

# Contents

Introduction to the BCSC . . . . .	xv
Introduction to Section 3 . . . . .	xvii
<b>Objectives . . . . .</b>	<b>1</b>
<b>Quick-Start Guide: Optics, Refraction, and Retinoscopy. . . . .</b>	<b>3</b>
Part 1: Optics . . . . .	3
Highlights . . . . .	3
Glossary . . . . .	3
Introduction . . . . .	5
The Camera Obscura: Pinhole Imaging . . . . .	5
Convex Lenses . . . . .	7
Combining Lenses . . . . .	8
Imaging Nearby Objects: Vergence and the Vergence Equation . . . . .	10
Concave Lenses . . . . .	11
Summary Thus Far . . . . .	12
Images in Denser Media . . . . .	13
A Very Much Simplified Model Eye . . . . .	13
Astigmatism . . . . .	16
Part 2: Refraction. . . . .	21
Highlights . . . . .	21
Glossary . . . . .	22
Overview of Clinical Refraction . . . . .	22
Step 1. Perform the Preliminaries . . . . .	24
Step 2. Occlude 1 Eye . . . . .	27
Step 3. Obtain Initial Estimate of the Refractive Error . . . . .	28
Step 4. Refine Cylinder Axis and Power . . . . .	31
Step 5. Refine Sphere Power . . . . .	34
Step 6. Occlude the Right Eye, Refract the Left Eye. . . . .	34
Step 7. Accommodative Control and Binocular Balance . . . . .	35
Step 8. Refract for Near Vision . . . . .	38
Final Remarks . . . . .	39
Part 3: Retinoscopy . . . . .	40
Highlights . . . . .	40
Glossary . . . . .	40
The Role of Retinoscopy . . . . .	41
Types of Retinoscopes . . . . .	41
Fundamental Concepts . . . . .	42
Preliminaries for Retinoscopy. . . . .	43
Basic Retinoscope Operation . . . . .	44

Putting It All Together . . . . .	49
Subjective Retinoscopy Findings . . . . .	51
Final Remarks . . . . .	51
<b>1 Geometric Optics . . . . .</b>	<b>53</b>
Highlights . . . . .	53
Glossary . . . . .	53
Introduction . . . . .	56
Refractive Index . . . . .	57
Flat Refracting Surfaces: Snell's Law . . . . .	58
Prisms . . . . .	58
Prism Power . . . . .	60
Fresnel Prisms . . . . .	63
Reflection . . . . .	64
Critical Angle and Total Internal Reflection . . . . .	64
Refraction by a Single Curved Surface . . . . .	66
Two-Sided Lenses . . . . .	70
Principal Planes and Ray Tracing . . . . .	71
Depth of Focus and Depth of Field . . . . .	73
General Refracting Systems . . . . .	76
Characteristics of Objects and Images: Real and Virtual . . . . .	79
Transverse Magnification . . . . .	80
Axial (Longitudinal) Magnification . . . . .	82
Conjugate Points . . . . .	83
Nodal Points . . . . .	83
The Reduced, or Equivalent, Optical System . . . . .	84
Aberrations . . . . .	86
Point Spread Function . . . . .	86
Wavefront Theory . . . . .	87
Chromatic Aberration . . . . .	92
Astigmatism . . . . .	92
The Conoid of Sturm . . . . .	93
The Spherical Equivalent . . . . .	94
The Power Cross . . . . .	95
Power-Versus-Meridian Graph . . . . .	97
Jackson Cross Cylinder . . . . .	97
Mirrors . . . . .	99
Telescopes . . . . .	102
Appendix 1-1 . . . . .	103
Derivation of the Vergence Equation and the Lensmaker's Equation	
From Snell's Law . . . . .	103
Appendix 1-2 . . . . .	105
Fermat's Principle . . . . .	105
Appendix 1-3 . . . . .	107
Derivation of the Vergence Equation for Mirrors . . . . .	107
Appendix 1-4 . . . . .	108
Dynamic Ray Tracing . . . . .	108

<b>2</b>	<b>Physical Optics</b>	<b>109</b>
	Highlights	109
	Glossary	109
	Introduction	111
	What Is Light?	111
	Visible Light	111
	Wave or Particle?	112
	Quantum Electrodynamics: Unifying Theory of Light	114
	Refraction and Reflection	114
	Scattering	114
	Phenomena of Light	116
	Polarization	116
	Interference and Coherence	117
	Diffraction	124
	Measures of Light	127
	Radiometry	127
	Photometry	128
	Conversion Between Radiometric and Photometric Outputs	129
	Light Sources: Lasers	130
	Fundamentals	130
	Therapeutic Laser–Tissue Interactions	132
	Light Hazards	138
	Appendix 2-1	139
	Reconciliation of Geometric Optics and Physical Optics	139
	Chapter Exercises	140
	Questions	140
	Answers	141
<b>3</b>	<b>Optics of the Human Eye</b>	<b>143</b>
	Highlights	143
	Glossary	143
	Introduction	145
	Schematic Eyes	145
	Important Axes of the Eye	148
	Pupil Size and Its Effect on Visual Resolution	149
	Visual Acuity	151
	Contrast Sensitivity and the Contrast Sensitivity Function	154
	Refractive States of the Eyes	157
	Binocular States of the Eyes	160
	Accommodation and Presbyopia	161
	Eye Growth and Refractive Errors	161
	Developmental Myopia	162
	Prevention of Myopia Progression	163
	Developmental Hyperopia	164
	Appendix 3-1	164
	Explanation of the ETDRS Visual Acuity Chart	164

