

Contents

| Hi | Historical introduction | | |
|----|-------------------------|--------------------------------------------------------------------------------------|----|
| I | Basi | c properties of the electromagnetic field | 1 |
| | | The electromagnetic field | 1 |
| | | 1.1.1 Maxwell's equations | 1 |
| | | 1.1.2 Material equations | 2 |
| | | 1.1.3 Boundary conditions at a surface of discontinuity | 4 |
| | | 1.1.4 The energy law of the electromagnetic field | 7 |
| | 1.2 | The wave equation and the velocity of light | 11 |
| | 1.3 | Scalar waves | 14 |
| | | 1.3.1 Plane waves | 15 |
| | | 1.3.2 Spherical waves | 16 |
| | | 1.3.3 Harmonic waves. The phase velocity | 16 |
| | | 1.3.4 Wave packets. The group velocity | 19 |
| | 1.4 | Vector waves | 24 |
| | | 1.4.1 The general electromagnetic plane wave | 24 |
| | | 1.4.2 The harmonic electromagnetic plane wave | 25 |
| | | (a) Elliptic polarization | 25 |
| | | (b) Linear and circular polarization | 29 |
| | | (c) Characterization of the state of polarization by Stokes parameters | 31 |
| | | 1.4.3 Harmonic vector waves of arbitrary form | 33 |
| | 1.5 | Reflection and refraction of a plane wave | 38 |
| | | 1.5.1 The laws of reflection and refraction | 38 |
| | | 1.5.2 Fresnel formulae | 40 |
| | | 1.5.3 The reflectivity and transmissivity; polarization on reflection and refraction | 43 |
| | | 1.5.4 Total reflection | 49 |
| | 1.6 | Wave propagation in a stratified medium. Theory of dielectric films | 54 |
| | | 1.6.1 The basic differential equations | 55 |
| | | 1.6.2 The characteristic matrix of a stratified medium | 58 |
| | | (a) A homogeneous dielectric film | 61 |
| | | (b) A stratified medium as a pile of thin homogeneous films | 62 |
| | | 1.6.3 The reflection and transmission coefficients | 63 |
| | | 1.6.4 A homogeneous dielectric film | 64 |
| | | 1.6.5 Periodically stratified media | 70 |
| II | Ele | ctromagnetic potentials and polarization | 75 |
| | 2.1 | The electrodynamic potentials in the vacuum | 76 |

xvi



| | | Contents | xvi |
|----|-----|--------------------------------------------------------------------------------------------------------|------------|
| | | 2.1.1 The vector and scalar potentials | 76 |
| | | 2.1.2 Retarded potentials | 78 |
| | 2.2 | | 80 |
| | | 2.2.1 The potentials in terms of polarization and magnetization | 80 |
| | | 2.2.2 Hertz vectors | 84 |
| | | 2.2.3 The field of a linear electric dipole | 85 |
| | 2.3 | The Lorentz-Lorenz formula and elementary dispersion theory | 89 |
| | | 2.3.1 The dielectric and magnetic susceptibilities | 89 |
| | | 2.3.2 The effective field | 9(|
| | | 2.3.3 The mean polarizability: the Lorentz–Lorenz formula | 92 |
| | | 2.3.4 Elementary theory of dispersion | 95 |
| | 2.4 | Propagation of electromagnetic waves treated by integral equations | 103 |
| | | 2.4.1 The basic integral equation | 104 |
| | | 2.4.2 The Ewald-Oseen extinction theorem and a rigorous derivation of the | |
| | | Lorentz-Lorenz formula | 105 |
| | | 2.4.3 Refraction and reflection of a plane wave, treated with the help of the | |
| | | Ewald-Oseen extinction theorem | 110 |
| Ш | Fou | indations of geometrical optics | 116 |
| | 3.1 | Approximation for very short wavelengths | 116 |
| | | 3.1.1 Derivation of the eikonal equation | 117 |
| | | 3.1.2 The light rays and the intensity law of geometrical optics | 120 |
| | | 3.1.3 Propagation of the amplitude vectors | 125 |
| | | 3.1.4 Generalizations and the limits of validity of geometrical optics | 127 |
| | 3.2 | 1 1 | 129 |
| | | 3.2.1 The differential equation of light rays | 129 |
