Master Course Description

No: EE 488/588

Title: Advanced Photonics

Credits: 4

UW Course Catalog Description

In-depth understanding and learning of advanced subjects in photonics. Topics include optical resonance, quantum nature of light and optical transitions, optical amplification, laser operation, and photodetection.

Coordinator: Lih Y. Lin, Professor of Electrical and Computer Engineering

Potential Instructors for this Course: Prof. Lih Y. Lin, Prof. Mo Li, Prof. Arka Majumdar

Goals: To introduce students advanced topics in modern optics and photonics based on quantum nature of light. To further prepare students for advanced or specialized graduate-level courses in the relevant fields.

Learning Objectives:

At the end of this course, students will be able to:

1. *Explain* the concept of optical resonance.
2. *Describe* key parameters and design principles of optical resonators.
3. *Describe* the quantum nature of light and optical transitions in medium.
4. *Explain* optical amplification.
5. *List* the necessary conditions for amplification to occur.
6. *Describe* laser operation principles and characteristics.
7. *Apply* underlying principles to *design* a laser.
8. *Describe* the principles for photodetectors and photodetection systems.
9. *Identify* key performance parameters for photodetectors and photodetection systems.

Textbook:

Jia-Ming Liu, “Principles of Photonics,” Cambridge University Press.

Reference Texts:

F. L. Pedrotti L. S. Pedrotti, and L. M. Pedrotti, “Introduction to Optics,” 3rd ed. Cambridge University Press.
B. E. A. Saleh and M. C. Teich, "Fundamentals of Photonics", 2nd ed. John Wiley & Sons.
J. T. Verdeyen, “Laser Electronics,” 3rd ed. Prentice Hall.

Prerequisites:

Either EE 485 or EE 487 or EE 587

Topics:

1. **Optical resonance:** Principle of optical resonators, photon lifetime and cavity quality factor, laser mode suppression, characteristics of laser beams in a resonator.
2. **Quantum nature of light and optical transitions:** Photon nature of light, optical transitions, transition rate equations, attenuation and amplification.
3. **Optical amplification:** Steady-state population in quasi-two-level, three-level, and four-level systems, conditions and parameters for optical gain.
4. **Laser operation:** Basic principles, steady-state laser operation, laser power characteristics and efficiencies, oscillating laser modes and linewidth, pulsed-laser operations.
5. **Photodetection:** Photodetection process, photodetector noise, performance parameters, photoconductors, junction photodiodes.

Course Structure: Class meets for two lectures a week, each consisting of a 100 minute session with 10 minute break in between. Homework is assigned for each topic. There is a midterm exam and a final project.

Grading: Homework (40%), midterm exam (30%), final project (30%).

Distinguishing Graduate and Undergraduate Components: All students are asked to design and model a laser system. The design goal for undergraduate students is to determine various parameters for the laser system using one of the example systems discussed in the lectures. The design goal for graduate students is to determine various parameters for the laser system using a laser gain material or system not covered in the lectures through searching literature. Additional homework problems with higher difficulty will also be assigned for graduate students.

Computer Resources: Mathematical programming software such as Matlab, Mathcad, or Mathematica will be useful for some of the homework problems and the final project.

Laboratory Resources: Not required.

Outcome Coverage:

(1) *Problems: An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.* The course applies knowledge of physics, engineering and mathematics to description and analysis of advanced topics in optics and photonics. Problem-solving is expected throughout the course. Relevance: High.

(7) *Learning: An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.* To solve problems and design devices and systems in photonics requires the

ability to acquire and apply new knowledge, tools and learning strategies in engineering, physics and math. Relevance: Medium.

Religious Accommodations

Washington state law requires that UW develop a policy for accommodation of student absences or significant hardship due to reasons of faith or conscience, or for organized religious activities. The UW's policy, including more information about how to request an accommodation, is available at https://registrar.washington.edu/staffandfaculty/religious-accommodations-policy/. Accommodations must be requested within the first two weeks of this course using the https://registrar.washington.edu/students/religious-accommodations-request/

Preparers: Lih Y. Lin

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