Chapter Exercises . . . . .	165
Questions . . . . .	165
Answers . . . . .	166
<b>4 Clinical Refraction . . . . .</b>	<b>169</b>
Highlights . . . . .	169
Glossary . . . . .	169
Introduction . . . . .	170
Minus Cylinder and Plus Cylinder Terminology . . . . .	170
Examination Room Length . . . . .	171
Objective Refraction Technique: Retinoscopy . . . . .	171
Fixation and Fogging . . . . .	174
Aberrations of the Retinoscopic Reflex . . . . .	174
Pseudoneutralization . . . . .	175
Cycloplegic Retinoscopy . . . . .	175
Subjective Refraction Techniques . . . . .	176
Stenopeic Slit Technique . . . . .	176
Cross-Cylinder Technique . . . . .	176
Refining the Sphere . . . . .	179
Binocular Balance . . . . .	181
Cycloplegic and Noncycloplegic Refraction . . . . .	182
Overrefraction . . . . .	182
Chapter Exercises . . . . .	183
Questions . . . . .	183
Answers . . . . .	183
<b>5 Eyeglasses . . . . .</b>	<b>185</b>
Highlights . . . . .	185
Glossary . . . . .	185
Spectacle Correction of Ametropias . . . . .	186
Spherical Correcting Lenses and the Far Point Concept . . . . .	186
The Importance of Vertex Distance . . . . .	186
Cylindrical Correcting Lenses and the Far Point Concept . . . . .	189
Pantoscopic Tilt . . . . .	190
Prescribing for Children . . . . .	191
Myopia . . . . .	191
Hyperopia . . . . .	192
Anisometropia . . . . .	192
Clinical Accommodative Problems . . . . .	192
Presbyopia . . . . .	193
Accommodative Insufficiency . . . . .	193
Accommodative Excess . . . . .	193
Accommodative Convergence/Accommodation Ratio . . . . .	194
Effect of Spectacle and Contact Lens Correction on Accommodation and Convergence . . . . .	195
Prescribing Multifocal Lenses . . . . .	195
Determining the Add Power of a Bifocal Lens . . . . .	195
Types of Bifocal Lenses . . . . .	198

Trifocal Lenses . . . . .	199
Progressive Addition Lenses . . . . .	199
Prentice's Rule and Bifocal Lens Design . . . . .	201
Occupation and Bifocal Segment . . . . .	207
Prescribing Special Lenses . . . . .	209
Aphakic Lenses . . . . .	209
Absorptive Lenses . . . . .	210
Special Lens Materials . . . . .	212
Therapeutic Use of Prisms . . . . .	214
Management of Anisometropia . . . . .	215
Troubleshooting for Dissatisfied Spectacle Wearers . . . . .	216
Pharmacologic Treatment of Presbyopia . . . . .	217
Chapter Exercises . . . . .	217
Questions . . . . .	217
Answers . . . . .	220
<b>6 Contact Lenses . . . . .</b>	<b>223</b>
Highlights . . . . .	223
Glossary . . . . .	223
Introduction . . . . .	224
Contact Lens Optics . . . . .	224
Anisometropia and Image Size . . . . .	224
Accommodation . . . . .	226
Correcting Astigmatism . . . . .	229
Contact Lens Materials . . . . .	231
Patient History and Examination . . . . .	232
Contact Lens Selection . . . . .	233
Contact Lens Fitting . . . . .	233
Soft Contact Lenses . . . . .	234
Corneal Rigid Gas-Permeable Contact Lenses . . . . .	236
Toric Soft Contact Lenses . . . . .	241
Contact Lenses for Presbyopia . . . . .	241
Keratoconus and the Abnormal Cornea . . . . .	243
Scleral Rigid Gas-Permeable Contact Lenses . . . . .	244
Contact Lens Overrefraction . . . . .	245
Therapeutic Use of Contact Lenses . . . . .	245
Orthokeratology and Corneal Reshaping . . . . .	246
Custom Contact Lenses . . . . .	247
Contact Lens Care and Solutions . . . . .	247
Contact Lens–Related Problems and Complications . . . . .	249
Infections . . . . .	249
Hypoxic/Metabolic Problems . . . . .	249
Toxicity . . . . .	251
Mechanical Problems . . . . .	251
Inflammation . . . . .	252
Dry Eye . . . . .	253
Over-the-Counter Contact Lenses . . . . .	253

