

CONTENTS

<i>Preface</i>		xi
CHAPTER 1	Introduction and Overview	1
1.1	The Idea of the Laser	1
1.2	What is a Laser?	3
1.3	Laser Materials and Types	7
1.4	Optical Properties of Laser Light	10
1.5	How Lasers are Used	15
1.6	What Have We Learned?	17
CHAPTER 2	Physical Basics	21
2.1	Electromagnetic Waves and Photons	21
2.2	Quantum and Classical Physics	29
2.3	Interactions of Light and Matter	41
2.4	Basic Optics and Simple Lenses	49
2.5	What Have We Learned?	55
CHAPTER 3	How Lasers Work	59
3.1	Building a Laser	59
3.2	Producing a Population Inversion	60
3.3	Resonant Cavities	66
3.4	Laser Beams and Resonance	73
3.5	Wavelength Selection and Tuning	81
3.6	Laser Excitation Techniques	84
3.7	What Have We Learned?	88
CHAPTER 4	Laser Characteristics	93
4.1	Coherence	93
4.2	Laser Wavelengths	96
4.3	Behavior of Laser Beams	101

4.4	Laser Power	105
4.5	Laser Efficiency	108
4.6	Duration of Emission	113
4.7	Polarization	117
4.8	What Have We Learned?	119
CHAPTER 5	Optics and Laser Accessories	125
5.1	Classical Optical Devices	125
5.2	Transparent Optical Materials	136
5.3	Optical Surfaces, Coatings and Filters	137
5.4	Nonlinear Optics	141
5.5	Beam Intensity and Pulse Control	145
5.6	Beam Direction and Propagation	151
5.7	Mounting and Positioning Equipment	153
5.8	Optical Measurement	155
5.9	What Have We Learned?	157
CHAPTER 6	Types of Lasers	161
6.1	Laser Oscillators and Optical Amplifiers	161
6.2	Laser Media	166
6.3	The Importance of Gain	173
6.4	Broadband and Wavelength-Tunable Lasers	175
6.5	Laser-Like Light Sources	178
6.6	What Have We Learned?	180
CHAPTER 7	Gas Lasers	185
7.1	The Gas Laser Family	185
7.2	Gas-Laser Basics	186
7.3	Helium-Neon Lasers	193
7.4	Argon- and Krypton-Ion Lasers	197
7.5	Metal-Vapor Lasers	200
7.6	Carbon Dioxide Laser	203
7.7	Excimer Lasers	208
7.8	Chemical Lasers	212
7.9	Other Gas Lasers	215
7.10	What Have We Learned?	216
CHAPTER 8	Solid-State and Fiber Lasers	223
8.1	What is a Solid-State Laser?	223
8.2	Solid-State Laser Materials	225
8.3	Optical Pumping	230
8.4	Ruby Lasers	234
8.5	Neodymium Lasers	237

8.6	Vibronic and Tunable Solid-State Lasers	243
8.7	Erbium and Other Eye-Safe Lasers	249
8.8	Rare-Earth-Doped Fiber Lasers	250
8.9	Rare-Earth-Doped Fiber Amplifiers	256
8.10	Raman Fiber Lasers and Amplifiers	258
8.11	What Have We Learned?	259
CHAPTER 9	Semiconductor Diode Lasers	265
9.1	Basics of Semiconductor Diode Lasers	265
9.2	Semiconductor Basics	267
9.3	Light Emission at Junctions	276
9.4	Layers and Confinement in Diode Lasers	281
9.5	Confinement in the Junction Plane	286
9.6	Edge-Emitting Diode Lasers	290
9.7	Surface-Emitting Diode Lasers	294
9.8	Quantum Wells and Dots	297
9.9	Quantum Cascade Lasers	298
9.10	Optical Properties of Diode Lasers	300
9.11	Diode Laser Materials and Wavelengths	302
9.12	Silicon Lasers	308
9.13	Packaging and Specialization of Diode Lasers	309
9.14	What Have We Learned?	312
CHAPTER 10	Other Lasers and Related Sources	317
10.1	Tunable Dye Lasers	317
10.2	Extreme-Ultraviolet Sources	323
10.3	Free-Electron Lasers	328
10.4	Silicon Lasers	332
10.5	What Have We Learned?	334
CHAPTER 11	Low-Power Laser Applications	339
11.1	Advantages of Laser Light	340
11.2	Reading with Lasers	341
11.3	Optical Disks and Data Storage	344
11.4	Laser Printing and Marking	347
11.5	Fiber-Optic Communications	350
11.6	Laser Measurement	355
11.7	Laser Pointers, Art, and Entertainment	359
11.8	Low-Power Defense Applications	361
11.9	Sensing and Spectroscopy	363
11.10	Holography	369
11.11	Other Low-Power Applications	372
11.12	What Have We Learned?	372

CHAPTER 12	High-Power Laser Applications	377
12.1	High- Versus Low-Power Laser Applications	377
12.2	Attractions of High-Power Lasers	378
12.3	Materials Working	379
12.4	Electronics Manufacturing	387
12.5	Three-Dimensional Modeling	389
12.6	Laser Medical Treatment	390
12.7	Photochemistry and Isotope Separation	398
12.8	Laser-Driven Nuclear Fusion	401
12.9	High-Energy Laser Weapons	403
12.10	Futuristic High-Power Laser Ideas	409
12.11	What Have We Learned?	410
CHAPTER 13	Lasers In Research	415
13.1	Lasers Open New Opportunities	415
13.2	Laser Spectroscopy	417
13.3	Manipulating Tiny Objects	421
13.4	Atom Lasers and Bose–Einstein Condensates	423
13.5	Slow Light	424
13.6	Nanoscale Lasers	425
13.7	Petawatt Lasers	426
13.8	Attosecond Pulses	428
13.9	Laser Acceleration	430
13.10	Other Emerging Research	430
13.11	What We Have Learned	433
	Answers to Quiz Questions	437
	Appendix A: Laser Safety	441
	Appendix B: Handy Numbers and Formulas	447
	Appendix C: Resources and Suggested Readings	451
	Glossary	455
	Index	467