



Applications in **Electro-Optics**

Leo Setian

Contents

Preface	xi
Acknowledgments	xv
Chapter 1. Fundamentals of Light	1
<i>Introduction</i>	2
<i>Light Communication</i>	9
<i>The Fiber Cable</i>	10
<i>The Communication System</i>	12
<i>Summary</i>	21
Chapter 2. Electrostatics	23
<i>The Electric Field</i>	24
<i>Electric Flux Density</i>	27
<i>Conductors, Semiconductors, and Dielectrics</i>	28
<i>Potential</i>	31
<i>Capacitance</i>	35
<i>Resistance</i>	40
<i>Displacement</i>	43
<i>Power and Energy</i>	48
<i>Maxwell's Equations</i>	51
<i>Summary</i>	54

Chapter 3. Magnetostatics	61
<i>Magnetic Field Intensity</i>	62
<i>Magnetic Flux Density</i>	70
<i>Magnetic Properties of Materials</i>	71
<i>Inductance</i>	75
<i>Magnetic Energy</i>	84
<i>Magnetic Scalar Potential</i>	88
<i>Maxwell's Equations</i>	90
<i>Summary</i>	93
Chapter 4. Electromagnetics	99
<i>Maxwell's, Continuity, and the Lorentz Force Equations</i>	100
<i>The Electric and Magnetic Fields</i>	109
<i>Poynting's Vector</i>	111
<i>Polarization</i>	113
<i>Boundary Conditions</i>	118
<i>Faraday's Law of Induction</i>	125
<i>Plane Waves in Various Media</i>	129
<i>Plane Waves at Oblique Incidence</i>	143
<i>Brewster's Angle</i>	157
<i>Summary</i>	158
Chapter 5. Transmission Lines and Waveguides	165
<i>Transmission Lines and Circuits</i>	166
<i>Transmission Lines and Reflections</i>	171
<i>Transmission Lines and Input Impedance</i>	176
<i>Some Special Transmission Lines</i>	180
<i>Power Movement on a Lossless Transmission Line</i>	182
<i>TE and TM Transmission Modes</i>	186
<i>Summary</i>	188
Chapter 6. The Nature of Light	193
<i>Ray and Wave Optics</i>	194
<i>Reflection/Refraction</i>	197
<i>Diffraction</i>	202
<i>Polarization of Light</i>	207
<i>Double Refraction</i>	211
<i>Optical Activity</i>	212

Contents	vii
<i>Summary</i>	214
Chapter 7. Devices	217
<i>Mirrors—Concave and Convex</i>	218
<i>Lenses—Convergent and Divergent</i>	224
<i>Prisms</i>	233
<i>Beamsplitters</i>	235
<i>Optical Filters</i>	238
<i>Resonator</i>	239
<i>Lasers</i>	242
<i>Summary</i>	245
Chapter 8. Components	251
<i>Semiconductor Theory</i>	251
<i>Semiconductor Diodes</i>	255
<i>Light Emitting Diodes (LEDs)</i>	259
<i>Photodetectors</i>	264
<i>Liquid Crystal Optics</i>	267
<i>Multiplexers</i>	270
<i>Summary</i>	272
Chapter 9. Fiber Construction and Characteristics	275
<i>Fiber Construction</i>	276
<i>Coupling and Connections</i>	282
<i>Dispersion and Attenuation in Fibers</i>	288
<i>Wavelength Division Multiplexing</i>	292
<i>Summary</i>	298
Chapter 10. Communication/Signal Processing	301
<i>Modulation and Demodulation</i>	303
<i>Analog and Digital Communication</i>	309
<i>Digital Communication</i>	311
<i>Optical Communication</i>	312
<i>Optical Signal Processing</i>	317
<i>Fabry-Perot Filter</i>	320
<i>Thin-Film Interference Filter</i>	322

<i>Tunable Filters</i>	323
<i>Summary</i>	325
Chapter 11. Applications	327
<i>Laboratory 1—Characteristics of a Helium-Neon Laser</i>	327
<i>Laboratory 2—Polarization, Reflection, and Filtering</i>	330
<i>Laboratory 3—Refraction and Index of Refraction</i>	333
<i>Laboratory 4—Index of Refraction for Solids</i>	336
<i>Laboratory 5—Lenses</i>	341
<i>Laboratory 6—Diffraction</i>	345
<i>Laboratory 7—Interferometers</i>	350
<i>Laboratory 8—Thin-Film Interference and Filters</i>	355
<i>Laboratory 9—Fiber Optics</i>	360
<i>Laboratory 10—Numerical Aperture</i>	362
<i>Laboratory 11—LED</i>	366
<i>Laboratory 12—Photodetectors</i>	371
<i>Laboratory 13—Fiber Coupling</i>	374
<i>Laboratory 14—Fiber Optic Communication</i>	378
<i>Laboratory 15—Linear Displacement</i>	381
Appendix A. Math Operations	385
<i>Trigonometric Identities</i>	385
<i>Fourier Transforms</i>	386
<i>Some Fourier Transform Pairs</i>	386
<i>Vector Operations</i>	386
Appendix B. Coordinate Systems	389
<i>The Rectangular Coordinate System</i>	389
<i>The Cylindrical Coordinate System</i>	390
<i>The Spherical Coordinate System</i>	392
Appendix C. Typical Permittivity of Common Materials	395
Appendix D. Typical Permeability of Common Materials	397

Contents	ix
Appendix E. Typical Conductivity of Common Materials	399
Appendix F. Approximate Indices of Refraction at Optic Frequencies	401
Appendix G. Typical Optical Fiber Cable Attenuation	403
Appendix H. Electromagnetic Frequency Spectrum	405
Appendix I. Several Semiconductor Material Wavelengths	407
Appendix J. Useful Constants	409
Appendix K. Radiometric and Photometric Fields	411
Appendix L. The Smith Chart	413
Bibliography	423
Index	425