| | | 3.2.2 The laws of refraction and reflection | 132 |
| | | 3.2.3 Ray congruences and their focal properties | 134 |
| | 3.3 | 8 | 135 |
| | | 3.3.1 Lagrange's integral invariant | 135 |
| | | 3.3.2 The principle of Fermat | 136 |
| | | 3.3.3 The theorem of Malus and Dupin and some related theorems | 139 |
| IV | | ometrical theory of optical imaging | 142 |
| | 4.1 | The characteristic functions of Hamilton | 142 |
| | | 4.1.1 The point characteristic | 142 |
| | | 4.1.2 The mixed characteristic | 144 |
| | | 4.1.3 The angle characteristic | 146 |
| | | 4.1.4 Approximate form of the angle characteristic of a refracting surface of revolution | 147 |
| | | 4.1.5 Approximate form of the angle characteristic of a reflecting surface of | 1.51 |
| | 4.2 | revolution | 151 |
| | 4.2 | Perfect imaging | 152 |
| | | 4.2.1 General theorems | 153 157 |
| | | 4.2.2 Maxwell's 'fish-eye' | |
| | 4.2 | 4.2.3 Stigmatic imaging of surfaces | 159 |
| | 4.3 | Projective transformation (collineation) with axial symmetry | 160 161 |
| | | 4.3.1 General formulae | 164 |
| | | 4.3.2 The telescopic case4.3.3 Classification of projective transformations | 165 |
| | | 4.3.4 Combination of projective transformations | |
| | 4.4 | Gaussian optics | 166 167 |
| | 7.4 | 4.4.1 Refracting surface of revolution | 167 |
| | | 1. 1.1 Konacung Sarrace of Tevolution | 10 |



| (Vii | i | Contents | |
|------|------|-----------------------------------------------------------------------------|-----|
| | | 4.4.2 Reflecting surface of revolution | 170 |
| | | 4.4.3 The thick lens | 171 |
| | | 4.4.4 The thin lens | 174 |
| | | 4.4.5 The general centred system | 175 |
| | 4.5 | Stigmatic imaging with wide-angle pencils | 178 |
| | | 4.5.1 The sine condition | 179 |
| | | 4.5.2 The Herschel condition | 180 |
| | 4.6 | Astigmatic pencils of rays | 181 |
| | | 4.6.1 Focal properties of a thin pencil | 181 |
| | | 4.6.2 Refraction of a thin pencil | 182 |
| | 4.7 | Chromatic aberration. Dispersion by a prism | 186 |
| | | 4.7.1 Chromatic aberration | 186 |
| | | 4.7.2 Dispersion by a prism | 190 |
| | 4.8 | Radiometry and apertures | 193 |
| | | 4.8.1 Basic concepts of radiometry | 194 |
| | | 4.8.2 Stops and pupils | 199 |
| | | 4.8.3 Brightness and illumination of images | 201 |
| | 4.9 | Ray tracing | 204 |
| | | 4.9.1 Oblique meridional rays | 204 |
| | | 4.9.2 Paraxial rays | 207 |
| | | 4.9.3 Skew rays | 208 |
| | 4.10 | | 211 |
| | | 4.10.1 Attainment of axial stigmatism | 211 |
| | | 4.10.2 Attainment of aplanatism | 214 |
| | 4.11 | | 217 |
| | | 4.11.1 Introduction | 217 |
| | | 4.11.2 Beam propagation in an absorbing medium | 218 |
| | | 4.11.3 Ray integrals and projections | 219 |
| | | 4.11.4 The <i>N</i> -dimensional Radon transform | 221 |
| | | 4.11.5 Reconstruction of cross-sections and the projection-slice theorem of | 222 |
| | | computerized tomography | 223 |
| V | Geor | netrical theory of aberrations | 228 |
| | 5.1 | Wave and ray aberrations; the aberration function | 229 |
| | 5.2 | The perturbation eikonal of Schwarzschild | 233 |
| | 5.3 | The primary (Seidel) aberrations | 236 |
| | | (a) Spherical aberration $(B \neq 0)$ | 238 |
| | | (b) Coma $(F \neq 0)$ | 238 |
| | | (c) Astigmatism $(C \neq 0)$ and curvature of field $(D \neq 0)$ | 240 |
| | | (d) Distortion $(E \neq 0)$ | 243 |
| | | Addition theorem for the primary aberrations | 244 |
| | 5.5 | The primary aberration coefficients of a general centred lens system | 246 |
| | | 5.5.1 The Seidel formulae in terms of two paraxial rays | 246 |
| | | 5.5.2 The Seidel formulae in terms of one paraxial ray | 251 |