Federal Law and Contact Lenses . . . . .	253
Chapter Exercises . . . . .	254
Questions . . . . .	254
Answers . . . . .	255
<b>7 Intraocular Lenses . . . . .</b>	<b>257</b>
Highlights . . . . .	257
Glossary . . . . .	257
Introduction . . . . .	258
Optical Considerations for Intraocular Lenses . . . . .	261
Intraocular Lens Power Calculation . . . . .	261
Intraocular Lens Power Calculation After Corneal	
Refractive Surgery . . . . .	269
Instrument Error . . . . .	269
Index of Refraction Error. . . . .	270
Formula Error . . . . .	270
Power Calculation Methods for Eyes After a	
Keratorefractive Procedure. . . . .	270
Special Consideration: Postoperative Refractive Surprise in Patients	
Who Have Undergone Myopic Keratorefractive Correction. . . . .	271
Intraocular Lens Power in Corneal Transplant Eyes . . . . .	271
Silicone Oil Eyes . . . . .	272
Pediatric Eyes . . . . .	272
Image Magnification . . . . .	273
Lens-Related Vision Disturbances. . . . .	273
Nonspherical Optics . . . . .	275
Multifocal Intraocular Lenses. . . . .	275
Types of Multifocal Intraocular Lenses . . . . .	276
Clinical Results of Multifocal Intraocular Lenses. . . . .	278
Modulation Transfer Function . . . . .	279
Intraocular Lens Standards. . . . .	281
Chapter Exercises. . . . .	282
Questions . . . . .	282
Answers . . . . .	283
<b>8 Optical Considerations in Keratorefractive Surgery . . . . .</b>	<b>285</b>
Highlights . . . . .	285
Glossary. . . . .	285
Introduction . . . . .	286
Corneal Shape . . . . .	286
Angle Kappa . . . . .	290
Pupil Size . . . . .	290
Irregular Astigmatism . . . . .	291
Application of Wavefront Analysis in Irregular Astigmatism. . . . .	292
Causes of Irregular Astigmatism. . . . .	295
Conclusion . . . . .	295

Appendix 8-1 . . . . .	296
Derivation of the Munnerlyn Formula . . . . .	296
Chapter Exercises . . . . .	298
Questions . . . . .	298
Answers . . . . .	299

**9 Optical Instruments . . . . . 301**

Highlights . . . . .	301
Glossary . . . . .	301
Introduction . . . . .	303
Refraction and Topography . . . . .	303
Lensmeter . . . . .	303
Autorefractors . . . . .	305
Keratometer . . . . .	307
Corneal Topography . . . . .	308
Wavefront Aberrometers . . . . .	309
Anterior- and Posterior-Segment Imaging . . . . .	312
Slit-Lamp Biomicroscope . . . . .	312
Examination Techniques . . . . .	313
Applanation Tonometry . . . . .	313
Surgical Microscope . . . . .	314
Specular Microscopy . . . . .	315
Auxiliary Lenses for Slit-Lamp Examination of the Retina . . . . .	316
Ophthalmoscopy . . . . .	317
Fundus Camera . . . . .	322
Scanning Laser Ophthalmoscope . . . . .	322
Optical Coherence Tomography . . . . .	324
Adaptive Optics . . . . .	329
Chapter Exercises . . . . .	331
Questions . . . . .	331
Answers . . . . .	332

**10 Vision Rehabilitation . . . . . 335**

Highlights . . . . .	335
Glossary . . . . .	335
Introduction . . . . .	336
Low Vision Evaluation: History . . . . .	338
Patients' Goals . . . . .	338
Ocular History . . . . .	338
General History . . . . .	338
Charles Bonnet Syndrome . . . . .	339
Low Vision Evaluation: Assessment of Visual Function . . . . .	339
Visual Acuity . . . . .	339
Refraction . . . . .	340
Contrast Sensitivity . . . . .	340
Central Visual Field . . . . .	340
Peripheral Visual Field . . . . .	342

Assessment of Other Visual Functions . . . . .	342
Performance of Visual Tasks . . . . .	343
Interventions. . . . .	345
Technology and Electronic Devices . . . . .	346
Optical Devices . . . . .	346
Nonoptical Aids and Alternative Strategies . . . . .	352
Sight Substitution . . . . .	352
Training . . . . .	352
Vision Rehabilitation for Field Loss . . . . .	353
Discussion With Patients . . . . .	353
Other Services . . . . .	354
Pediatric Vision Rehabilitation . . . . .	355
Resources . . . . .	355
Materials for Patients . . . . .	355
Materials for Ophthalmologists . . . . .	355
Chapter Exercises. . . . .	355
Questions . . . . .	355
Answers . . . . .	356
Epilogue. . . . .	357
Additional Materials and Resources . . . . .	358
Requesting Continuing Medical Education Credit. . . . .	359
Study Questions . . . . .	361
Answers. . . . .	369
Index . . . . .	377