Contents

Hi	istoric	eal introduction	XXV
I	Basi	ic properties of the electromagnetic field	1
	1.1		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
I		ctromagnetic potentials and polarization	75
	2.1	The electrodynamic potentials in the vacuum	76

Contents	XVI
Contents	AVI

		2.1.1 The vector and scalar potentials	76
		2.1.2 Retarded potentials	78
	2.2	Polarization and magnetization	80
		2.2.1 The potentials in terms of polarization and magnetization	80
		2.2.2 Hertz vectors	84
	2.2	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 2.3.2 The effective field	89 90
		17.	90
		2.3.3 The mean polarizability: the Lorentz–Lorenz formula2.3.4 Elementary theory of dispersion	95
	2.4	Propagation of electromagnetic waves treated by integral equations	103
	2.4	2.4.1 The basic integral equation	103
		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	General properties of rays	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	Other basic theorems of geometrical optics	135
		3.3.1 Lagrange's integral invariant	135
		3.3.2 The principle of Fermat	136 139
		3.3.3 The theorem of Malus and Dupin and some related theorems	139
IV	Geo	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	1.47
		revolution	147
		4.1.5 Approximate form of the angle characteristic of a reflecting surface of	151
	4.3	revolution	151 152
	4.2	Perfect imaging 4.2.1 General theorems	153
		4.2.2 Maxwell's 'fish-eye'	157
		4.2.3 Stigmatic imaging of surfaces	159
	4.3	Projective transformation (collineation) with axial symmetry	160
	4.3	4.3.1 General formulae	161
		4.3.2 The telescopic case	164
		4.3.3 Classification of projective transformations	165
		4.3.4 Combination of projective transformations	166
	4.4	Gaussian optics	167
		4.4.1 Refracting surface of revolution	167

xviii 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	8	211
		4.10.1 Attainment of axial stigmatism	211
		4.10.2 Attainment of aplanatism	214
	4.1	F-3, (((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	
		computerized tomography	223
7	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
	5.4	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
	5.6	Example: The primary aberrations of a thin lens	254
	5.7	The chromatic aberration of a general centred lens system	257
Ί	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

	6.5 6.6	Instruments of illumination The microscope	279 281
VII	Flo	ments of the theory of interference and interferometers	286
V 11	7.1	Introduction	286
	7.1	Interference of two monochromatic waves	287
	7.3	Two-beam interference: division of wave-front	290
	1.5	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	Č	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	2.4
		interference microscopes 7.5.7 The Mach–Zehnder interferometer; the Bates wave-front shearing inter-	34:
		ferometer 7.5.8 The coherence length; the application of two-beam interference to the	348
		study of the fine structure of spectral lines	352
	7.6	•	359
		7.6.1 Multiple-beam fringes with a plane-parallel plate	360 360
		7.6.2 The Fabry-Perot interferometer	300
		7.6.3 The application of the Fabry-Perot interferometer to the study of the fine structure of spectral lines7.6.4 The application of the Fabry-Perot interferometer to the comparison of	376
		wavelengths	37
		7.6.5 The Lummer–Gehrcke interferometer	380
		7.6.6 Interference filters	386
		7.6.7 Multiple-beam fringes with thin films	39
		7.6.8 Multiple-beam fringes with two plane-parallel plates	40
		(a) Fringes with monochromatic and quasi-monochromatic light	40
		(b) Fringes of superposition	40
	7.7	The comparison of wavelengths with the standard metre	40
VIII		ements of the theory of diffraction	41
	8.		41. 41.
	8.2 8.3	, ,	41
	ð	8.3.1 The integral theorem of Kirchhoff	41
		8.3.2 Kirchhoff's diffraction theory	42
		8.3.3 Fraunhofer and Fresnel diffraction	42
	8.4		43
	0.4	8.4.1 The image field due to a monochromatic oscillator	43
		8.4.2 The total image field	43