| | | 5.5.3 Petzval's theorem | 253 |
| | | Example: The primary aberrations of a thin lens | 254 |
| | 5.7 | The chromatic aberration of a general centred lens system | 257 |
| VΙ | Ima | ge-forming instruments | 261 |
| - | 6.1 | The eye | 261 |
| | 6.2 | The camera | 263 |
| | 6.3 | The refracting telescope | 267 |
| | 6.4 | The reflecting telescope | 274 |
| | | | |



| | | Contents | xix |
|------|------|------------------------------------------------------------------------------------|------------|
| | 6.5 | Instruments of illumination | 279 |
| | 6.6 | The microscope | 281 |
| VII | Elei | ments of the theory of interference and interferometers | 286 |
| | 7.1 | Introduction | 286 |
| | 7.2 | Interference of two monochromatic waves | 287 |
| | 7.3 | Two-beam interference: division of wave-front | 290 |
| | | 7.3.1 Young's experiment | 290 |
| | | 7.3.2 Fresnel's mirrors and similar arrangements | 292 |
| | | 7.3.3 Fringes with quasi-monochromatic and white light | 295 |
| | | 7.3.4 Use of slit sources; visibility of fringes | 296 |
| | | 7.3.5 Application to the measurement of optical path difference: the Rayleigh | |
| | | interferometer | 299 |
| | | 7.3.6 Application to the measurement of angular dimensions of sources: | |
| | | the Michelson stellar interferometer | 302 |
| | 7.4 | Standing waves | 308 |
| | 7.5 | Two-beam interference: division of amplitude | 313 |
| | | 7.5.1 Fringes with a plane-parallel plate | 313 |
| | | 7.5.2 Fringes with thin films; the Fizeau interferometer | 318 |
| | | 7.5.3 Localization of fringes | 325 |
| | | 7.5.4 The Michelson interferometer | 334 |
| | | 7.5.5 The Twyman–Green and related interferometers | 336 |
| | | 7.5.6 Fringes with two identical plates: the Jamin interferometer and | |
| | | interference microscopes | 341 |
| | | 7.5.7 The Mach–Zehnder interferometer; the Bates wave-front shearing inter- | |
| | | ferometer | 348 |
| | | 7.5.8 The coherence length; the application of two-beam interference to the | |
| | | study of the fine structure of spectral lines | 352 |
| | 7.6 | Multiple-beam interference | 359 |
| | | 7.6.1 Multiple-beam fringes with a plane-parallel plate | 360 |
| | | 7.6.2 The Fabry–Perot interferometer | 366 |
| | | 7.6.3 The application of the Fabry–Perot interferometer to the study of the | 2=0 |
| | | fine structure of spectral lines | 370 |
| | | 7.6.4 The application of the Fabry–Perot interferometer to the comparison of | 255 |
| | | wavelengths | 377 |
| | | 7.6.5 The Lummer–Gehrcke interferometer | 380 |
| | | 7.6.6 Interference filters | 386 |
| | | 7.6.7 Multiple-beam fringes with thin films | 391 |
| | | 7.6.8 Multiple-beam fringes with two plane-parallel plates | 401 |
| | | (a) Fringes with monochromatic and quasi-monochromatic light | 401 405 |
| | 7.7 | (b) Fringes of superposition The comparison of wavelengths with the standard metre | 403 |
| | /./ | The comparison of wavelengths with the standard metre | 409 |
| VIII | Ele | ements of the theory of diffraction | 412 |
| | 8.1 | | 412 |
| | 8.2 | | 413 |
| | 8.3 | | 417 |
| | | 8.3.1 The integral theorem of Kirchhoff | 417 |
| | | 8.3.2 Kirchhoff's diffraction theory | 421 |
| | | 8.3.3 Fraunhofer and Fresnel diffraction | 425 |
| | 8.4 | | 430 |
| | | 8.4.1 The image field due to a monochromatic oscillator | 431 |
| | | 8.4.2 The total image field | 434 |



| XX | | Contents | |
|----|-----|-------------------------------------------------------------------------------------------------------------------|------------|
| | 8.5 | Fraunhofer diffraction at apertures of various forms | 436 |
