

Topics to be covered in EE 6317, Physical Optics, Summer 2011

1. Course overview
 - a. Optics markets
 - b. Optics professional organizations
 - c. Prerequisite for this course: Undergraduate electromagnetics
 - d. Geometrical vs. physical optics
 - e. Course outcomes
 - f. University requirements
 - g. Areas covered by this course
 - i. Polarization
 - ii. Interference
 - iii. Diffraction

2. Mathematical description of wave motion
 - a. Scalar wave equation
 - b. Maxwell's equations
 - i. Differential form
 - ii. Integral form
 - iii. Boundary conditions at media interfaces
 - c. The vector wave equations
 - d. Transform-space forms of Maxwell's equations and the wave equations; the Helmholtz equation
 - e. Boundary conditions for the scalar Helmholtz equation
 - f. One-dimensional wave motion
 - i. Transmission-line formulas (for later use in the derivation of the Fresnel formulas and the description of interference)
 - ii. Exact solutions of the scalar Helmholtz equation: Plane wave, Bessel beam

3. Propagation of light
 - a. Plane waves
 - i. Poynting's theorem
 - ii. Wave impedance
 - b. Spherical waves (complex representation)
 - c. Green's theorem
 - d. Green function for the Helmholtz equation

4. Mathematical description of fully polarized light
 - a. Parallel-plate waveguide as a polarization-sensitive device
 - b. Plane, circular, and elliptical polarization
 - c. Reflection at normal incidence to a dielectric interface

- i. Relation to reflection at a resistive discontinuity on a transmission line
 - d. Reflection at oblique incidence: Continuity of the tangential components of E and H
 - e. Derivation of the Fresnel formulas
 - f. Brewster's angle
 - g. Examples of practical polarization-sensitive devices
- 4. Interference and interferometers
 - a. Interference of polarized beams
 - b. Wavefront-splitting interferometers
 - i. Young's experiment
 - c. Amplitude-splitting interferometers
 - i. Michelson
 - ii. Mach-Zehnder
 - iii. Fabry-Pérot interferometers and longitudinal modes
- 5. Diffraction
 - a. Definition and examples
 - b. Large-Fresnel-number vs. small-Fresnel-number regimes
 - c. Examples
 - d. Fraunhofer diffraction: Introduction
 - e. PDE approach vs. integral-equation approach
 - f. Fresnel-Kirchhoff diffraction theory
 - g. Fresnel's approximation
 - h. Fraunhofer regime
 - i. Rectangular and circular apertures; Rayleigh criterion for resolution
 - ii. Fraunhofer diffraction pattern as the Fourier transform of the object
 - iii. Diffraction by periodically arranged identical apertures in 2-d
 - iv. Diffraction gratings
 - v. Diffraction by randomly arranged identical apertures
 - vi. Diffraction by periodically arranged identical objects in 3-d
 - vii. Bragg-von Laue theory of X-ray diffraction
 - viii. Dynamical theory of X-ray diffraction
 - ix. Photonic crystals
 - i. Fresnel regime
 - i. Fresnel's construction; Fresnel zones
 - ii. Fresnel diffraction by a straight edge; Cornu spiral
 - iii. Fresnel diffraction by a circular aperture and a circular obstacle
- 6. The paraxial wave equation and Gaussian optics
 - a. Paraxial approximation
 - b. Free-space solutions of the PWE
 - c. Gaussian modes

d. Gaussian optics

7. Basics of coherence theory

- a. Fringe visibility in a Michelson interferometer
- b. Self coherence function
- c. Complex degree of coherence
- d. Coherence time and coherence length
- e. Mutual coherence function and complex degree of coherence for different beams
- f. Mutual intensity, complex coherence area and coherence area
- g. Fully incoherent source; chaotic light; acquisition of coherence through propagation
- h. Speckle

8. Partially polarized light

- a. Jones vector
- b. Polarization matrix (Jones matrix)
- c. Definition of partial polarization
- d. Coherency matrix
- e. Degree of polarization
- f. Stokes parameters and Stokes vector
- g. Mueller matrix
- h. Poincaré sphere