Table of contents

- Authors' preface (p. xiii)
- Physical constants and conversion factors (p. xv)
- Acknowledgements (p. xvi)
- 1 Light As Waves, Rays and Photons (p. 1)
- 1.1 The Nature of Light (p. 1)
- 1.2 Waves and Rays (p. 4)
- 1.3 Total Internal Reflection (p. 6)
- 1.4 The Light Wave (p. 7)
- 1.5 Electromagnetic Waves (p. 10)
- 1.6 The Electromagnetic Spectrum (p. 11)
- **1.7 Waves and Photons** (p. 12)
- **1.8 Further Reading** (p. 14)
- Numerical Examples 1 (p. 15)
- **Problems 1** (p. 15)
- 2 Geometric Optics (p. 19)
- **2.1 The Thin Prism** (p. 19)
- 2.2 The Lens as an Assembly of Prisms (p. 22)
- 2.3 Refraction at a Spherical Surface (p. 23)
- 2.4 Two Surfaces: the Simple Lens (p. 25)
- **2.5 Imaging in Spherical Mirrors** (p. 26)
- 2.6 General properties of Imaging Systems (p. 27)
- 2.7 Separated Thin Lenses in Air (p. 29)
- **2.8 Perfect Imaging** (p. 31)
- 2.9 Perfect Imaging of Surfaces (p. 32)
- 2.10 Ray and Wave Aberrations (p. 33)
- 2.11 Wave Aberration On Axis--Spherical Aberration (p. 34)
- 2.12 Off-Axis Aberrations (p. 37)
- **2.13 The Influence of Aperture Stops** (p. 39)
- 2.14 The Correction of Chromatic Aberration (p. 40)
- 2.15 Achromatism in Separated Lens Systems (p. 42)
- 2.16 Adaptive Optics (p. 42)
- **2.17 Further Reading** (p. 43)
- Numerical Examples 2 (p. 43)
- Problems 2 (p. 44)
- 3 Optical Instruments (p. 47)
- **3.1 The Human Eye** (p. 47)
- 3.2 The Simple Lens Magnifier (p. 50)
- **3.3 The Telescope** (p. 51)
- 3.4 Advantages of the Various Types of Telescope (p. 53)
- **3.5 Binoculars** (p. 55)
- 3.6 The Compound Microscope (p. 58)
- 3.7 The Confocal Scanning Microscope (p. 59)
- **3.8 The Camera** (p. 61)
- 3.9 Illumination in Optical Instruments (p. 64)

- **3.10 Further Reading** (p. 66)
- Numerical Examples 3 (p. 66)
- **Problems 3** (p. 66)
- 4 Periodic and Non-Periodic Waves (p. 69)
- 4.1 Simple Harmonic Waves (p. 70)
- 4.2 Positive and Negative Frequencies (p. 72)
- **4.3 Standing Waves** (p. 74)
- 4.4 Beats Between Oscillations (p. 76)
- 4.5 Similarities Between Beats and Standing Wave Patterns (p. 77)
- 4.6 Standing Waves at a Reflector (p. 78)
- **4.7 The Doppler Effect** (p. 80)
- **4.8 Doppler Radar** (p. 81)
- 4.9 Astronomical Aberration (p. 82)
- **4.10 Fourier Series** (p. 83)
- 4.11 Modulated Waves: Fourier Transforms (p. 86)
- 4.12 Modulation by a Non-periodic Function (p. 87)
- **4.13 Convolution** (p. 89)
- 4.14 Delta and Grating Functions (p. 90)
- 4.15 Autocorrelation and the Power Spectrum (p. 91)
- **4.16 Wave Groups** (p. 91)
- 4.17 An Angular Spread of Plane Waves (p. 93)
- **4.18 Further Reading** (p. 94)
- Numerical Example 4 (p. 94)
- **Problems 4** (p. 94)
- 5 Electromagnetic Waves (p. 97)
- 5.1 Maxwell's Equations (p. 98)
- **5.2 Transverse Waves** (p. 100)
- **5.3 Energy Flow** (p. 102)
- 5.4 Reflection and Transmission: Fresnel's Equations (p. 103)
- 5.5 Total Internal Reflection: Evanescent Waves (p. 107)
- 5.6 Photon Momentum and Radiation Pressure (p. 109)
- 5.7 Black-body Radiation (p. 110)
- **5.8 Further Reading** (p. 113)
- Numerical Examples 5 (p. 114)
- Problems 5 (p. 114)
- 6 Polarization of Light (p. 115)
- **6.1 Polarization of Transverse Waves** (p. 116)
- 6.2 Analysis of Elliptically Polarized Waves (p. 119)
- **6.3 Polarizers** (p. 119)
- **6.4 Birefringent Polarizers** (p. 122)
- 6.5 Quarter- and Half-wave Plates (p. 124)
- **6.6 Optical Activity** (p. 125)
- **6.7 Induced Birefringence** (p. 126)
- **6.8 Formal Descriptions of Polarization** (p. 130)
- **6.9 Further Reading** (p. 131)
- Numerical Example 6 (p. 132)

