FALL 2015 – PHYSICS 460/EE 470 – PHYSICAL OPTICS

MWF 8:30–9:20 WAT 417A

Instructor: Eric B. Szarmes, Associate Professor of Physics

Course description: This course presents the fundamentals of classical physical optics in sufficient depth to provide both a solid understanding of optical phenomena, and a solid background for research in contemporary optics. Fundamental ideas are unified through a mathematical treatment emphasizing Fourier analysis and linear systems theory for the description of linear wave propagation. Core topics include the propagation and interaction of optical fields and waves in matter, the vector nature of polarization phenomena, and the wave nature of light including temporal coherence and interferometry and spatial coherence and diffraction (Fourier optics). Specialized topics of interest include Gaussian transverse mode analysis and laser resonator optics, ultrafast pulse propagation and pulse shaping, and an introduction to nonlinear optics including the coupled wave theory of second harmonic generation.

Textbook: B.E.A. Saleh and M.C. Teich, *Fundamentals of Photonics*, 2^{nd} Ed., Wiley, New York, 2007

Reference: A.E. Siegman, *Lasers*, University Science Books, Mill Valley CA, 1986

Grades based on: Problem sets (70%); Midterm exam (10%); Final exam (20%)

COURSE OUTLINE

1. Preliminary:
   - Fourier analysis and linear systems theory — *App A, B*
   - Maxwell's equations and optical fields in media — *Ch 5*
2. Polarization:
   - physical and mathematical description; Jones matrix analysis — *Ch 6*
   - anisotropic media; birefringence vs. optical activity
   - polarization control and devices
3. Ray optics:
   - review of principles — *Ch 1*
   - paraxial analysis of simple elements; aberrations
   - ABCD matrix analysis; applications to periodic systems
4. Wave optics:
   - solutions of the wave equation; mathematical representation and physical properties — *Ch 2*
   - solutions of the paraxial wave equation; validity of the paraxial approximation
   - spatial and temporal properties of waves; diffraction and interference
5. Beam optics:
   - the fundamental and higher-order Gaussian transverse modes — *Ch 3*
   - propagation and transformation of Gaussian beams in ABCD systems
   - transverse mode analysis; orthogonal functions and mode decomposition

(Midterm examination)

6. Spatial coherence and diffraction theory:
   - integral solutions of the wave equation (Huygen vs. Fresnel) — *Ch 4*
   - Fresnel and Fraunhofer diffraction
   - Fourier optics and spatial filtering; holography
7. Temporal coherence and interferometry:
   - concept of coherence; physical description of interference — *Ch 11*
   - interferometers and spectral analysis
8. Laser resonator theory:
   - longitudinal mode structure and feedback; tunability — *Ch 10*
   - transverse mode structure and resonator stability analysis
9. Linear pulse propagation:
   - group velocity dispersion; pulse compression and frequency chirping — *Ch 22*
   - space-time analogy and pulse shaping
10. Intro. to nonlinear optics:
    - physical description; taxonomy of nonlinear optical processes — *Ch 21*
    - coupled-wave analysis of second harmonic generation

(Final examination)