UNIVERSITY OF CENTRAL FLORIDA

OSE 6445 - FUND OF ULTRAFAST OPTICS

Section: 0001

Optics and Photonics

Course Information

Term: Fall 2024
Class Meeting Days: MW
Class Meeting Time: 13:30 - 14:45
Class Meeting Location: CROL A214
Modality: P
Credit Hours: 3.00

Combined Section Information

This syllabus applies to sections OSE 6445 0001, OSE 6445 0V02.

Section Meeting Information

Instructor Information

Peter Delfyett
Title: University Distinguished Professor, Pegasus Professor, Trustee Chair
Office Location: CREOL A-231
Office Hours:
3:00pm-4:00pm
Phone: 407 823 6812
Email: delfyett@creol.ucf.edu

Course Description

OSE 6445 OPT-OPT 3(3,0)Fundamentals of Ultrafast Optics: PR: Graduate standing, and OSE 6111 or PHY 5346, and OSE 6525, or C.I. Introductory concepts: Ultrafast Optical Signal Generation, Ultrafast Signal Detection, Ultrafast Optical Signal Transmission, and Ultrafast Optical Signal Processing. Spring.

Fundamentals of Ultrafast Optics

OSE 6445 (3 Credits)

Time: Monday, Wednesday 1:30-2:45

Place: CREOL A214

Instructor: P. J. Delfyett, CREOL A-231, (407) 823-6812, delfyett@creol.ucf.edu

Office Hours: *Open door policy* or from 3:00-4:00pm Mondays and Wednesdays; Rm A-231. Also, Zoom meetings can be scheduled at any time, if I am available.

Webcourse: Each student is REQUIRED to complete an assignment on Webcourse by the end of the first week of class.

Course Goals: To have students become proficient in understanding state of the art technical literature (i.e., scientific journal publications) in areas that develop and use picosecond and femtosecond photonic technologies for scientific and commercial applications.

Student Learning Outcomes: The successful student will be able to analyze ultrashort pulse propagation, generation, measurement systems both analytically and computationally.

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Course Description:

Introductory Concepts (The following are the necessary fundamental quantities that are required in understanding the generation, transmission, detection and manipulation of ultrafast optical signals).

> Definition of Electric Fields, Intensity, Spectral Field & Intensity, Temporal and Spectral Phase, Instantaneous Frequency & Group Delay, Dispersion & Dispersion Engineering (Computer Project of Linear Pulse Propagation).

Ultrafast Optical Signal Transmission (Students learn about linear and nonlinear pulse propagation and the mathematical procedures, e.g., split-step Fourier, for predicting the characteristics, both temporal and spectral, owing to nonlinear effects.

> Optical fibers, pulse compression, soliton propagation, Bragg reflectors, saturable absorption, gain saturation, group delay dispersion (Computer project: nonlinear pulse propagation/solitons; pulse compression).

Ultrafast Optical Signal Generation (The techniques described in this portion of the course are the primary methods of generating ultrafast optical signals with temporal durations in the picosecond and femtosecond regime. The students gain practice in using the fundamental definitions in interpreting the temporal and spectral characteristics of optical signals generated by these methods).

Mode-locking (active, AM&FM, passive via saturable absorber/saturable gain, Kerr lensing, other nonlinear effects), Gain Switching, Direct Modulation, Attosecond pulse generation (Computer Project – Numerical Simulation of Passive Mode-locking w/ Gain Saturation, Optical Frequency Combs and Stabilization).

Ultrafast Signal Detection (Methodologies are discussed for detecting, measuring and characterizing optical signals that are sufficiently fast and beyond the capabilities for conventional electronics).

Ultrafast photodetectors (PIN, avalanche, photoconductive), streak camera, nonlinear optical correlation techniques, joint time-frequency measurements, and multi-heterodyne detection between 2 ultrafast lasers (computer simulation of autocorrelation, spectrogram & SHG FROG).

Ultrafast Optical Signal Processing (Methods for manipulating and processing of ultrafast optical signals. These are critical techniques for future optical communication networks, computer interconnects and advanced ultrahigh speed signal processing).

Pulse shaping, arbitrary waveform generation (optical and RF), optical sampling, optical analog to digital converters, computing and logic, nonlinear switching, photonic network architectures (OTDM, DWDM, OCDMA), and matched filtering.

Course Requirements:

Students are required to have a background or have covered courses in the following areas: physical optics (including coherence, interference, wave propagation), differential equations (including Fourier transforms, wave equations), and lasers. Nonlinear optics is desired but not required. It is desired that students should have completed the optics core curriculum, but it is not required.

