UCF CREOL, THE COLLEGE OF OPTICS AND PHOTONICS

# Course Syllabus

# OSE 4520 LASER ENGINEERING, 3 Credit Hours


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**Office:** CREOL, Rm. A-231
**Office Hours:** Tuesday, Thursday, 3:00-4:00pm (or by Zoom appointment)


**Term:** Spring 2021
**Class Meeting Days:** Tuesday, Thursday
**Class Meeting Time:** 4:30-5:45pm
**Class Location** CREOL 102-103
**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.

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**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% |

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|---|---|
| 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. |
| > B ≥ | Good, has a strong understanding of most or all of the concepts and is able to apply them to stated and defined situations. |
| > C ≥ | Average, has a basic understanding of the major concepts of the course and is able to apply to basic situations. |
| > D ≥ | 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. |
| > 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:**

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|---|---|
| First Day of Class | Jan. 11 |
| Last Day to Drop Classes: | Jan. 15, Mar 26 |
| Last Day to Add Classes: | Jan. 15 |
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| Final Exam: | April 29; 4:00-6:50pm |

| **COURSE, TERM, INSTRUCTOR**<br>**Daily Schedule (subject to change)** | | | |
|---|---|---|---|
| Week | Date | Concepts Presented: | Textbook chapter |
| 1 | Jan 12, 14 | Overview, Energy states in atoms, Basic stimulated emission, Power and energy, Monochromaticity | |
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| 2 | 19, 21 | Coherency and linewidth, spatial coherence, longitudinal and transverse modes, gain profile. | |
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| 3 | 26, 28 | Laser states, multiple-state laser systems, linewidth and the uncertainty principle | |
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| 4 | Feb 2, 4 | Broadening of fundamental linewidths; basics of gain, blackbody radiation, gain | |
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| 5 | 9, 11 | Longitudinal modes in the laser resonator cavity, quantitative analysis of a Fabry Perot etalon, illustrative Fabry Perot etalon calculations | |
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| 6 | 16, 18 | Review, Midterm | |
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| 7 | 23, 25 | TEM transverse modes, Gaussian beam propagation, ray matricies | |
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| 8 | Mar 2, 4 | Gaussian beams in resonant cavities, ABCD Law | |
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| 9 | 9, 11 | Saturation of the exponential gain process | |
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| 10 | 16, 18 | Homogeneous and inhomogeneous gain saturation | |
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| 11 | 23, 25 | Rate equations, Laser output power characteristics | |
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| 12 | 30, Apr 1 | Relaxation oscillations | |
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| 13 | 6, 8 | Q-switching; Mode-locking | |
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|---|---|---|---|
| 14 | 13, 15 | Spring Break | |
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| 15 | 20, 22 | Semiconductor Lasers, nonlinear processes, e.g., second harmonic generation; Raman scattering, Semester Review | |
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| | Thursday, Apr. 29, 2018<br>4:00 PM – 6:50 PM | Final Exam (Thursday, April 29th) | |