Master Course Description – EE 487/587

Title: Introduction to Photonics

Credits: 4

UW Course Catalog Description

Introduction to optical principles and phenomena. Topics include electromagnetic theory of light, optical interference, diffraction, polarization, optical waveguides, and optical fibers.

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 acquaint students with vocabulary, major principles, and phenomena of modern optics and photonics. To prepare students for advanced courses in the field of photonics.

Learning Objectives:

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

1. *Explain* concepts in electromagnetic theory that are relevant to the behavior of light.
2. *Apply* major concepts of electromagnetic theory to the behavior of light.
3. *Describe* basic light propagation in free space and materials.
4. *Apply* polarization to the treatment of light.
5. *Formulate* and *derive* equations for interference and diffraction of light.
6. *Explain* phenomena of interference and diffraction.
7. *Analyze* optical waveguide structures.
8. *Design* an optical waveguide structure or other photonic system.

Textbook:

F. L. Pedrotti L. S. Pedrotti, and L. M. Pedrotti, “Introduction to Optics,” 3rd ed. Cambridge University Press.

Reference Texts:

Jia-Ming Liu, “Principles of Photonics,” 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 by Topic:

1. Basic principles of electromagnetism (PHYS 123, EE 361, or Equivalent)
2. Complex numbers and functions
3. Introductory differential and integral calculus, linear differential equations

Prerequisites by Course:

E E 361; either MATH 207 or MATH 307; either MATH 208 or MATH 308; either PHYS 123 or PHYS 143

Topics:

1. **Electromagnetic theory of light:** Optical wave functions, wave equations, Maxwell's equations in media, optical power and energy.
2. **Polarization:** Jones vectors and Jones matrices, reflection and refraction at dielectric interfaces, polarization devices.
3. **Interference:** Principle of superposition and interference, two-beam interference and interferometry, multi-wave interference, Fabry-Perot interferometer, group/phase velocity and dispersion.
4. **Diffraction:** Fraunhofer diffraction, diffraction grating, Fresnel diffraction.
5. **Optical waveguides:** Total internal reflection, different waveguide structures, modes in optical waveguides, effective index, modal dispersion, applications in optical fibers.

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 an optical waveguide. The design goals for undergraduate students include determining the effective index and electric-field mode profile of a one-dimensional waveguides. The design goals for graduate students include determining the effective index and electric-field mode profile of a two-dimensional waveguides. Additional homework problems with higher difficulty will 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 and mathematics to description and analysis of optical phenomena, devices and

systems. Electromagnetic theory and optics formalisms are used throughout the course. Relevance: High.

(7) *Learning: An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.* To solve problems in photonics requires the ability to acquire and apply new knowledge, tools and learning strategies in engineering, physics and math. Relevance: Medium. **Preparers:** Lih Y. Lin

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