CREOL OSE6334: Nonlinear Optics
College of Optics and Photonics
University of Central Florida

COURSE SYLLABUS

Instructor:	Dr. Konstantin Vodopyanov	Term:	Fall 2019
Office:	CREOL Room A113	Class Meeting Days:	Mo, Wed
Phone:	407 823 6818	Meeting Hours:	1:30–2:45 PM
E-Mail:	vodopyanov@creol.ucf.edu	Class Location:	Room 102
Website:	http://www.mircoms.com		
Office Hours:	Fridays 5-6 pm (or by appointment)	TA:	n/a

I. Welcome!

Welcome to the CREOL OSE6334 course: Nonlinear Optics.

II. University Course Catalog Description:

Maxwell's equations in nonlinear media, frequency conversion techniques (SHG, SFG, OPO), stimulated scattering, phase conjugation, wave-guided optics, nonlinear crystals.

III. Course Description:

This course is about the interaction of *intense* light with matter, when the interaction becomes *nonlinear*. 'Nonlinear' means that the Newton's superposition principle ("the net response caused by two stimuli is the sum of the responses that would have been caused by each stimulus individually") is no longer valid. In fact, nowadays nonlinear effects in some materials can be produced by lasers with only mW power. The topics to be covered include: Maxwell's equations in nonlinear media, coupled-wave equations, 2-nd and 3-rd order nonlinear susceptibilities, nonlinear-optical tensors, nonlinear crystals, phase-matching, frequency conversion techniques (sum-frequency, second harmonic, difference-frequency generation, and parametric amplification and oscillation), multiphoton absorption, intensity-dependent refractive index, self-focusing, stimulated Raman and Brillouin scattering, and supercontinuum generation.

IV. Learning Outcomes:

Students will get knowledge of a variety of nonlinear effects in laser physics and develop an intuitive understanding of nonlinear optics. They will get a solid grasp of various aspects of nonlinear optics, from understanding nonlinear materials, frequency up- and down-conversion, and supercontinuum 'white-light' generation, to nonlinear fluorescence microscopy and high-field interactions.

V. Course Prerequisites

OSE6111 Optical Wave Propagation

VI. Course Credits:

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VII. Main textbook:

Robert W. Boyd, Nonlinear Optics, 3-rd Edition, (Academic Press, 2008).

VIII. Other textbooks:

B.E.A. Saleh, M.C. Teich, Fundamentals of Photonics (Wiley 1991)
G.I. Stegeman, R.A. Stegeman, Nonlinear Optics Phenomena, Materials, and Devices (Wiley, 2012)
A. Yariv, Quantum Electronics, 3-rd Edition, (Wiley 2003)
Y.R. Shen, The Principles of Nonlinear Optics (Wiley 2003)

IX. Basis for Final Grade:

Assessment	Percent of Final Grade
Homework	35 %
Midterm Exam	35 %
Final Exam (in the form of 10-min presentation)	30 %
	100%

Grading scale:

Grading Scale (%)	
94-100	A
90-93	A-
87-89	B+
84-86	B
80-83	B-
77-79	C+
74-76	C
70-73	C-
67-69	D+
64-66	D
60-63	D-
0 - 59	F

X. Grade Dissemination

Graded tests and materials in this course will be returned individually only by request. You can access your scores at any time using "myUCF Grades" in the portal. Please note that scores returned mid-semester are unofficial grades. If you need help accessing myUCF Grades, see the online tutorial: https://myucfgrades.ucf.edu/help/.

XI. Course Policies: Grades

Late Work Policy: There are no make-ups for the homework, or the final exam. Late homework submission penalty: 10% will be deduced for each day of the delay.

Grades of "Incomplete":
The current university policy concerning incomplete grades will be followed in this course. Incomplete grades are given only in situations where *unexpected emergencies prevent a student from completing the course and the remaining work can be completed the next semester*. Instructor is the final authority on whether you qualify for an incomplete. Incomplete work must be finished by the end of the subsequent semester or the "I" will automatically be recorded as an "F" on your transcript.

XII. Course Policies: Technology and Media

Email: Please use email vodopyanov@creol.ucf.edu for all correspondence.

Website: All information concerning the course will be posted on WebCourses. This site will reflect latest changes, contain some key scientific papers, as well as lecture handouts that will be posted for each lecture the day before the lecture (may be very late evening).

