UNIVERSITY OF CENTRAL FLORIDA

# OSE 4520 - Laser Engineering

**Section:** 0001

*Optics and Photonics*

## Course Information

**Term:** Spring 2025
**Class Meeting Days:** TR
**Class Meeting Time:** 12:00PM - 01:15PM
**Class Meeting Location:** BA1 O146
**Modality:** P
**Credit Hours:** 3.00

## Instructor Information

Peter Delfyett
**Title:** University Distinguished Professor of Optics, ECE & Physics
**Office Location:** CREOL A-231
**Office Hours:**
Tuesday, Thursday, 3:00pm-4pm
**Email:** delfyett@creol.ucf.edu

## Teaching Assistants

Mr. Shahebul Hasan <shahebul.hasan@ucf.edu>

## Course Description

OSE 4520 OPTIC 3(3,0)Laser Engineering: PR: PHY 4424??or EEL 4440C or C (2.0 GPA) or higher in OSE 3052 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. Spring

**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:** $C^2$ processes, e.g., second harmonic generation; $C^3$ processes

## Student Learning Outcomes

After successful completion of this course, students will be able to:

- **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 |

## Course Materials and Resources

**Laser Engineering,**
**ISBN:** ISBN 0-020366921-7
**Authors:** Kelin J. Kuhn,
**Publisher:** Prentice Hall,
**Publication Date:** (1998)

## Course Assessment and Grading Procedure

**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**

## Assignment Schedule

| Due Date | Assignment Name | Assignment Type | Points |
|---|---|---|---|
| | No Zoom link? | Discussion | 0 |
| | Student Lounge | Discussion | 0 |
| 1/18/25 | Academic Activity | Assignment | 0 |

## Grading Scale

| Letter Grade | Percentage |
|---|---|
| A | 94-100% |
| A- | 90-93% |
| B+ | 87-89% |
| B | 84-86% |
| B- | 80-83% |
| C+ | 77-79% |
| C | 74-76% |
| C- | 70-73% |
| D+ | 67-69% |
| D | 64-66% |
| D- | 61-63% |
| F | 0-60% |

## Policies for Course Grade

### Makeup Work Policy - With Instructor's Permission

### Missed/Late Assignments - WIth Instructor's Permission

### Attendance - MANDATORY

## Course Accessibility

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) (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.

## Academic Integrity

Students should familiarize themselves with UCF's Code of Conduct at Student Conduct and Integrity Office. According to Section 1, "Academic Misconduct," students are prohibited from engaging in:

a. Academic misconduct is defined as any submitted work or behavior that obstructs the instructor of record's ability to accurately assess the student's understanding or completion of the course materials or degree requirements (e.g., assignment, quiz, and/or exam). Examples of academic misconduct include but are not limited to: plagiarism, unauthorized assistance to complete an academic exercise; unauthorized communication with others during an examination, course assignment, or project; falsifying or misrepresenting academic work; providing misleading information to create a personal advantage to complete course/degree requirements; or multiple submission(s) of academic work without permission of the instructor of record.

b. Any student who knowingly helps another violate academic behavior standards is also in violation of the standards.

c. Commercial Use of Academic Material. Selling of course material to another person and/or uploading course material to a third-party vendor without authorization or without the express written permission of the University and the instructor of record. Course materials include but are not limited to class notes, the instructor of record's slide deck, tests, quizzes, labs, instruction sheets, homework, study guides, and handouts.

d. Soliciting assistance with academic coursework and/or degree requirements. The solicitation of assistance with an assignment, lab, quiz, test, paper, etc., without authorization of the instructor of record or designee is prohibited. This includes but is not limited to asking for answers to a quiz, trading answers, or offering to pay another to complete an assignment. It is considered Academic Misconduct to solicit assistance with academic coursework and/or degree requirements, even if the solicitation did not yield actual assistance (for example, if there was no response to the solicitation).

**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*. UCF faculty members have a responsibility for students' education and the value of a UCF degree, and so seek to prevent unethical behavior and respond to academic misconduct when necessary. Penalties for violating rules, policies, and instructions within this course can range from a zero on the exercise to an "F" letter grade in the course. In addition, an Academic Misconduct report could be filed with the Office of Student Conduct and Academic Integrity, which could lead to disciplinary warning, disciplinary probation, or deferred suspension or separation from the University through suspension, dismissal, or expulsion with the addition of a "Z" designation on one's transcript.

