## CONTENTS

### PREFACE TO THE SECOND EDITION

v

### PREFACE TO THE FIRST EDITION

xi

### 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 35

### 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

### Reading List

72

### Problems

73

100
### CONTENTS

#### 5 ELECTROMAGNETIC OPTICS

- 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

- 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

- 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

- 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

- 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

- 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
## Contents

### 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
<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>SEMICONDUCTOR PHOTON SOURCES</td>
<td>680</td>
</tr>
<tr>
<td>17.1</td>
<td>Light-Emitting Diodes</td>
<td>682</td>
</tr>
<tr>
<td>17.2</td>
<td>Semiconductor Optical Amplifiers</td>
<td>702</td>
</tr>
<tr>
<td>17.3</td>
<td>Laser Diodes</td>
<td>716</td>
</tr>
<tr>
<td>17.4</td>
<td>Quantum-Confined and Microcavity Lasers</td>
<td>728</td>
</tr>
<tr>
<td></td>
<td>Reading List</td>
<td>741</td>
</tr>
<tr>
<td></td>
<td>Problems</td>
<td>745</td>
</tr>
<tr>
<td>18</td>
<td>SEMICONDUCTOR PHOTON DETECTORS</td>
<td>748</td>
</tr>
<tr>
<td>18.1</td>
<td>Photodetectors</td>
<td>749</td>
</tr>
<tr>
<td>18.2</td>
<td>Photoconductors</td>
<td>758</td>
</tr>
<tr>
<td>18.3</td>
<td>Photodiodes</td>
<td>762</td>
</tr>
<tr>
<td>18.4</td>
<td>Avalanche Photodiodes</td>
<td>767</td>
</tr>
<tr>
<td>18.5</td>
<td>Array Detectors</td>
<td>775</td>
</tr>
<tr>
<td>18.6</td>
<td>Noise in Photodetectors</td>
<td>777</td>
</tr>
<tr>
<td></td>
<td>Reading List</td>
<td>798</td>
</tr>
<tr>
<td></td>
<td>Problems</td>
<td>800</td>
</tr>
<tr>
<td>19</td>
<td>ACOUSTO-OPTICS</td>
<td>804</td>
</tr>
<tr>
<td>19.1</td>
<td>Interaction of Light and Sound</td>
<td>806</td>
</tr>
<tr>
<td>19.2</td>
<td>Acousto-Optic Devices</td>
<td>819</td>
</tr>
<tr>
<td>19.3</td>
<td>Acousto-Optics of Anisotropic Media</td>
<td>828</td>
</tr>
<tr>
<td></td>
<td>Reading List</td>
<td>832</td>
</tr>
<tr>
<td></td>
<td>Problems</td>
<td>832</td>
</tr>
<tr>
<td>20</td>
<td>ELECTRO-OPTICS</td>
<td>834</td>
</tr>
<tr>
<td>20.1</td>
<td>Principles of Electro-Optics</td>
<td>836</td>
</tr>
<tr>
<td>20.2</td>
<td>Electro-Optics of Anisotropic Media</td>
<td>849</td>
</tr>
<tr>
<td>20.3</td>
<td>Electro-Optics of Liquid Crystals</td>
<td>856</td>
</tr>
<tr>
<td>20.4</td>
<td>Photorefractivity</td>
<td>863</td>
</tr>
<tr>
<td>20.5</td>
<td>Electroabsorption</td>
<td>868</td>
</tr>
<tr>
<td></td>
<td>Reading List</td>
<td>869</td>
</tr>
<tr>
<td></td>
<td>Problems</td>
<td>871</td>
</tr>
<tr>
<td>21</td>
<td>NONLINEAR OPTICS</td>
<td>873</td>
</tr>
<tr>
<td>21.1</td>
<td>Nonlinear Optical Media</td>
<td>875</td>
</tr>
<tr>
<td>21.2</td>
<td>Second-Order Nonlinear Optics</td>
<td>879</td>
</tr>
<tr>
<td>21.3</td>
<td>Third-Order Nonlinear Optics</td>
<td>894</td>
</tr>
<tr>
<td>21.4</td>
<td>Second-Order Nonlinear Optics: Coupled-Wave Theory</td>
<td>905</td>
</tr>
<tr>
<td>21.5</td>
<td>Third-Order Nonlinear Optics: Coupled-Wave Theory</td>
<td>917</td>
</tr>
<tr>
<td>21.6</td>
<td>Anisotropic Nonlinear Media</td>
<td>924</td>
</tr>
<tr>
<td>21.7</td>
<td>Dispersive Nonlinear Media</td>
<td>927</td>
</tr>
<tr>
<td></td>
<td>Reading List</td>
<td>932</td>
</tr>
<tr>
<td></td>
<td>Problems</td>
<td>934</td>
</tr>
<tr>
<td>22</td>
<td>ULTRAFAST OPTICS</td>
<td>936</td>
</tr>
<tr>
<td>22.1</td>
<td>Pulse Characteristics</td>
<td>937</td>
</tr>
<tr>
<td>22.2</td>
<td>Pulse Shaping and Compression</td>
<td>946</td>
</tr>
<tr>
<td>22.3</td>
<td>Pulse Propagation in Optical Fibers</td>
<td>960</td>
</tr>
</tbody>
</table>