Physical Optics – List of Themes

1. Basic properties of the electromagnetic field, Maxwell's equations, material equations, equation of continuity. Boundary conditions at a surface of discontinuity. The energy law of the electromagnetic field. Density of the energy, Poynting vector.
2. Electromagnetic waves, wave equation. Scalar waves, plane and spherical waves. Harmonic waves, phase velocity. Wave packets, group velocity. Fourier's theorem.
3. Electromagnetic waves, wave equation. Vector waves, general harmonic vector waves, Fourier's theorem. Complex form of the harmonic vector waves, density of the energy, Poynting vector. Polarization properties of general harmonic vector waves.
4. General electromagnetic plane waves. The harmonic electromagnetic plane wave and its polarization properties. Density of the energy, Poynting vector.
5. Representation of polarization states by a Jones vector, orthogonal and orthonormal pairs of Jones vectors. Transformation of the Jones vector under the effect of a coordinate rotation. Jones calculus, Jones matrices of simple optical elements (free propagation, linear polarizer, phase retarder).
6. Representation of polarization states by a Stokes vector. Partially polarized light, degree of polarization, Poincare sphere. Transformation of the Stokes vector under the effect of a coordinate rotation. Müller calculus, Müller matrices of simple optical elements (linear polarizer, phase retarder). The measurement of Stokes parameters.
7. Reflection and refraction of a plane wave. Fresnel's equations for reflection and transmission. The reflectivity and transmissivity, polarization on reflection and refraction. Total reflection.
8. Wave propagation in a stratified medium. Theory of dielectric films. The characteristic matrix of a stratified medium. A homogeneous dielectric film. A stratified medium as a pile of thin homogeneous films. The reflection and transmission coefficients.
9. Electromagnetic waves in conductors. Complex dielectric constant and complex refractive index. Electromagnetic plane waves in absorbing medium. Refraction and reflection at a metal surface.
10. Elementary theory of dispersion, Lorentz model, Drude model. Kramers-Kronig relations.
11. Interference of two monochromatic waves. Interference experiments, interferometers. Conditions for interference, the mutual coherence function and the complex degree of coherence, visibility of the interference fringes.
12. Diffraction of light, Huygens-Fresnel principle. Kirchhoff's diffraction theory, Fraunhofer and Fresnel diffraction. Babinet's principle. The Rayleigh-Sommerfeld diffraction integrals.
13. The dielectric tensor of an anisotropic medium, system of principal dielectric axes. Monochromatic plane wave in an anisotropic medium, the phase velocity and the ray velocity. Fresnel's equation of wave normals. Rule of duality.
14. The ellipsoid of wave normals. Constructions for determining the directions of vibration. The normal surface and the ray surface. Optical classification of crystals. Light propagation in uniaxial crystals. Light propagation in biaxial crystals.

Proposed literature

M. Born and E. Wolf, *Principles of Optics* (7th expanded edition, Cambridge University Press, 1999)

E. Hecht and A. Zajac, *Optics* (Addison Wesley Publishing Company, 1997)

M. V. Klein and T. E. Furtak, *Optics* (John Wiley & Sons, 1986)

W. Lauterborn and T. Kurz, *Coherent optics* (Springer-Verlag, 2002)

G. R. Fowles, *Introduction to Modern Optics* (Dover Publications Inc., 1975)

D. Goldstein, *Polarized light* (Second Edition, Revised and Expanded Marcel Dekker, Inc. 2003)