

Contents

Preface.....	ix
Author	xi

Chapter 1 Optical Systems and Components.....	1
--	---

1.1 Chapter Descriptions	2
References	5

Chapter 2 Light Sources.....	7
-------------------------------------	---

2.1 Lasers (Light Amplification by Stimulated Emission of Radiation)	7
2.2 Light-Emitting Diodes.....	8
2.3 Selecting Light Sources.....	8
2.4 Conversion from Radiometric to Photometric Quantities	9
2.5 Conversion from Photometric to Radiometric Quantities	12
2.6 Thermal Sources.....	12
2.7 Blackbody Radiation	12
References	14

Chapter 3 Light Detection.....	15
---------------------------------------	----

3.1 Photon Detectors	15
3.2 Thermal Detectors.....	17
3.3 Noise in Photodiodes	17
3.4 Photodetectors for Low-Light Level Detection	18
3.5 Integrating Spheres for Light Measurement.....	18
3.6 Lock-In Amplification for Detecting Low-Light Level Signals	19
3.7 Detector Figures of Merit	20
3.7.1 Detectivity	20
3.7.2 Noise Equivalent Temperature Difference	21
3.8 Spectrometers	22
References	22

Chapter 4 Manipulation of Light	23
--	----

4.1 Reflection.....	23
4.1.1 Reflection from Flat Mirror.....	23
4.2 Refraction	23
4.2.1 Reflection Coefficient at Dielectric Interface.....	27
4.3 Diffraction	27

4.3.1	Diffraction Gratings	28
4.4	Interference.....	28
4.5	Absorption	29
4.6	Diffusers and Scattering.....	30
4.6.1	Small Particle Scattering.....	30
4.6.2	Large Particle Scattering.....	30
4.6.3	Application of Diffusers.....	31
4.7	Suggested Experiments	34
	References	43
Chapter 5	Polarization	45
5.1	Polarizers	45
5.2	Birefringence, Retardation, and Wave Plates	45
5.3	Polarized Light Reflection	47
5.4	Polarization of Small Particle Scattering	51
5.5	Suggested Experiments	53
	References	59
Chapter 6	Geometrical Optics	61
6.1	Ray Tracing Methods	61
6.2	Lens Maker's Formula.....	62
6.3	Thin Lens Formulation.....	62
6.4	Ray Tracing Formulation.....	63
6.5	Graphical Method of Ray Tracing.....	63
6.6	Principal Plane Method.....	64
6.7	Matrix Method of Ray Tracing.....	65
6.8	Sign Conventions	67
6.9	Beam Shaping from Laser Diode	69
	References	70
Chapter 7	Imaging Systems	71
7.1	Optical Resolution	71
7.2	Two-Dimensional Imaging Systems.....	75
7.3	One-Dimensional Imaging Systems; Line Scan Sensors	76
7.4	Stops	77
7.5	Monochromatic Aberrations	77
7.6	Chromatic Aberrations	79
7.7	Various Types of Illumination.....	82
7.7.1	Coherent Illumination	82
7.7.2	Incoherent or Partially Coherent Illumination	83
7.7.3	Point Source and Diffuse Illumination and Multiangle Illumination	83
	References	85

Chapter 8	Guiding Lightwaves	87
8.1	Light Guiding and Total Internal Reflection	87
8.2	Fiber Optics	90
8.3	Planar Waveguides and Integrated Optics.....	90
8.4	Coupling Between Fibers and Waveguides	91
8.5	Active Integrated Optical Devices	93
8.6	Suggested Simulations.....	94
8.7	Suggested Experiments	94
	References	100
Chapter 9	Optics, Electronics, Software, and Applications.....	101
9.1	Combining Optics, Electronics, and Software	101
9.2	Separating Optical and Electronics Effects.....	103
9.3	Applications.....	103
Chapter 10	Optical Sensing	107
10.1	Optical Sensors and Sensing Mechanism.....	107
10.1.1	Sensing Change in Light Intensity	107
10.1.2	Sensing Change in Absorption	108
10.1.3	Change in Color (Wavelength)	108
10.1.4	Change in Refractive Index.....	108
10.1.5	Interferometric Optical Sensors	108
10.1.5.1	Some Applications of Interferometry	112
10.1.6	Sensing Change in Polarization Angle.....	112
10.1.6.1	Polarization-Dependent Reflection	112
10.1.6.2	Polarimetric-Based Electric and Magnetic Sensors.....	112
10.1.7	Sensing by Detecting Changes in Diffraction Angle or Wavelength	113
10.1.8	Spectral Sensing of Temperature	113
10.1.9	Sensing Fluorescence Emission	114
10.1.10	Sensing Fluorescence Lifetime	114
10.1.11	Holography-Based Sensors.....	115
10.1.12	Surface Plasmon Based Sensors.....	116
10.2	Fiber Optic Sensors	117
10.2.1	Intensity Detection Fiber Optic Sensors	117
10.2.2	Evanescence Field Fiber Optic Sensors.....	118
10.2.3	Fiber-Grating Sensors	119
10.2.4	Michelson and Mach-Zehnder Interferometric Fiber Optic Sensors	120
10.2.5	Sagnac Interferometer Fiber Optic Sensors for Rotation Sensors.....	121
10.2.6	Integrated Optical Sensors	122

10.3 Imaging Sensors	122
10.4 Starting Point to Design or Choose a Sensing System	123
References	123
Chapter 11 Advanced Experiments	125
References	139
Chapter 12 Advanced Topics	141
References	144
Appendix A: Simulations	145
Appendix B: Computing Diffraction Pattern.....	155
Appendix C: Polarization Calculations Using Jones Vectors and Matrices	159
Appendix D: MATLAB® Simulation Function Files	163
Index.....	201