# 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