Prerequisites:

OSE 6111 Optical Wave Propagation and

OSE 6525 Laser Engineering or PHY 5346 or CI

Computer Literacy

Students are required to be able to utilize standard mathematical coding software (e.g., MatLab, MathCad, Python, Mathematica or other) to perform the simulation exercises.

Exam and Grade Policy

There will be a midterm exam and a final exam. Homework's will be assigned to provide guidance as to how to do problems. ***An emphasis of the evaluation will be on the homework assignments that are computer based projects.*** Late homework is NOT accepted, and will be graded as "zero". The final grade will be posted electronically through UCF. The final exam will be given on the day scheduled by UCF. For written exams performed remotely, Proctor-Hub will be used, and the student must have the appropriate interface (webcam, etc.).

Approximate weighting: Homeworks: 10%; Midterm: 45%; Final: 45 %; Total: 100%.

Grading Policy: The +/- system will be used.

Plagiarism: It is your responsibility to know the rules regarding academic honesty. Failure to comply with these rules may result in failing the course, as well as expulsion from the program.

Reference Materials

1. **Ultrafast Optics, A. M. Weiner, Wiley, 2009, ISBN 978-0-471-41539-8. (Required).**
2. **Ultrashort Laser Pulse Phenomena, J. C. Diels & W. Rudolph, Academic Press, 2006, ISBN 13: 978-0-12-215493-5. (Optional).**
3. **Ultrafast Lasers, U. Keller, Springer, 2021, ISBN 978-3-030-82531-7**
4. **Femtosecond Laser Pulses, C. Rulliere -editor, Springer, (2003), ISBN 0-387-01769-0**

Other useful resources

5. Laser Electronics, 3rd. Ed., J.T. Verdeyen, Prentice Hall, 1995, ISBN 0-13-706666-X
6. Ultrashort Laser Pulses & Applications, W. Kaiser, Ed., Springer Verlag, (1988).
7. Principles and Applications of Optical Communications, M. K. Liu, IRWIN, 1996, ISBN 0-256-16415-0.
8. Fundamentals of Photonics, B. Saleh & M. Teich, J. Wiley (1991)

9. Optical Fiber Communications V:A & V:B, I. P. Kaminow, T. Li, A. Willner, Academic Press (1997) ISBN 978-0-12-374171-4.

10. Compact Sources of Ultrashort Pulses, I. Duling, Ed., Cambridge University Press (1995) ISBN 0-521-46192-8.

11. Ultrafast Lasers, Technology & Applications – M. Fermann, et al., Marcel Dekker (2003) ISBN 0-8247-0841-5.

Final Exam:

When: The Final Exam will be held during the time set by the University Final Exam Schedule – No exceptions (see below).

Monday, December 2nd, 2024 1pm -4 pm, as scheduled by UCF.

Where: A-214.

Course Description:

This course covers the fundamental concepts in the generation, modulation, multiplexing, transmission and measurement of optical signals with temporal durations of picoseconds to attoseconds. Applications of these signals in areas of optical communication and signal processing will also be covered.

Instructor Intro

Peter Delfyett received the B.E.(E.E.) degree from The City College 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 Graduate School & University Center of the City University of New

York (1987,1988). He did his PhD work under the supervision of Prof. Robert Alfano, discoverer of white light supercontinuum. Delfyett's 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 currently 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 APS, AAAS, 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 850 scientific publications, conference proceedings and invited presentations, and 45 US patents.

Student Learning Outcomes

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

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Course Materials and Resources

Course Material will be sent to students through the "Announcements" portal

Course Assessment and Grading Procedure

There will be a midterm exam and a final exam. Homework's (approximately 5) will be assigned to provide guidance as to how to do problems. ***An emphasis of the evaluation will be on the homework assignments that are computer based projects.*** Late homework is NOT accepted, and will be graded as "zero". The final grade will be posted electronically through UCF. The final exam will be given on the day scheduled by UCF. For written exams performed remotely, Proctor-Hub will be used, and the student must have the appropriate interface (webcam, etc.).

Approximate weighting: Homeworks: 10%; Midterm: 45%; Final: 45 %; Total: 100%.
Grading Policy: The +/- system will be used.

Assignment Schedule

Due Date	Assignment Name	Assignment Type	Points
	Student Lounge	Discussion	0
8/23	Academic Engagement Activity	Assignment	1

Grading Scale

Letter Grade	Percentage
A	94-100%
A-	90-93%
B+	87-89%
B	84-86%
B-	80-83%

Letter Grade	Percentage
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

Missed/Late Assignments

Attendance

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.

Reporting an Incident or Issue

If you believe you have experienced abusive or discriminatory behavior by any faculty of 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.

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 of 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	

Week	Topic
2	
3	
4	
5	
6	
7	
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9	
10	
11	
12	
13	
14	
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16	