe to study molecular and phonon dynamics in condensed matter, using both supercontinuum and optical phase conjugation techniques. After obtaining the Ph.D. degree, he joined Bell Communication Research as a Member of the Technical Staff, where he concentrated his efforts towards generating ultrafast high power optical pulses from semiconductor diode lasers, for applications in ultra-wideband optical signal processing and communications. Some of his technical accomplishments were the development of the world's fastest, most powerful mode-locked semiconductor laser diode, the demonstration of an optically distributed clocking network for high-speed digital switches and supercomputer applications, and the first observation of the optical nonlinearity induced by the cooling of highly excited electron-hole pairs in semiconductor optical amplifiers. In 1993, he moved to University of Central Florida, where he is University Distinguished Professor, Pegasus Professor and Trustee Chair Professor of Optics, ECE & Physics in CREOL, The College of Optics and Photonics, and is currently serving as the Director of the Townes Laser Institute. In 2003, Dr. Delfyett founded "Raydiance, Inc." a spin-off company developing high power, ultrafast laser systems, based on his research, for applications in medicine, consumer electronics, defense, material processing, biotechnology, automotive and other key technological markets. He is a Fellow of the AAAS, APS, IEEE, NAI, NSBP, OSA, and SPIE. He is also the recipient of the NSF PECASE Award, the APS Edward Bouchet Award, the Medalist from the Florida Academy of Science, the Townsend Harris Award, the IEEE Photonics Society's William Streifer Scientific Achievement Award, and the APS Arthur L Schawlow Prize in Laser Science. Most recently, he was elected to the National Academy of Engineering (NAE). He has over 800 scientific publications, conference proceedings and invited presentations, and 45 US patents.