| | | 8.5.1 The rectangular aperture and the slit | 436 |
| | | 8.5.2 The circular aperture | 439 |
| | | 8.5.3 Other forms of aperture | 443 |
| | 8.6 | Fraunhofer diffraction in optical instruments | 446 |
| | | 8.6.1 Diffraction gratings | 446 |
| | | (a) The principle of the diffraction grating | 446 |
| | | (b) Types of grating | 453 |
| | | (c) Grating spectrographs | 458 |
| | | 8.6.2 Resolving power of image-forming systems | 461 |
| | | 8.6.3 Image formation in the microscope | 465 |
| | | (a) Incoherent illumination | 465 |
| | | (b) Coherent illumination – Abbe's theory | 467 |
| | | (c) Coherent illumination – Zernike's phase contrast method of | |
| | | observation | 472 |
| | 8.7 | \mathcal{E} | 476 |
| | | 8.7.1 The diffraction integral | 476 |
| | | 8.7.2 Fresnel's integrals | 478 |
| | 0.0 | 8.7.3 Fresnel diffraction at a straight edge | 481 |
| | 8.8 | E | 484 |
| | | 8.8.1 Evaluation of the diffraction integral in terms of Lommel functions | 484 |
| | | 8.8.2 The distribution of intensity | 489 490 |
| | | (a) Intensity in the geometrical focal plane | 490 |
| | | (b) Intensity along the axis(c) Intensity along the boundary of the geometrical shadow | 491 |
| | | 8.8.3 The integrated intensity | 491 |
| | | 8.8.4 The phase behaviour | 494 |
| | 8.9 | • | 499 |
| | 8.1 | · · · · · · · · · · · · · · · · · · · | 504 |
| | 0.1 | 8.10.1 Producing the positive hologram | 504 |
| | | 8.10.2 The reconstruction | 506 |
| | 8.1 | | 512 |
| | | 8.11.1 The Rayleigh diffraction integrals | 512 |
| | | 8.11.2 The Rayleigh–Sommerfeld diffraction integrals | 514 |
| | | , , | |
| IX | The | diffraction theory of aberrations | 517 |
| | 9.1 | The diffraction integral in the presence of aberrations | 518 |
| | | 9.1.1 The diffraction integral | 518 |
| | | 9.1.2. The displacement theorem. Change of reference sphere | 520 |
| | | 9.1.3. A relation between the intensity and the average deformation of | |
| | | wave-fronts | 522 |
| | 9.2 | Expansion of the aberration function | 523 |
| | | 9.2.1 The circle polynomials of Zernike | 523 |
| | 0.2 | 9.2.2 Expansion of the aberration function | 525 |
| | 9.3 | Tolerance conditions for primary aberrations | 527 |
| | 9.4 | The diffraction pattern associated with a single aberration | 532 |
| | | 9.4.1 Primary spherical aberration | 536 |
| | | 9.4.2 Primary coma 9.4.3 Primary astigmatism | 538 539 |
| | 9.5 | Imaging of extended objects | 543 |
| | 1.5 | 9.5.1 Coherent illumination | 543 |
| | | 9.5.2 Incoherent illumination | 543 547 |
| | | | |



| | | Contents | XX |
|----|-------|--------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| X | Inter | erence and diffraction with partially coherent light | 554 |
| | 10.1 | Introduction | 554 |
| | 10.2 | A complex representation of real polychromatic fields | 557 |
| | 10.3 | The correlation functions of light beams | 562 |
| | | 10.3.1 Interference of two partially coherent beams. The mutual coherence | |
| | | function and the complex degree of coherence | 562 |
| | | 10.3.2 Spectral representation of mutual coherence | 566 |
| | 10.4 | Interference and diffraction with quasi-monochromatic light | 569 |
| | 1011 | 10.4.1 Interference with quasi-monochromatic light. The mutual intensity 10.4.2 Calculation of mutual intensity and degree of coherence for light from | 569 |
| | | an extended incoherent quasi-monochromatic source | 572 |
| | | (a) The van Cittert–Zernike theorem | 572 |
| | | (b) Hopkins' formula | 577 |
| | | 10.4.3 An example | 578 |
| | | 10.4.4 Propagation of mutual intensity | 580 |
| | 10.5 | Interference with broad-band light and the spectral degree of coherence. | 360 |