- Problems 6 (p. 132)
- 7 Interference and Fraunhofer Diffraction (p. 133)
- **7.1 Interference** (p. 134)
- **7.2 Young's Experiment** (p. 136)
- 7.3 Diffraction at a Single Slit (p. 139)
- **7.4 The General Aperture** (p. 142)
- 7.5 Rectangular and Circular Apertures (p. 144)
- 7.6 The Field at the Edge of an Aperture (p. 148)
- **7.7 Further Reading** (p. 149)
- Numerical Examples 7 (p. 149)
- **Problems 7** (p. 149)
- 8 Fresnel Diffraction (p. 151)
- 8.1 Fraunhofer and Fresnel Diffraction (p. 151)
- 8.2 Shadow Edges Fresnel Diffraction at a Straight Edge (p. 153)
- 8.3 Diffraction of Cylindrical Wavefronts (p. 157)
- 8.4 Fresnel Diffraction by Slits and Strip Obstacles (p. 159)
- 8.5 Spherical Waves and Circular Apertures: Half-period Zones (p. 162)
- **8.6 Fresnel-Kirchhoff Diffraction Theory** (p. 166)
- **8.7 Babinet's Principle** (p. 167)
- **8.8 Further Reading** (p. 168)
- Numerical Examples 8 (p. 168)
- **Problems 8** (p. 168)
- 9 Interference by Division of Amplitude (p. 169)
- **9.1 Newton's Rings** (p. 169)
- 9.2 Interference Effects with a Plane-parallel Plate (p. 173)
- **9.3 Thin Films** (p. 175)
- 9.4 Michelson's Spectral Interferometer (p. 177)
- **9.5 Multiple Beam Interference** (p. 179)
- **9.6 The Fabry-Perot Interferometer** (p. 182)
- **9.7 Interference Filters** (p. 183)
- **9.8 Further Reading** (p. 184)
- Numerical Examples 9 (p. 184)
- **Problems 9** (p. 184)
- 10 The Diffraction Grating and Its Applications (p. 187)
- 10.1 The Diffraction Grating (p. 187)
- 10.2 Diffraction Pattern of the Grating (p. 191)
- 10.3 The Effect of Slit Width and Shape (p. 192)
- **10.4 Fourier Transforms in Grating Theory** (p. 193)
- 10.5 Missing Orders and Blazed Gratings (p. 195)
- **10.6 Making Gratings** (p. 196)
- 10.7 Radio Antenna Arrays (p. 198)
- 10.8 X-ray Diffraction with a Ruled Grating (p. 200)
- 10.9 Diffraction by a Crystal Lattice (p. 202)
- **10.10 Further Reading** (p. 204)
- Numerical Examples 10 (p. 204)
- **Problems 10** (p. 205)

