UCF CREOL, THE COLLEGE OF OPTICS AND PHOTONICS

Course Syllabus

OSE 6525 - Laser Engineering

Instructor:

Dr. Axel Schülzgen
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Class Hours:

Tuesdays 5:00 – 7:30 p.m. at Lockheed Martin, room: TBD
Office: Room A115 CREOL Building
Email: axel@creol.ucf.edu

Office Hours: Monday, Wednesday 1:00 – 2:00 p.m., subject to change

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 description and learning outcomes:

This course is titled "Laser Engineering" but could as well have been titled "Laser Principles". It is an introductory course in lasers, so in fact there is more "Laser Principles" and little "Engineering" in it. The chief purpose is for students to obtain a solid understanding of the basic principles of lasers and to be familiar with the operation of most common laser types. The course is taught in the classical approximation so a knowledge of quantum mechanics is not required.

This course is being taught to satisfy the requirements of the optics Ph.D. curriculum.

The primary ***learning outcomes*** are:

- To understand the difference between laser and thermal radiation.
- To become conversant with the Einstein treatment of absorption and emission and to be able to describe laser media with rate equations, and to solve these.
- To understand gain saturation and broadening and to calculate cw laser output powers.
- To determine stability of laser cavities and calculate Gaussian laser cavity modes, as well as how they propagate in free space and how they are focused.
- To understand and calculate pulsed laser outputs.
- To be knowledgeable about the principles of operation of the most common laser types.

<u>Topics:</u> (A detailed schedule with dates will be posted on the website.)

Introduction, history, properties of laser light
Blackbody radiation, Planck's theorem

Absorption, spontaneous & stimulated emission
Rate Equations
Line broadening mechanisms, homogeneously and inhomogeneously broadened lines
Saturation effects

Energy levels: atoms, molecules, solid-state
3 and 4 level systems
Laser threshold and cw operation, Quasi-3 level lasers, optimum output coupling, ASE

Paraxial beams, cavity modes, ABCD matrices, Stable and unstable resonators
Gaussian beams
Properties of resonators
Passive resonators, eigenmodes, cavity Q

Electrical and optical pumping
Transient behavior, relaxation oscillation
Q-switching and mode-locking, short pulse characterization,

Semiconductors: band structure & density of states
Absorption and gain spectra, low-dimensional semiconductors

Semiconductor diodes, homojunction and heterojunction lasers
Quantum well lasers and VCSELs
Crystalline lasers
Glass and fiber lasers
Gas lasers: amplification in atoms, ions and molecules
Frequency conversion: SHG, sum frequency, parametric amplification and oscillation

<u>Textbook:</u>

“Principles of Lasers”, Orazio Svelto, 5th edition, (Springer)
Reading assignments will be taken from this textbook.

Other useful reference books:

“Laser Electronics”, J. Verdeyen, (Prentice-Hall)
“Laser Fundamentals” W. T. Silfvast, (Cambridge)
“Lasers” A.E. Siegman
“Optical Electronics in Modern Communications", 5th edition, A. Yariv, (Oxford)
Almost any other text titled “…Lasers…” will probably provide insight on the topic.

Class Web site:

http://webcourses.ucf.edu

This site will reflect latest changes and contain homework and reading assignments. Slides used for classes will be available for download before each class. If you want a hard copy of the slides, print them. You are required to read the notes prior to class.

Teaching and Learning

Most people learn things for themselves. As a teacher, my job is to help you learn the material. In order to help you learn in depth, I plan to use some class time for detailed discussion of concepts and group project work. Credit will be given for these activities. These types of activities require that students actually carry out reading assignments prior to class. Hence I will occasionally set quizzes to ensure that students come to class prepared.

Grading Policy:

Homework	15%
quizzes	5%
In class participation	5%
Two mid-terms, each worth 20% of total grade	40%
Final exam	35%

All students are expected to participate in the mid-term and final exams.

Final Exam: May 1, 2018, 1:00 p.m - 3:50 p.m.

Grading Scale:

90-100 A
80-89 B
70-79 C
60-69 D
0 - 59 F

Academic Activity:

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 24, 2018. Failure to do so will result in a delay in the disbursement of your financial aid.
Assignment: In one paragraph, explain why you are taking the laser engineering course? Send your answer per email or upload it. The deadline for this assignment is August 24, 2018.

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 Rules 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 A MINIMUM. 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.

Class Schedule

DAY	DATE			
Thu	8/23/2018	Lecture 1	Introduction	Introduction, history, properties of laser light
Thu	8/23/2018	Lecture 2	Int'n radiation/atoms & ions	Blackbody radiation, Planck's theorem
Thu	8/30/2018	Lecture 3	Int'n radiation/atoms & ions	Absorption, spontaneous & stimulated emission
Thu	8/30/2018	Lecture 4	Int'n radiation/atoms & ions	Line broadening mechanisms, homogeneously broadened lines
Thu	9/6/2018	Lecture 5	Int'n radiation/atoms & ions	Line broadening mechanisms, inhomogeneously broadened lines
Thu	9/6/2018	Lecture 6	The laser	Saturation effects
Thu	9/13/2018	Lecture 7	The laser	Saturation of inhom. broadened lines, spectral hole burning
Thu	9/13/2018	Lecture 8	The laser	Energy levels: atoms, molecules, solid-state
Thu	9/20/2018	Lecture 9	The laser	2, 3, and 4-level lasers
Thu	9/20/2018	Lecture 10	The laser	Continuous wave operation, output coupling, space independent model
Thu	9/27/2018		Midterm 1	Light interaction with matter: The Laser
Thu	10/4/2018	Lecture 11	Modes in lasers	Paraxial beams, modes, ABCD matrices, resonator stability
Thu	10/4/2018	Lecture 12	Modes in lasers	Gaussian beams, higher order modes
Thu	10/11/2018	Lecture 13	Modes in lasers	Passive resonators, eigenmodes, stability
Thu	10/11/2018	Lecture 14	Modes in lasers	multiple modes, unstable resonators, Fabry-Perot interferometer
Thu	10/18/2018	Lecture 15	Modes in lasers	Longitudinal modes, cavity Q
Thu	10/18/2018	Lecture 16	Laser pumping	Electrical and optical pumping methods
Tue	10/25/2018	Lecture 17	Pulsed lasers	Transient behavior, relaxation oscillation
Thu	10/25/2018	Lecture 18	Pulsed lasers	Q-switching
Thu	11/1/2018	Lecture 19	Pulsed lasers	Mode-locking
Thu	11/1/2018	Lecture 20	Pulsed lasers	Measurement of laser dynamics, recap
Thu	11/8/2018		Midterm 2	Modes and laser dynamics
Thu	11/15/2018	Lecture 21	Semiconductor lasers	Electronic structure of semiconductors, optical spectra
Tue	11/15/2018	Lecture 22	Semiconductor lasers	Gain in semiconductors, spectra of quantum structures
Thu	11/29/2018	Lecture 23	Semiconductor lasers	Semiconductor diodes, quantum well lasers and VCSELs
Tue	11/29/2018	Lecture 24	Solid-state lasers	Selected lasers: vibronic, excimer, fiber lasers
		Final Exam	12/6/2018; 5:00 p.m - 7:50 p.m	