| | 10.5 | Correlation-induced spectral changes | 585 |
| | 10.6 | Some applications | 590 |
| | 10.0 | 10.6.1 The degree of coherence in the image of an extended incoherent | 330 |
| | | quasi-monochromatic source | 590 |
| | | 10.6.2 The influence of the condenser on resolution in a microscope | 595 |
| | | (a) Critical illumination | 595 |
| | | (b) Köhler's illumination | 598 |
| | | 10.6.3 Imaging with partially coherent quasi-monochromatic illumination | 599 |
| | | (a) Transmission of mutual intensity through an optical system | 599 |
| | | (b) Images of transilluminated objects | 602 |
| | 10.7 | Some theorems relating to mutual coherence | 606 |
| | 10.7 | 10.7.1 Calculation of mutual coherence for light from an incoherent source | 606 |
| | | 10.7.1 Calculation of mutual coherence for fight from an incoherent source 10.7.2 Propagation of mutual coherence | 609 |
| | 10.8 | Rigorous theory of partial coherence | 610 |
| | 10.8 | 10.8.1 Wave equations for mutual coherence | 610 |
| | | 10.8.2 Rigorous formulation of the propagation law for mutual coherence | 612 |
| | | | |
| | 10.9 | 10.8.3 The coherence time and the effective spectral width | 615 |
| | 10.9 | Polarization properties of quasi-monochromatic light 10.9.1 The coherency matrix of a quasi-monochromatic plane wave | |
| | | | 619 |
| | | (a) Completely unpolarized light (natural light) | |
| | | (b) Complete polarized light | 624 |
| | | 10.9.2 Some equivalent representations. The degree of polarization of a light | 626 |
| | | wave 10.9.3 The Stokes parameters of a quasi-monochromatic plane wave | 630 |
| ΧI | Rigo | ous diffraction theory | 633 |
| | 11.1 | Introduction | 633 |
| | 11.2 | Boundary conditions and surface currents | 635 |
| | 11.3 | Diffraction by a plane screen: electromagnetic form of Babinet's principle | 636 |
| | 11.4 | Two-dimensional diffraction by a plane screen | 638 |
| | | 11.4.1 The scalar nature of two-dimensional electromagnetic fields | 638 |
| | | 11.4.2 An angular spectrum of plane waves | 639 |
| | | 11.4.3 Formulation in terms of dual integral equations | 642 |
| | 11.5 | Two-dimensional diffraction of a plane wave by a half-plane | 643 |
| | | 11.5.1 Solution of the dual integral equations for <i>E</i> -polarization | 643 |
| | | 11.5.2 Expression of the solution in terms of Fresnel integrals | 645 |
| | | 11.5.3 The nature of the solution | 648 |



| XX11 | | Contents | |
|----------------|------|--------------------------------------------------------------------------------|-----|
| | | 11.5.4 The solution for <i>H</i> -polarization | 652 |
| | | 11.5.5 Some numerical calculations | 653 |
| | | 11.5.6 Comparison with approximate theory and with experimental results | 656 |
| | 11.6 | Three-dimensional diffraction of a plane wave by a half-plane | 657 |
| | | Diffraction of a field due to a localized source by a half-plane | 659 |
| | | 11.7.1 A line-current parallel to the diffracting edge | 659 |
| | | 11.7.2 A dipole | 664 |
| | 11.8 | Other problems | 667 |
| | | 11.8.1 Two parallel half-planes | 667 |
| | | 11.8.2 An infinite stack of parallel, staggered half-planes | 669 |
| | | 11.8.3 A strip | 670 |
| | | 11.8.4 Further problems | 671 |
| | 11.9 | Uniqueness of solution | 672 |
| XII | | action of light by ultrasonic waves | 674 |
| | 12.1 | Qualitative description of the phenomenon and summary of theories based on | |
| | | Maxwell's differential equations | 674 |
| | | 12.1.1 Qualitative description of the phenomenon | 674 |
| | | 12.1.2 Summary of theories based on Maxwell's equations | 677 |
