Objectives of Photonics I: The course will introduce classical optics from first principles at a first year graduate level. The theory of electromagnetic and physical optics is systematically presented, and forms the base for further study in guided wave optics, optical resonators, plasmonics, electro- and acousto-optics, nonlinear optics and lasers.

Instructor: Chang-Hua Liu

Prerequisites: Optics, Electromagnetic theory or Graduate standing

Office hours: TBD or by appointment (send me an email: chliu@ee.nthu.edu.tw)

Textbook: None required. I will post the lecture notes.

Supplementary References:

B.E.A. Saleh and M.C. Teich, Fundamentals of Photonics (Wiley)

E. Hecht, Optics (Addison Wesley)

R. Guenther, Modern Optics (Wiley)

M. Born and E. Wolf, Principles of Optics (Cambridge)

A. Yariv, P. Yeh, Optical waves in Crystals (Wiley)

Grades:

Homework: 20%

Quiz and Participation: 10%

Exam 1: 30% Exam 2: 30%

Final Presentation: 10%

Course Outline:

1. Electromagnetic wave
Theory:
- Maxwell's equations and harmonic plane wave solutions
- Energy density and flow
- Nonmonochromatic waves and pulses
- Modes and the Helmholtz equation
- General mode problem and density of modes
- Reflection and refraction at boundaries
Technical applications:
- Waveguides
- Fiber optics

2. Classical light-matter interactions
Theory:
- Dipole radiation
- Lorentz atom model
- Index of refraction & Sellmeier's equation
- Resonant absorption and dispersion
- Kramers-Kronig relations

Technical applications:
- Optical forces and optical trapping
- Plasmonic nanoparticles

3. Interference
Theory:
- Superposition: addition of waves
- Young's interference
- Interference in dielectric layers and periodic structures
- Michelson interferometer
- N slits and diffraction gratings
Technical applications:
- Distributed Bragg reflectors
- Basic introduction of photonic crystals
- Wavelength-division multiplexing (WDM)

4. Diffraction and Beam Propagation
Theory:
- Angular spectrum representation
- Paraxial wave propagation
- Fraunhofer diffraction
- Fresnel diffraction
Technical applications:
- Image formation and resolution, spatial filtering, 4f lens system, Fresnel zone plates

5. Optical waves in anisotropic dielectric medium (part of the materials might be taught in photonics II)
Theory:
- Polarization of light: vector nature of waves, representations of a polarization state
- Birefringence
- Jones calculus and its applications
- Electro-optic and acousto-optic effects
Technical applications:
- Polarizer, waveplate, optical modulator