# CONTENTS

## PREFACE TO THE SECOND EDITION

## PREFACE TO THE FIRST EDITION

### 1 RAY OPTICS

1.1 Postulates of Ray Optics 3  
1.2 Simple Optical Components 6  
1.3 Graded-Index Optics 17  
1.4 Matrix Optics 24  
   Reading List 34  
   Problems 36

### 2 WAVE OPTICS

2.1 Postulates of Wave Optics 40  
2.2 Monochromatic Waves 41  
2.3 Relation Between Wave Optics and Ray Optics 49  
2.4 Simple Optical Components 50  
2.5 Interference 58  
2.6 Polychromatic and Pulsed Light 66  
   Reading List 72  
   Problems 73

### 3 BEAM OPTICS

3.1 The Gaussian Beam 75  
3.2 Transmission Through Optical Components 86  
3.3 Hermite–Gaussian Beams 94  
3.4 Laguerre–Gaussian and Bessel Beams 97  
   Reading List 100  
   Problems 100

### 4 FOURIER OPTICS

4.1 Propagation of Light in Free Space 105  
4.2 Optical Fourier Transform 116  
4.3 Diffraction of Light 121  
4.4 Image Formation 127  
4.5 Holography 138  
   Reading List 145  
   Problems 147
5 ELECTROMAGNETIC OPTICS 150
  5.1 Electromagnetic Theory of Light 152
  5.2 Electromagnetic Waves in Dielectric Media 156
  5.3 Monochromatic Electromagnetic Waves 162
  5.4 Elementary Electromagnetic Waves 164
  5.5 Absorption and Dispersion 170
  5.6 Pulse Propagation in Dispersive Media 184
  5.7 Optics of Magnetic Materials and Metamaterials 190
  Reading List 193
  Problems 195

6 POLARIZATION OPTICS 197
  6.1 Polarization of Light 199
  6.2 Reflection and Refraction 209
  6.3 Optics of Anisotropic Media 215
  6.4 Optical Activity and Magneto-Optics 228
  6.5 Optics of Liquid Crystals 232
  6.6 Polarization Devices 235
  Reading List 239
  Problems 240

7 PHOTONIC-CRYSTAL OPTICS 243
  7.1 Optics of Dielectric Layered Media 246
  7.2 One-Dimensional Photonic Crystals 265
  7.3 Two- and Three-Dimensional Photonic Crystals 279
  Reading List 286
  Problems 288

8 GUIDED-WAVE OPTICS 289
  8.1 Planar-Mirror Waveguides 291
  8.2 Planar Dielectric Waveguides 299
  8.3 Two-Dimensional Waveguides 308
  8.4 Photonic-Crystal Waveguides 311
  8.5 Optical Coupling in Waveguides 313
  8.6 Sub-Wavelength Metal Waveguides (Plasmonics) 321
  Reading List 322
  Problems 323

9 FIBER OPTICS 325
  9.1 Guided Rays 327
  9.2 Guided Waves 331
  9.3 Attenuation and Dispersion 348
  9.4 Holey and Photonic-Crystal Fibers 359
  Reading List 362
  Problems 363

10 RESONATOR OPTICS 365
  10.1 Planar-Mirror Resonators 367
  10.2 Spherical-Mirror Resonators 378
  10.3 Two- and Three-Dimensional Resonators 390
  10.4 Microresonators 394
  Reading List 400
  Problems 400
11 STATISTICAL OPTICS
   11.1 Statistical Properties of Random Light
   11.2 Interference of Partially Coherent Light
   11.3 Transmission of Partially Coherent Light Through Optical Systems
   11.4 Partial Polarization
      Reading List
      Problems

12 PHOTON OPTICS
   12.1 The Photon
   12.2 Photon Streams
   12.3 Quantum States of Light
      Reading List
      Problems

13 PHOTONS AND ATOMS
   13.1 Energy Levels
   13.2 Occupation of Energy Levels
   13.3 Interactions of Photons with Atoms
   13.4 Thermal Light
   13.5 Luminescence and Light Scattering
      Reading List
      Problems

14 LASER AMPLIFIERS
   14.1 Theory of Laser Amplification
   14.2 Amplifier Pumping
   14.3 Common Laser Amplifiers
   14.4 Amplifier Nonlinearity
   14.5 Amplifier Noise
      Reading List
      Problems

15 LASERS
   15.1 Theory of Laser Oscillation
   15.2 Characteristics of the Laser Output
   15.3 Common Lasers
   15.4 Pulsed Lasers
      Reading List
      Problems

16 SEMICONDUCTOR OPTICS
   16.1 Semiconductors
   16.2 Interactions of Photons with Charge Carriers
      Reading List
      Problems

CONTENTS
17 SEMICONDUCTOR PHOTON SOURCES 680
  17.1 Light-Emitting Diodes 682
  17.2 Semiconductor Optical Amplifiers 702
  17.3 Laser Diodes 716
  17.4 Quantum-Confined and Microcavity Lasers 728
      Reading List 741
      Problems 745

18 SEMICONDUCTOR PHOTON DETECTORS 748
  18.1 Photodetectors 749
  18.2 Photoconductors 758
  18.3 Photodiodes 762
  18.4 Avalanche Photodiodes 767
  18.5 Array Detectors 775
  18.6 Noise in Photodetectors 777
      Reading List 798
      Problems 800

19 ACOUSTO-OPTICS 804
  19.1 Interaction of Light and Sound 806
  19.2 Acousto-Optic Devices 819
  *19.3 Acousto-Optics of Anisotropic Media 828
      Reading List 832
      Problems 832

20 ELECTRO-OPTICS 834
  20.1 Principles of Electro-Optics 836
  *20.2 Electro-Optics of Anisotropic Media 849
  20.3 Electro-Optics of Liquid Crystals 856
  *20.4 Photorefractivity 863
  20.5 Electroabsorption 868
      Reading List 869
      Problems 871

21 NONLINEAR OPTICS 873
  21.1 Nonlinear Optical Media 875
  21.2 Second-Order Nonlinear Optics 879
  21.3 Third-Order Nonlinear Optics 894
  *21.4 Second-Order Nonlinear Optics: Coupled-Wave Theory 905
  *21.5 Third-Order Nonlinear Optics: Coupled-Wave Theory 917
  *21.6 Anisotropic Nonlinear Media 924
  *21.7 Dispersive Nonlinear Media 927
      Reading List 932
      Problems 934

22 ULTRAFAST OPTICS 936
  22.1 Pulse Characteristics 937
  22.2 Pulse Shaping and Compression 946
  22.3 Pulse Propagation in Optical Fibers 960