ECE4751 Course Syllabus

ECE4751

Laser Theory and Applications (3-0-0-3)

CMPE Degree
This course is Elective for the CMPE degree.

EE Degree
This course is Elective for the EE degree.

Lab Hours
0 supervised lab hours and 0 unsupervised lab hours

Course Coordinator
Adibi,Ali

Prerequisites
PHYS 2212

Corequisites
None

Catalog Description
Provides an introduction to the theory and applications of laser principles and related instrumentation. Emphasis is on the fundamental principles underlying laser action. Crosslisted with PHYS 4751.

Textbook(s)
O'Shea, Callen & Rhodes, *Introduction to Lasers and Their Applications*, Addison Wesley, 1978. ISBN 9780201055092 (required)

Course Outcomes
Upon successful completion of this course, students should be able to:

1. Analyze the propagation of an optical beam with an arbitrary polarization inside a free-space optical system with polarization-sensitive components.
2. Analyze three-level and four-leve laser systems through detailed calculation of the gain, population inversion, and cavity modes.
3. Analyze and design stable mirror-based cavities for achieving single-mode or multi-mode operation; analyze the longitudinal and transverse modes and their Gaussian beam profiles in a mirror-based cavity.
4. Analyze different classes of lasers (gas, liquid, solid-state, excimer, and seminconductor laser); also design a stable laser with a given set of specifications using simple building blocks (a variety of gain media, a series of mirrors, filters, switches, and modulators).
5. Design (conceptually using fundamental building blocks) active and passive Q-switched and mode-locked pulsed lasers and analyze their pulse properties .
6. Analyze, explain, and compare in detail the data sheets of different commercial laser systems.

7. Design simple experiments to measure the fundamental properties of a laser (especially its divergence angle, coherence length, and beam profile).
8. Analyze different classes of optical detectors (photomultiplier tubes and semiconductor detectors).
9. Analyze an optical communication system formed through building blocks (laser source, modulator, fiber, detector) in terms of the signal to noise rato and the bit error rate for simple modulation schemes.
10. Analyze and design Fabry-Perot-based filters and spectrometrs.

Student Outcomes

In the parentheses for each Student Outcome:
"P" for primary indicates the outcome is a major focus of the entire course.
“M” for moderate indicates the outcome is the focus of at least one component of the course, but not majority of course material.
“LN” for “little to none” indicates that the course does not contribute significantly to this outcome.

1. (P) An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. (LN) An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
3. (LN) An ability to communicate effectively with a range of audiences
4. (LN) An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
5. (LN) An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
6. (M) An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7. (LN) An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Topical Outline

Introduction

Properties of Laser light
- Wave motion
- Laws of Reflection and Refraction
- Monochromaticity
- Directionality and Brightness
- Interference and Coherence
- Polarization

Gaussian Beams

Introduction to Lasers
- Stimulated Emission
- Einstein Coefficients
- Lineshape
- Threshold and Steady State Conditions
- Two, Three, and Four Level Laser Systems

Laser Dynamics
- Q-switching and Mode-locking
- Saturable Absorbers and Amplifiers

Laser Examples
- Gas Lasers
- Excimer Lasers
- Doped Insulator Lasers
- Dye Lasers
- Semiconductor Lasers

Detection and Characterization of Optical Radiation
- Thermal Detectors
- Quantum Detectors
- Measurement Techniques

Optical Communication
- Fiber Optics
- Systems

Power Applications
- Beam Focussing
- Material Processing
- Scanning Systems

Holography