| | 12.2 | Diffraction of light by ultrasonic waves as treated by the integral equation | |
| | | method | 680 |
| | | 12.2.1 Integral equation for E-polarization | 682 |
| | | 12.2.2 The trial solution of the integral equation | 682 |
| | | 12.2.3 Expressions for the amplitudes of the light waves in the diffracted and | |
| | | reflected spectra | 686 |
| | | 12.2.4 Solution of the equations by a method of successive approximations | 686 |
| | | 12.2.5 Expressions for the intensities of the first and second order lines for | 606 |
| | | some special cases | 689 |
| | | 12.2.6 Some qualitative results | 691 |
| | | 12.2.7 The Raman–Nath approximation | 693 |
| XIII | Scat | tering from inhomogeneous media | 695 |
| | 13.1 | , e | 695 |
| | | 13.1.1 Derivation of the basic integral equation | 695 |
| | | 13.1.2 The first-order Born approximation | 699 |
| | | 13.1.3 Scattering from periodic potentials | 703 |
| | | 13.1.4 Multiple scattering | 708 |
| | 13.2 | 8 4 7 | 710 |
| | | potential | 710 |
| | | 13.2.1 Angular spectrum representation of the scattered field | 711 |
| | 12.2 | 13.2.2 The basic theorem of diffraction tomography | 713 |
| | 13.3 | | 716 |
| | 13.4 | • • | 724 |
| | 13.5 | • | 726 |
| | 13.6 | · · | 729 |
| | | 13.6.1 The integro-differential equations of electromagnetic scattering theory | 729 |
| | | 13.6.2 The far field | 730 |
| | | 13.6.3 The optical cross-section theorem for scattering of electromagnetic | 732 |
| | | waves | 132 |
| XIV | Onti | cs of metals | 735 |
| 4 3.1 ¥ | 14.1 | | 735 |
| | | | |



| | | Contents | xxiii |
|----|-------|-----------------------------------------------------------------------------|-------|
| | 14.2 | Refraction and reflection at a metal surface | 739 |
| | 14.3 | Elementary electron theory of the optical constants of metals | 749 |
| | 14.4 | | |
| | | films | 752 |
| | | 14.4.1 An absorbing film on a transparent substrate | 752 |
| | | 14.4.2 A transparent film on an absorbing substrate | 758 |
| | 14.5 | Diffraction by a conducting sphere; theory of Mie | 759 |
| | | 14.5.1 Mathematical solution of the problem | 760 |
| | | (a) Representation of the field in terms of Debye's potentials | 760 |
| | | (b) Series expansions for the field components | 765 |
| | | (c) Summary of formulae relating to the associated Legendre func- | |
| | | tions and to the cylindrical functions | 772 |
| | | 14.5.2 Some consequences of Mie's formulae | 774 |
| | | (a) The partial waves | 774 |
| | | (b) Limiting cases | 775 |
| | | (c) Intensity and polarization of the scattered light | 780 |
| | | 14.5.3 Total scattering and extinction | 784 |
| | | (a) Some general considerations | 784 |
| | | (b) Computational results | 785 |
| XV | Optio | es of crystals | 790 |
| | 15.1 | • | 790 |
| | 15.2 | The structure of a monochromatic plane wave in an anisotropic medium | 792 |
| | | 15.2.1 The phase velocity and the ray velocity | 792 |
| | | 15.2.2 Fresnel's formulae for the propagation of light in crystals | 795 |
| | | 15.2.3 Geometrical constructions for determining the velocities of | |
| | | propagation and the directions of vibration | 799 |
| | | (a) The ellipsoid of wave normals | 799 |
| | | (b) The ray ellipsoid | 802 |
| | | (c) The normal surface and the ray surface | 803 |
| | 15.3 | Optical properties of uniaxial and biaxial crystals | 805 |
| | | 15.3.1 The optical classification of crystals | 805 |
| | | 15.3.2 Light propagation in uniaxial crystals | 806 |
| | | 15.3.3 Light propagation in biaxial crystals | 808 |
| | | 15.3.4 Refraction in crystals | 811 |
| | | (a) Double refraction | 811 |