Being found in violation of academic conduct standards could result in a student having to disclose such behavior on a graduate school application, being removed from a leadership position within a student organization, the recipient of scholarships, participation in University activities such as study abroad, internships, etc.

Let's avoid all of this by demonstrating values of honesty, trust, and integrity. No grade is worth compromising your integrity and moving your moral compass. Stay true to doing the right thing: take the zero, not a shortcut.

## Title IX

Title IX prohibits sex discrimination, including sexual misconduct, sexual violence, sexual harassment, and retaliation. If you or someone you know has been harassed or assaulted, you can find resources available to support the victim, including confidential resources and information concerning reporting options at Let's Be Clear and UCF Cares.

For more information on diversity and inclusion, Title IX, accessibility, or UCF's complaint processes contact:

- Title IX – OIE – Office of Institutional Equity & askanadvocate@ucf.edu
- Disability Accommodation – Student Accessibility Services – Student Accessibility Services & sas@ucf.edu
- Access and Community Engagement (including the Ginsberg Center for Inclusion and Community Engagement, Military and Veteran Student Success, and HSI Initiatives)
- UCF Compliance and Ethics Office – Compliance, Ethics, and Risk Office & complianceandethics@ucf.edu
- The Ombuds Office is a safe place to discuss concerns.

## Reporting an Incident or Issue

If you believe you have experienced abusive or discriminatory behavior by any faculty or staff member, contact the Office of Institutional Equity online or at 407-823-1336. You can also choose to report using the UCF Integrity Line and can report anonymously or as yourself at 1-855-877-6049 or using the online form. UCF cares about you and takes every report seriously. For more information see the Reporting an Incident or Issue Webpage.

## 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

At UCF Public Safety and Police, safety is the top priority. Emergencies on campus are rare, but if one should arise, it's important to be familiar with some basic safety and security concepts.

- In an emergency, always dial 911.
- Every UCF classroom has an **Emergency Procedure Guide** posted on a wall near the door, which will show you how to respond to a variety of situations. This guide can also be found online here.
- In the event of an active threat, remember **AVOID, DENY, DEFEND**. Choose the best course of action and act immediately. Watch the video here to learn more.
    - **AVOID**. Pay attention to your surroundings and have an exit plan. Get as much distance and as many barriers between you and the threat as quickly as possible.
    - **DENY.** When avoiding is difficult or impossible, deny the threat access to you and your space. Lockdown by creating barriers, turning the lights off and remaining quiet and out of sight. Make sure your cell phone is silenced, but do not turn it off.
    - **DEFEND.** When you are unable to put distance between yourself and the threat, be prepared to protect yourself. Commit to your actions, be aggressive and do not fight fairly. Do whatever it takes to survive.
- For emergencies on campus, UCF will utilize the UCF Alert system. All UCF students, faculty and staff are automatically enrolled to receive these email and text alerts, however, it's a good idea to frequently ensure your contact information is up to date.

## Financial Aid Accountability

All instructors/faculty are required to document students' academic activity at the beginning of each course. In order to document that you began this course, please

complete this activity by the end of the first week of classes or as soon as possible after adding the course. Failure to do so may result in a delay in the disbursement of your financial aid.

## Class Schedule

| Week | Topic |
|---|---|
| 1 | Overview, Energy states in atoms, Basic stimulated emission, Power and energy, Monochromaticity |
| 2 | Coherence and linewidth, spatial coherence, longitudinal and transverse modes, gain profile. |
| 3 | Laser states, multiple-state laser systems, linewidth and the uncertainty principle. |
| 4 | Broadening of fundamental linewidths; basics of gain, blackbody radiation, gain. |
| 5 | Longitudinal modes in the laser resonator cavity, quantitative analysis of a Fabry Perot etalon, illustrative Fabry Perot etalon calculations. |
| 6 | Review, Midterm |
| 7 | TEM transverse modes, Gaussian beam propagation, ray matricies. |
| 8 | Gaussian beams in resonant cavities, ABCD Law |
| 9 | Saturation of the exponential gain process |
| 10 | Homogeneous and inhomogeneous gain saturation |
| 11 | Spring Break |
| 12 | Rate equations, Laser output power characteristics |
| 13 | Optical Amplification |
| 14 | Transient Processes: Relaxation Oscillations, Q-switching & Mode-locking |
| 15 | Nonlinear processes, e.g., second harmonic generation; Raman scattering, Semiconductor Lasers (if time permits), Semester Review |
| 16 | Final Exam |