- 11 Interferometry: Length and Angle (p. 207)
- 11.1 The Rayleigh Refractometer (p. 208)
- 11.2 Wedge Fringes and End Gauges (p. 208)
- 11.3 The Twyman and Green Interferometer (p. 209)
- **11.4 The Standard of Length** (p. 211)
- 11.5 The Michelson-Morley Experiment (p. 213)
- 11.6 The Ring Interferometer (p. 214)
- 11.7 Optical Fibres in Interferometers (p. 216)
- 11.8 Detecting Gravitational Waves by Interferometry (p. 218)
- 11.9 Double Source Interferometers (p. 218)
- 11.10 The Effect of Slit Width (p. 220)
- 11.11 Source Size and Coherence (p. 221)
- 11.12 Michelson's Stellar Interferometer (p. 223)
- 11.13 Very Long Baseline Interferometry (p. 226)
- 11.14 The Intensity Interferometer (p. 227)
- 11.15 Further Reading (p. 229)
- Numerical Examples 11 (p. 229)
- **Problems 11** (p. 230)
- 12 Prism and Grating Spectrometers (p. 233)
- 12.1 The Prism Spectrometer (p. 233)
- 12.2 The Grating Spectrometer (p. 236)
- 12.3 Resolving Power in Wavelength (p. 238)
- 12.4 Resolving Power: Prism Spectrometers (p. 239)
- 12.5 Resolving Power: Grating Spectrometers (p. 241)
- **12.6 Concave Gratings** (p. 243)
- 12.7 Blazed, Echellette, Echelle and Echelon Gratings (p. 244)
- 12.8 Efficiency of Spectrographs (p. 247)
- Numerical Examples 12 (p. 248)
- **Problems 12** (p. 249)
- 13 High Resolution Spectrometry (p. 251)
- 13.1 The Shape and Broadening of Spectral Lines (p. 251)
- 13.2 Natural Linewidths (p. 252)
- 13.3 Pressure Broadening (p. 253)
- 13.4 Doppler Broadening (p. 254)
- 13.5 Twin-beam Spectrometry: Fourier Transform Spectrometry (p. 256)
- 13.6 Practical Fourier Spectrometry (p. 259)
- 13.7 Intensity, or Photon correlation Spectroscopy (p. 260)
- 13.8 Scattered Laser Light (p. 263)
- 13.9 Further Reading (p. 263)
- Numerical Examples 13 (p. 264)
- 14 Coherence and Correlation (p. 265)
- 14.1 Temporal and Spectral Coherence (p. 265)
- 14.2 Correlation as a Measure of Coherence (p. 267)
- 14.3 Autocorrelation and Coherence (p. 269)
- 14.4 Two-dimensional Angular Resolution (p. 271)
- 14.5 The Intensity Interferometer (p. 273)

- **14.6 Spatial Filtering** (p. 275)
- **14.7 Further Reading** (p. 278)
- Numerical Examples 14 (p. 278)
- **Problems 14** (p. 278)
- **15 Lasers** (p. 279)
- 15.1 Stimulated Emission (p. 279)
- 15.2 Pumping: the Energy Source (p. 281)
- 15.3 Absorption and Emission of Radiation (p. 283)
- **15.4 Laser Gain** (p. 286)
- 15.5 Population Inversion (p. 289)
- 15.6 Threshold Gain Coefficient (p. 289)
- **15.7 Laser Resonators** (p. 291)
- 15.8 Beam Irradiance and Divergence (p. 293)
- 15.9 Examples of Important Laser Systems (p. 295)
- **15.10 Further Reading** (p. 297)
- Numerical Examples 15 (p. 297)
- **Problems 15** (p. 298)
- 16 Semiconductors and Semiconductor Lasers (p. 301)
- **16.1 Semiconductors** (p. 301)
- **16.2 Semiconductor Diodes** (p. 304)
- 16.3 Light-emitting Diodes and Semiconductor Lasers (p. 306)
- 16.4 Semiconductor Laser Cavities (p. 309)
- 16.5 Wavelengths and Tuning of Semiconductor Lasers (p. 311)
- 16.6 Electroluminescence in Organic Semiconductors (p. 312)
- **16.7 Further Reading** (p. 313)
- **17 Laser Light** (p. 315)
- **17.1 Laser Linewidth** (p. 315)
- **17.2 Spatial Coherence** (p. 319)
- 17.3 Temporal Coherence and Coherence Length (p. 322)
- **17.4 Laser Pulse Duration** (p. 323)
- **17.5 Brightness** (p. 327)
- **17.6 Focusing Laser Light** (p. 327)
- **17.7 Nonlinear Optics** (p. 328)
- **17.8 Further Reading** (p. 329)
- Numerical Examples 17 (p. 330)
- Problems 17 (p. 330)
- **18 Fibre Optics** (p. 331)
- **18.1 The Light Pipe** (p. 332)
- **18.2 Guided Waves** (p. 333)
- 18.3 The Slab Dielectric Guide (p. 336)
- 18.4 Evanescent Fields in Fibre Optics (p. 338)
- 18.5 Cylindrical Fibres and Waveguides (p. 340)
- **18.6 Numerical Aperture** (p. 342)
- 18.7 Materials for Optical Fibres (p. 343)
- **18.8 Dispersion in Optical Fibres** (p. 345)
- **18.9 Dispersion Compensation** (p. 349)