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.		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.		476
		8.7.1 The diffraction integral	476
		8.7.2 Fresnel's integrals	478
	8.	8.7.3 Fresnel diffraction at a straight edge	481
	0.		484
		8.8.1 Evaluation of the diffraction integral in terms of Lommel functions8.8.2 The distribution of intensity	484
		(a) Intensity in the geometrical focal plane	489
		(b) Intensity along the axis	490 491
		(c) Intensity along the boundary of the geometrical shadow	491
		8.8.3 The integrated intensity	492
		8.8.4 The phase behaviour	494
	8.		499
	8.	10 Gabor's method of imaging by reconstructed wave-fronts (holography)	504
		8.10.1 Producing the positive hologram	504
		8.10.2 The reconstruction	506
	8.	11 The Rayleigh-Sommerfeld diffraction integrals	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
		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	538
	0.5	9.4.3 Primary astigmatism	539
	9.5	Imaging of extended objects	543
		9.5.1 Coherent illumination 9.5.2 Incoherent illumination	543 547
		7.3.4 INCONCIONI MUMINIZATOR	5 47

Contents	XXI

Int	erference and diffraction with partially coherent light	55
10.		55
10.	A complex representation of real polychromatic fields	55
10.	1 1	56
	10.3.1 Interference of two partially coherent beams. The mutual coherence	
	function and the complex degree of coherence	56
	10.3.2 Spectral representation of mutual coherence	56
10.		56
10.	10.4.1 Interference with quasi-monochromatic light. The mutual intensity	56
	10.4.2 Calculation of mutual intensity and degree of coherence for light from	50
	an extended incoherent quasi-monochromatic source	57
	(a) The van Cittert–Zernike theorem	57
	(b) Hopkins' formula	57
		57
	10.4.3 An example	
10	10.4.4 Propagation of mutual intensity	58
10.		5 0
	Correlation-induced spectral changes	58
10.	11	59
	10.6.1 The degree of coherence in the image of an extended incoherent	
	quasi-monochromatic source	59
	10.6.2 The influence of the condenser on resolution in a microscope	59
	(a) Critical illumination	59
	(b) Köhler's illumination	59
	10.6.3 Imaging with partially coherent quasi-monochromatic illumination	59
	(a) Transmission of mutual intensity through an optical system	59
	(b) Images of transilluminated objects	60
10.	Some theorems relating to mutual coherence	60
	10.7.1 Calculation of mutual coherence for light from an incoherent source	60
	10.7.2 Propagation of mutual coherence	60
10.	Rigorous theory of partial coherence	61
	10.8.1 Wave equations for mutual coherence	61
	10.8.2 Rigorous formulation of the propagation law for mutual coherence	61
	10.8.3 The coherence time and the effective spectral width	61
10.		
	1 otalization properties of quasi monormonaria ingin	- 01
10.		
10.	10.9.1 The coherency matrix of a quasi-monochromatic plane wave	61
10.	10.9.1 The coherency matrix of a quasi-monochromatic plane wave (a) Completely unpolarized light (natural light)	61 62
10.	10.9.1 The coherency matrix of a quasi-monochromatic plane wave (a) Completely unpolarized light (natural light) (b) Complete polarized light	61 62
10.	 10.9.1 The coherency matrix of a quasi-monochromatic plane wave (a) Completely unpolarized light (natural light) (b) Complete polarized light 10.9.2 Some equivalent representations. The degree of polarization of a light 	61 62 62
10.	 10.9.1 The coherency matrix of a quasi-monochromatic plane wave (a) Completely unpolarized light (natural light) (b) Complete polarized light 10.9.2 Some equivalent representations. The degree of polarization of a light wave 	61 62 62
10.	 10.9.1 The coherency matrix of a quasi-monochromatic plane wave (a) Completely unpolarized light (natural light) (b) Complete polarized light 10.9.2 Some equivalent representations. The degree of polarization of a light 	61 62 62
ı R	10.9.1 The coherency matrix of a quasi-monochromatic plane wave (a) Completely unpolarized light (natural light) (b) Complete polarized light 10.9.2 Some equivalent representations. The degree of polarization of a light wave 10.9.3 The Stokes parameters of a quasi-monochromatic plane wave gorous diffraction theory	61 62 62 62 63
I R	10.9.1 The coherency matrix of a quasi-monochromatic plane wave (a) Completely unpolarized light (natural light) (b) Complete polarized light 10.9.2 Some equivalent representations. The degree of polarization of a light wave 10.9.3 The Stokes parameters of a quasi-monochromatic plane wave gorous diffraction theory 1 Introduction	61 62 62 63 63 63
I R	10.9.1 The coherency matrix of a quasi-monochromatic plane wave (a) Completely unpolarized light (natural light) (b) Complete polarized light 10.9.2 Some equivalent representations. The degree of polarization of a light wave 10.9.3 The Stokes parameters of a quasi-monochromatic plane wave gorous diffraction theory 1 Introduction	61 62 62 63 63 63
