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ELEC 463 Syllabus

Objective

The primary objective of the course is to provide both an analytical and a physical understanding of how laser devices operate, based on the physics involved. Secondary objectives are to provide some familiarity with currently important laser devices, their performance characteristics, and some practical applications.

Text

Required: *Lasers,* A. E. Siegman, University Science Books. (10% discount at http://www.uscibooks.com/siegman.htm)

Additional Sources: *Laser Electronics*, Joseph T. Verdeyen, Prentice-Hall; *Laser Fundamentals*, W. T. Silfvast, Cambridge University Press.

Course Outline

Introduction: A summary of the topics to be covered; how lasers work, their properties, and some applications. (Chapter 1 of *Lasers)*

Atomic Transitions: We use a classical electron oscillator model to develop an accurate analytical description of how light interacts with the energy levels of atoms or molecules; spontaneous and stimulated transitions, resonance, damping, line broadening, polarization and susceptibility. (Chapters 2 & 3)

Atomic Rate Equations: Development of the rate equations that describe how atoms make signal-stimulated transitions, and non-stimulated relaxation transitions between levels; use of these equations to analyze laser pumping, population inversion, and gain saturation. (Chapters 4 & 6)

Amplification: Use of simple electromagnetic wave propagation and transmission line theory to explain how optical signals are amplified and phase-shifted as the pass through resonant laser media; stimulated transition cross sections, saturation. (Chapter 7)

Optical Feedback: Oscillation requires positive feedback. We examine the resonance properties, including reflection and transmission, of optical resonators and interferometers, and how these change with an internal amplifying laser medium. (Chapter 11)

Laser Oscillators: We combine amplification and feedback to understand laser threshold, oscillation buildup, output power, and output coupling considerations. (Chapter 12 and parts of Chapter 13)

Optical Beams and Resonators: We describe the transverse spatial properties of the beams produced by lasers, which are not conveniently described by plane waves. We start with paraxial ray optics and matrices, followed by a diffraction theory model, and then connect the two. We describe the properties of Hermite-gaussian beams in free space and as modified by optical elements. We discuss the properties of optical resonators with curved mirrors and the beams they produce. (Chapters 14, 15, 17, 19, and class notes.)

Laser Dynamics: We develop simple laser cavity equations combining atomic population levels and resonator photon number to study laser spiking, amplitude modulation, mode competition, Q-switching, and mode locking. (Section 24.5, and portions of Chapters 25–28)

Linear Pulse Propagation: The extremely short optical pulses produced by lasers are modified by propagation through dispersive materials, such as fibers. We introduce the fundamental concepts of phase and group velocities, pulse broadening, compression, and distortion. Some nonlinear effects will be described qualitatively, such as self-focusing, self-phase modulation and soliton propagation. (Chapter 9 and portions of Chapter 10)

Laser Systems, Engineering, and Applications: Student presentations on topics of interest that involve lasers, photonics, or optics.

Course Style and Grading

I hope this course will be more participatory than typical engineering courses. While there will be some lectures, the text is quite clear and there is no need for me to transcribe material from the book to the board so students can transcribe it to their notes. Instead, we will use class time to discuss issues raised by the assigned material, problems, and supplementary topics. Homework will be assigned weekly and collected, and then students will be asked to present their solutions in class. It is important that students keep up with the assigned reading and problems. This will be encouraged by more frequent quizes, about 4 during the semester. At the end of the semester, students will give a short oral presentation on a topic of their choice related to lasers, photonics, or optics.

Grades will be based on the exams (65%), homework (10%), class participation (15%), and an oral presentation (10%); no final exam. The exams are pledged. The exact conditions—open book, notes, time limits, etc.—will be clearly specified for each in advance. In the case of an open-notes exam, you may use only notes that you have written. Unless otherwise notified, you are encouraged to work with others on assignments and problems to be discussed in class. However, you may not simply *copy* problem solutions from any source.

Special Accommodations

Any student with a disability requiring accommodations in this course is encouraged to contact me during the first week of class. In addition, such students should contact Disabled Student Services in the Ley Student Center.