| | | (b) Conical refraction | 813 |
| | 15.4 | Measurements in crystal optics | 818 |
| | | 15.4.1 The Nicol prism | 818 |
| | | 15.4.2 Compensators | 820 |
| | | (a) The quarter-wave plate | 820 |
| | | (b) Babinet's compensator | 821 |
| | | (c) Soleil's compensator | 823 |
| | | (d) Berek's compensator | 823 |
| | | 15.4.3 Interference with crystal plates | 823 |
| | | 15.4.4 Interference figures from uniaxial crystal plates | 829 |
| | | 15.4.5 Interference figures from biaxial crystal plates | 831 |
| | | 15.4.6 Location of optic axes and determination of the principal refractive | |
| | | indices of a crystalline medium | 833 |
| | 15.5 | Stress birefringence and form birefringence | 834 |
| | | 15.5.1 Stress birefringence | 834 |
| | | 15.5.2 Form birefringence | 837 |



| xxiv | Contents | |
|--------------|-----------------------------------------------------------------------------------------------------------------------------------------|------------|
| | 15.6 Absorbing crystals 15.6.1 Light propagation in an absorbing anisotropic medium | 840 840 |
| | 15.6.2 Interference figures from absorbing crystal plates | 846 |
| | (a) Uniaxial crystals | 847 |
| | (b) Biaxial crystals | 848 |
| | 15.6.3 Dichroic polarizers | 849 |
| App | endices | 853 |
| I | The Calculus of variations | 853 |
| | 1 Euler's equations as necessary conditions for an extremum | 853 |
| | 2 Hilbert's independence integral and the Hamilton-Jacobi equation | 855 |
| | 3 The field of extremals | 856 |
| | 4 Determination of all extremals from the solution of the Hamilton–Jacobi equation | 858 |
| | 5 Hamilton's canonical equations | 860 |
| | The special case when the independent variable does not appear explicitly in the integrand Discontinuities | 861 862 |
| | 8 Weierstrass' and Legendre's conditions (sufficiency conditions for an extremum) | 864 |
| | 9 Minimum of the variational integral when one end point is constrained to a surface | 866 |
| | 10 Jacobi's criterion for a minimum | 867 |
| | 11 Example I: Optics | 868 |
| | 12 Example II: Mechanics of material points | 870 |
| II | Light optics, electron optics and wave mechanics | 873 |
| | 1 The Hamiltonian analogy in elementary form | 873 |
| | 2 The Hamiltonian analogy in variational form | 876 |
| | 3 Wave mechanics of free electrons | 879 |
| | 4 The application of optical principles to electron optics | 881 |
| Ш | Asymptotic approximations to integrals | 883 |
| | 1 The method of steepest descent | 883 |
| | 2 The method of stationary phase | 888 |
| | 3 Double integrals | 890 |
| IV | The Dirac delta function | 892 |
| V | A mathematical lemma used in the rigorous derivation of the Lorentz-Lorenz formula (§2.4.2) | 898 |
| VI | Propagation of discontinuities in an electromagnetic field (§3.1.1) | 901 |
| V 1 | 1 Relations connecting discontinuous changes in field vectors | 901 |
| | 2 The field on a moving discontinuity surface | 903 |
| | | |
| VII | The circle polynomials of Zernike (§9.2.1) | 905 |
| | 1 Some general considerations 2 Explicit expressions for the radial polynomials $R_m^{\pm m}(\rho)$ | 905 |
| 37111 | | 907 |
| VIII | Proof of the inequality $ \mu_{12}(v) \le 1$ for the spectral degree of coherence (§10.5) | 911 |
| IX X | Proof of a reciprocity inequality (§10.8.3) Evaluation of two integrals (\$12.2.2) | 912 |
| | Evaluation of two integrals (§12.2.2) Energy conservation in scalar variefields (§12.2.) | 914 |
| XI XII | Energy conservation in scalar wavefields (§13.3) Proof of Jones' lemma (§13.3) | 918 |
| ЛП | Troof of Jones Tellina (813.3) | 921 |
| | or index | 925 |
| Subje | ect index | 936 |