I R 11 11	10.9.1 The coherency matrix of a quasi-monochromatic plane wave (a) Completely unpolarized light (natural light) (b) Complete polarized light 10.9.2 Some equivalent representations. The degree of polarization of a light wave 10.9.3 The Stokes parameters of a quasi-monochromatic plane wave gorous diffraction theory 1 Introduction	61 62 62 63 63 63 63
I R 1: 1: 1:	10.9.1 The coherency matrix of a quasi-monochromatic plane wave (a) Completely unpolarized light (natural light) (b) Complete polarized light 10.9.2 Some equivalent representations. The degree of polarization of a light wave 10.9.3 The Stokes parameters of a quasi-monochromatic plane wave gorous diffraction theory 1 Introduction 2 Boundary conditions and surface currents	61 62 62 63 63 63 63 63
I R 1: 1: 1:	10.9.1 The coherency matrix of a quasi-monochromatic plane wave (a) Completely unpolarized light (natural light) (b) Complete polarized light 10.9.2 Some equivalent representations. The degree of polarization of a light wave 10.9.3 The Stokes parameters of a quasi-monochromatic plane wave gorous diffraction theory 1 Introduction 2 Boundary conditions and surface currents 3 Diffraction by a plane screen: electromagnetic form of Babinet's principle	61 62 62 63 63 63 63 63
I R 1: 1:	10.9.1 The coherency matrix of a quasi-monochromatic plane wave (a) Completely unpolarized light (natural light) (b) Complete polarized light 10.9.2 Some equivalent representations. The degree of polarization of a light wave 10.9.3 The Stokes parameters of a quasi-monochromatic plane wave gorous diffraction theory 1 Introduction 2 Boundary conditions and surface currents 3 Diffraction by a plane screen: electromagnetic form of Babinet's principle 4 Two-dimensional diffraction by a plane screen 11.4.1 The scalar nature of two-dimensional electromagnetic fields	61 62 62 63 63 63 63 63 63 63
I R 1: 1: 1:	10.9.1 The coherency matrix of a quasi-monochromatic plane wave (a) Completely unpolarized light (natural light) (b) Complete polarized light 10.9.2 Some equivalent representations. The degree of polarization of a light wave 10.9.3 The Stokes parameters of a quasi-monochromatic plane wave gorous diffraction theory 1 Introduction 2 Boundary conditions and surface currents 3 Diffraction by a plane screen: electromagnetic form of Babinet's principle 4 Two-dimensional diffraction by a plane screen 11.4.1 The scalar nature of two-dimensional electromagnetic fields 11.4.2 An angular spectrum of plane waves	61 62 62 63 63 63 63 63 63 63 63
I R 11 11 11	10.9.1 The coherency matrix of a quasi-monochromatic plane wave (a) Completely unpolarized light (natural light) (b) Complete polarized light 10.9.2 Some equivalent representations. The degree of polarization of a light wave 10.9.3 The Stokes parameters of a quasi-monochromatic plane wave gorous diffraction theory 1 Introduction 2 Boundary conditions and surface currents 3 Diffraction by a plane screen: electromagnetic form of Babinet's principle 4 Two-dimensional diffraction by a plane screen 11.4.1 The scalar nature of two-dimensional electromagnetic fields 11.4.2 An angular spectrum of plane waves 11.4.3 Formulation in terms of dual integral equations	61 62 62 63 63 63 63 63 63 63 63 63 63 63 64
I R 1: 1: 1:	10.9.1 The coherency matrix of a quasi-monochromatic plane wave (a) Completely unpolarized light (natural light) (b) Complete polarized light 10.9.2 Some equivalent representations. The degree of polarization of a light wave 10.9.3 The Stokes parameters of a quasi-monochromatic plane wave gorous diffraction theory 1 Introduction 2 Boundary conditions and surface currents 3 Diffraction by a plane screen: electromagnetic form of Babinet's principle 4 Two-dimensional diffraction by a plane screen 11.4.1 The scalar nature of two-dimensional electromagnetic fields 11.4.2 An angular spectrum of plane waves 11.4.3 Formulation in terms of dual integral equations 5 Two-dimensional diffraction of a plane wave by a half-plane	61 62 62 63 63 63 63 63 63 63 64 64 64
I R 1: 1: 1:	10.9.1 The coherency matrix of a quasi-monochromatic plane wave (a) Completely unpolarized light (natural light) (b) Complete polarized light 10.9.2 Some equivalent representations. The degree of polarization of a light wave 10.9.3 The Stokes parameters of a quasi-monochromatic plane wave gorous diffraction theory 1 Introduction 2 Boundary conditions and surface currents 3 Diffraction by a plane screen: electromagnetic form of Babinet's principle 4 Two-dimensional diffraction by a plane screen 11.4.1 The scalar nature of two-dimensional electromagnetic fields 11.4.2 An angular spectrum of plane waves 11.4.3 Formulation in terms of dual integral equations	61 61 62 62 63 63 63 63 63 63 64 64 64 64

