

# Content

## 1 A Brief History 1

- 1.1 Prolegomenon 1
- 1.2 In the Beginning 1
- 1.3 From the Seventeenth Century 2
- 1.4 The Nineteenth Century 4
- 1.5 Twentieth-Century Optics 7

## 2 Wave Motion 10

- 2.1 One-Dimensional Waves 10
- 2.2 Harmonic Waves 14
- 2.3 Phase and Phase Velocity 17
- 2.4 The Superposition Principle 20
- 2.5 The Complex Representation 21
- 2.6 Phasors and the Addition of Waves 23
- 2.7 Plane Waves 24
- 2.8 The Three-Dimensional Differential Wave Equation 27
- 2.9 Spherical Waves 28
- 2.10 Cylindrical Waves 31
- Problems 32

## 3 Electromagnetic Theory, Photons, and Light 36

- 3.1 Basic Laws of Electromagnetic Theory 37
- 3.2 Electromagnetic Waves 44
- 3.3 Energy and Momentum 47
- 3.4 Radiation 58
- 3.5 Light in Bulk Matter 66
- 3.6 The Electromagnetic-Photon Spectrum 73
- 3.7 Quantum Field Theory 80
- Problems 82

## 4 The Propagation of Light 86

- 4.1 Introduction 86

- 4.2 Rayleigh Scattering 86
- 4.3 Reflection 95
- 4.4 Refraction 100
- 4.5 Fermat's Principle 106
- 4.6 The Electromagnetic Approach 111
- 4.7 Total Internal Reflection 122
- 4.8 Optical Properties of Metals 127
- 4.9 Familiar Aspects of the Interaction of Light and Matter 131
- 4.10 The Stokes Treatment of Reflection and Refraction 136
- 4.11 Photons, Waves, and Probability 137
- Problems 141

## 5 Geometrical Optics 149

- 5.1 Introductory Remarks 149
- 5.2 Lenses 150
- 5.3 Stops 171
- 5.4 Mirrors 175
- 5.5 Prisms 186
- 5.6 Fiberoptics 193
- 5.7 Optical Systems 201
- 5.8 Wavefront Shaping 226
- 5.9 Gravitational Lensing 231
- Problems 234

## 6 More on Geometrical Optics 243

- 6.1 Thick Lenses and Lens Systems 243
- 6.2 Analytical Ray Tracing 246
- 6.3 Aberrations 253
- 6.4 GRIN Systems 273
- 6.5 Concluding Remarks 276
- Problems 277

**7 The Superposition of Waves 281**

- 7.1 The Addition of Waves of the Same Frequency 282
- 7.2 The Addition of Waves of Different Frequency 294
- 7.3 Anharmonic Periodic Waves 302
- 7.4 Nonperiodic Waves 308  
Problems 320

**8 Polarization 325**

- 8.1 The Nature of Polarized Light 325
- 8.2 Polarizers 331
- 8.3 Dichroism 333
- 8.4 Birefringence 336
- 8.5 Scattering and Polarization 344
- 8.6 Polarization by Reflection 348
- 8.7 Retarders 352
- 8.8 Circular Polarizers 357
- 8.9 Polarization of Polychromatic Light 358
- 8.10 Optical Activity 360
- 8.11 Induced Optical Effects—Optical Modulators 365
- 8.12 Liquid Crystals 370
- 8.13 A Mathematical Description of Polarization 372  
Problems 379

**9 Interference 385**

- 9.1 General Considerations 386
- 9.2 Conditions for Interference 390
- 9.3 Wavefront-splitting Interferometers 393
- 9.4 Amplitude-splitting Interferometers 400
- 9.5 Types and Localization of Interference Fringes 414
- 9.6 Multiple-Beam Interference 416
- 9.7 Applications of Single and Multilayer Films 425
- 9.8 Applications of Interferometry 431  
Problems 438

**10 Diffraction 443**

- 10.1 Preliminary Considerations 443
- 10.2 Fraunhofer Diffraction 452
- 10.3 Fresnel Diffraction 485
- 10.4 Kirchhoff's Scalar Diffraction Theory 510
- 10.5 Boundary Diffraction Waves 512  
Problems 514

**11 Fourier Optics 519**

- 11.1 Introduction 519
- 11.2 Fourier Transforms 519
- 11.3 Optical Applications 529  
Problems 556

**12 Basics of Coherence Theory 560**

- 12.1 Introduction 560
- 12.2 Visibility 562
- 12.3 The Mutual Coherence Function and the Degree of Coherence 566
- 12.4 Coherence and Stellar Interferometry 573  
Problems 578

**13 Modern Optics: Lasers and Other Topics 581**

- 13.1 Lasers and Laserlight 581
- 13.2 Imagery — The Spatial Distribution of Optical Information 606
- 13.3 Holography 623
- 13.4 Nonlinear Optics 639  
Problems 644

**Appendix 1 649****Appendix 2 652****Table 1 653****Solutions to Selected Problems 658****Bibliography 685****Index 689**