- **18.10 Hole-array Light Guide** (p. 352)
- 18.11 Fabrication of Optical Fibres (p. 352)
- **18.12 Further Reading** (p. 354)
- Numerical Examples 18 (p. 354)
- **Problems 18** (p. 354)
- **19 Holography** (p. 357)
- 19.1 Reconstructing a Plane Wave (p. 358)
- 19.2 Holographic Recording (p. 359)
- 19.3 Gabor's Original Method (p. 361)
- **19.4 Aspect Effects** (p. 362)
- **19.5** Holographic Interferometry (p. 363)
- **19.6 Phase Holograms** (p. 364)
- 19.7 Holography in Colour (p. 365)
- 19.8 Holography of Moving Objects (p. 366)
- 19.9 Holographic Optical Elements (p. 366)
- 19.10 Holographic Data Storage (p. 367)
- **19.11 Further Reading** (p. 367)
- 20 Radiation, Scattering and Refraction (p. 369)
- 20.1 Radiation Processes (p. 369)
- **20.2 The Hertzian Dipole** (p. 370)
- **20.3 Free-Free Radiation** (p. 372)
- **20.4 Synchrotron Radiation** (p. 373)
- **20.5 Cerenkov Radiation** (p. 374)
- 20.6 Rayleigh Scattering (p. 375)
- **20.7 Raman Scattering** (p. 376)
- 20.8 Thomson and Compton Scattering by Electrons (p. 377)
- **20.9 Polarization in Dielectrics** (p. 377)
- **20.10 Free Electrons** (p. 379)
- 20.11 Resonant Atoms in Gases (p. 380)
- **20.12 Anisotropic Refraction** (p. 381)
- **20.13 Further Reading** (p. 382)
- 21 The Detection of Light (p. 383)
- **21.1 Photoemissive Detectors** (p. 383)
- 21.2 Semiconductor Detectors (p. 386)
- 21.3 Semiconductor Junction Photodiodes (p. 388)
- **21.4 Imaging Detectors** (p. 391)
- 21.5 Noise in Photodetectors (p. 392)
- **21.6 Image Intensifiers** (p. 394)
- **21.7 Photography** (p. 397)
- **21.8 Thermal Detectors** (p. 398)
- **21.9 Further Reading** (p. 399)
- Numerical Examples 21 (p. 399)
- 22 Optics and Photonics in Nature (p. 401)
- 22.1 Light and Colour in the Open Air (p. 401)
- **22.2** The Development of Eyes (p. 402)
- **22.3 Corneal Focusing** (p. 403)

- **22.4 Compound Eyes** (p. 405)
- **22.5 Reflection Optics** (p. 406)
- 22.6 Thin Film Reflectors in Nature (p. 407)
- 22.7 Biological Light Detectors (p. 408)
- **22.8 Photosynthesis** (p. 410)
- 22.9 Further Reading (p. 411)
- Appendix Radiometry and Photometry (p. 413)
- Solutions to Numerical Examples (p. 417)
- Solutions to Problems (p. 423)
- **Index** (p. 435)