xxii		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
	11.7	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
	110	11.8.4 Further problems	671
	11.9	Uniqueness of solution	672
XII		raction 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	080
		some special cases	689
		12.2.6 Some qualitative results	691
		12.2.7 The Raman–Nath approximation	693
			0,5
XIII	Scat	ttering from inhomogeneous media	695
	13.1	, 8	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		
		potential	710
		13.2.1 Angular spectrum representation of the scattered field	711
		13.2.2 The basic theorem of diffraction tomography	713
	13.3	1	716
	13.4	· · · · · · · · · · · · · · · · · · ·	724
	13.5	•	726
	13.6	e e	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 waves	732
		waves	
XIV		cs of metals	735
	14.1	Wave propagation in a conductor	735

Contents	XXII

	140		720
	14.2	Refraction and reflection at a metal surface	739 749
	14.3	Elementary electron theory of the optical constants of metals	749
	14.4	Wave propagation in a stratified conducting medium. Theory of metallic films	752
			752 752
		14.4.1 An absorbing film on a transparent substrate 14.4.2 A transparent film on an absorbing substrate	758
	14.5	Diffraction by a conducting sphere; theory of Mie	759
	14.3	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-	, 02
		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
χv	Ontic	s of crystals	790
		The dielectric tensor of an anisotropic medium	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
	15.4	(b) Conical refraction	813 818
	15.4	Measurements in crystal optics	818
		15.4.1 The Nicol prism 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	83
		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	83

xxiv Contents

		sorbing crystals	840
	15.	6.1 Light propagation in an absorbing anisotropic medium	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	pendices		853
I	The Calculus of variations		853
	1 Euler's	equations as necessary conditions for an extremum	853
		s independence integral and the Hamilton-Jacobi equation	855
		d of extremals	856
	4 Determ	ination of all extremals from the solution of the Hamilton-Jacobi equation	858
	5 Hamilto	on's canonical equations	860
	6 The spe	cial case when the independent variable does not appear explicitly in the integrand	861
	7 Discont		
	8 Weierst	rass' and Legendre's conditions (sufficiency conditions for an extremum)	864
	9 Minimu	im of the variational integral when one end point is constrained to a surface	866
	10 Jacobi's	criterion for a minimum	867
	11 Exampl		868
	12 Exampl	e II: Mechanics of material points	870
II	Light optic	s, electron optics and wave mechanics	873
	1 The Ham	iltonian analogy in elementary form	873
		iltonian analogy in variational form	876
	3 Wave me	chanics of free electrons	879
	4 The appl	ication of optical principles to electron optics	881
Ш	Asymptotic	approximations to integrals	883
		and of steepest descent	883
		od of stationary phase	888
	3 Double in		890
IV		lelta function	892
V	A mathema	tical lemma used in the rigorous derivation of the Lorentz-Lorenz formula	072
•	(§2.4.2)	treat termina used in the rigorous derivation of the Lorentz-Lorenz Jormula	898
VI	Propagation	of discontinuities in an electromagnetic field (§3.1.1)	901
		connecting discontinuous changes in field vectors	901
		on a moving discontinuity surface	901
* ***		·	
VII		olynomials of Zernike (§9.2.1)	905
		eral considerations	905
	2 Explicit e	xpressions for the radial polynomials $R_m^{\pm m}(\rho)$	907
VIII	Proof of the	inequality $ \mu_{12}(v) \leqslant 1$ for the spectral degree of coherence (§10.5)	911
IX	Proof of a re	eciprocity inequality (§10.8.3)	912
X	Evaluation	of two integrals (§12.2.2)	914
XI	Energy conservation in scalar wavefields (§13.3)		918
XII	Proof of Jor	nes' lemma (§13.3)	921
Auth	or index		925
	Subject index		
22016			936