# 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