XIII. Course Policies: Student Expectations

Disability Access: The University of Central Florida is committed to providing reasonable accommodations for all persons with disabilities. Students with disabilities who need accommodations in this course must contact the professor at the beginning of the semester to discuss needed accommodations. No accommodations will be provided until the student has met with the professor to request accommodations. Students who need accommodations must be registered with Student Disability Services, Student Resource Center Room 132, phone (407) 823-2371, TTY/TDD only phone (407) 823-2116, before requesting accommodations from the professor.

Attendance Policy:
• Regular class attendance is strongly advised and is necessary for students to understand many of the topics covered.
• Students must be on time to class.
• If missed a class, it is the responsibility of the student to find out the materials covered.

Professionalism Policy:
Per university policy and classroom etiquette; mobile phones, iPods, *etc*. **must be silenced** during all classroom lectures. Those not heeding this rule will be asked to leave the classroom immediately so as to not disrupt the learning environment. Please arrive on time for all class meetings. Students who

habitually disturb the class by talking, arriving late, *etc*., and have been warned may suffer a reduction in their final class grade.

Academic Conduct Policy:
Academic dishonesty in any form will not be tolerated. As in all University courses, The Golden Rule of Conduct will be applied. Violations of these rules will result in a record of the infraction being placed in your file and receiving a zero on the work in question. At the instructor's discretion, you may also receive a failing grade for the course. Confirmation of such incidents can also result in expulsion from the University.

XIV. Important Dates to Remember

Withdrawal Deadline: Thursday, Aug 29, 2019
Final Exam (in the form of 10-min scientific presentation): 1:00–3:50pm, Dec 9, 2019

XV. Schedule, Fall 2019

1	26-Aug	Lecture 1. (online) Linear electrodynamics. Introduction to nonlinear optics.
2	28-Aug	No class [Conf. in Dijon, France]
3	2-Sep	Labor day, no class
4	4-Sep	Lecture 2. Mathematical formalism of nonlinear optics
5	9-Sep	Lecture 3. Nonlinear susceptibility of a classical anharmonic oscillator.
6	11-Sep	Lecture 4. Quantum-mechanical perturbation theory for the nonlinear optical susceptibility
7	16-Sep	Lecture 5. Coupled-wave equations
8	18-Sep	Lecture 6. Sum-frequency and second-harmonic generation
9	23-Sep	Lecture 7. Second-order $X^{(2)}$ nonlinear optical materials
10	25-Sep	Lecture 8. Phase matching
11	30-Sep	Lecture 9. Quasi-phase-matching (QPM)
12	2-Oct	Lecture 10. Second-harmonic generation inside a resonator cavity
13	7-Oct	No class [Conf. in Bol, Croatia]
14	9-Oct	Lecture 11. (online) Difference-frequency generation.
17	14-Oct	Lecture 12. Optical parametric oscillators and amplifiers.
16	16-Oct	No class, Prepare for the Midterm exam.
15	21-Oct	**Midterm exam**
18	23-Oct	Lecture 13. Discussing midterm exam. Bandwidth and OPO tuning curves
19	28-Oct	Lecture 14. Conversion efficiency of the nonlinear optical processes
20	30-Oct	Lecture 15. Frequency conversion using femtosecond optical pulses
21	4-Nov	Lecture 16. Third-order $X^{(3)}$ nonlinear susceptibility
22	6-Nov	Lecture 17. Kerr effect. Intensity-dependent refractive index.
23	11-Nov	Lecture 18. Self-focusing. Self-phase modulation
24	13-Nov	Lecture 19. Third harmonic generation. Parametric processes due to 4-wave mixing
25	18-Nov	Lecture 20. Phase conjugation, optical limiting, all-optical switching.
26	20-Nov	Lecture 21. Techniques for measuring second- and third-order nonlinearities; Z-scan
27	25-Nov	Lecture 22. Nonlinear phase shift due to cascaded effects
28	27-Nov	Lecture 23. Stimulated Raman and Brillouin scattering

29	2-Dec	Lecture 24. Modern examples: Two-photon microscopy, high-field interactions.
30	4-Dec	Lecture 25. Discussing topics for the Final Exam
31	9-Dec	**Final Exam (students' talks, 10 min) 1:00 - 3: 50 - official (2:50 hours)**
32	11-Dec	Final Grades