ECE 597TN/697TN - Photonics

Department of Electrical and Computer Engineering
University of Massachusetts Amherst

Syllabus

Spring 2018

Instructor

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Time and Location

Lecture: 10:00AM-11:15AM Tuesdays and Thursdays, ELab 323
Office hours: 11:20AM-noon Tuesdays and Thursdays or by appointment, Knowles 211C

Prerequisite:

ECE 333 (Fields and Waves I), Physics 422 (Electricity and Magnetism II), or equivalent.

Course Overview

This course introduces students to the fundamental operating principles of optical components and photonic devices. Three different descriptions of optical propagation and interaction (geometrical optics, wave optics, and electromagnetic optics) with increasing complexity and accuracy are presented. Physical phenomena and photonic devices whose operation can be described within the scope of each theory are introduced and discussed.

Resources

Main text:
Saleh, B. E. A. & Teich, M. C. *Fundamentals of photonics*. 2nd edn, (Wiley Interscience, 2007).
e-book version available here through UMass Library.
Other References:
Yariv, A. *Optical electronics in modern communications*. 5th edn, (Oxford University Press, 1997).
Hecht, E. *Optics*. 4th edn, (Addison-Wesley, 2002).
Goodman, J. W. *Introduction to Fourier optics*. 3rd edn, (Roberts & Co., 2005).
Haus, H. A. *Waves and fields in optoelectronics*. (Prentice-Hall, 1984).

Grading

Homework 30%
Midterm (tentatively 5:00PM-7:00PM on Thursday March 8, 2018) 20%
Project 30%
Final Exam (10:30AM-12:30PM on Wednesday May 9, 2018) 20%

Homework Policies

Weekly problem sets (~10 total) will be assigned on Thursdays, and are due the following Thursday in class before the start of the lecture. Students get one late homework pass and may turn their homework in without a penalty at the beginning of the lecture following the due date.

Collaboration on problem sets is allowed and encouraged. However, you must write your own solutions to the problems, and must cite all people with whom you have collaborated.

Project

Each student should conduct a critical literature review on an active research area in the field of photonics, present it in a 12-min-talk and a 2-page report. A list of project topics will be provided in the second part of the course (after the midterm), and the students are also welcome to propose their topics of interest.

Exam Policies

The class will have one in class midterm and the final exam. The midterm will cover the materials before the spring break and the final exam will cover the materials after the break. The exams are closed-book, but students are allowed to bring one double-sided page of notes. Use of calculators is also allowed.

Course Topics

Ray optics
Fermat principle, laws of reflection and refraction, optical components, paraxial ray tracing (transfer matrix (ABCD) approach), spot diagram, optical design software

Wave optics
Helmholtz equation, paraxial equation, Gaussian beams, ABCD approach, other types of beams, Angular spectrum method, resolution limit, Fresnel and Fraunhofer diffraction, optical Fourier transform, 4f-system, holography

Electromagnetic optics
Optics of dielectric media, absorption, dispersion, anisotropy, nonlinearity, optical properties of conductive media, vectorial beams, Kramers-Kronig relation

Polarization of light
Reflection and refraction from planar interfaces, Jones matrix, Stocks parameters and Poincare sphere, light propagation in anisotropic media, optical activity and magneto-optics effect, liquid crystals, polarization manipulation components

Optical waveguides
Guided waves, slab waveguide modes, optical fibers, commonly used photonics waveguides, coupling into and between optical waveguides, optical waveguide components

Periodic structures
Bragg mirror, Bloch modes, band structure, photonic bandgap and photonic crystals

Optical resonators
Free space resonators, quality factor and life-time, micro-resonators, coupling to resonators, mode dynamics

Optical amplification and gain
Interaction of light with atoms, spontaneous and stimulated emission, population inversion and optical gain, gain nonlinearity

Lasers
Optical feedback, lasing condition and threshold, spectral distribution, common types of lasers, pulsed lasers

Time-permitting: Electro-optics, Nonlinear optics, and Acousto-optics