Index

actuator influence functions, 303	equivalent stiffness, 108, 109, 112–122
adaptive optical system, 301	
adhesive bonds, 151, 153, 159	f-number, 45
air bags, 182	failure theories, 251
Airy disk, 45	Fick's law, 297, 298
aspheric polynomials, 77	flexures, 118, 162-164, 167, 169,
assembly, 174, 195–198	172–176, 180, 195–197
augment actuators, 307	focus error, 286, 287, 375, 376
automeshing, 107	Fourier's law, 297
Beer's law, 293	frequency domain, 51
bending moment of inertia, 111, 118	Grid Sag surface, 94
biaxial, 267	hockey-puck bond, 154, 157, 158
blur diameter, 44	Hooke's law, 105, 115, 119, 149,
bulk volumetric absorption, 293,	154, 156
294, 371, 372	image contrast, 49
cell shapes, 108, 110	image jitter, 221
cell size, 109	image motion, 333
coating-cure shrinkage, 138, 141,	impulse response, 50
143	incompressible bonds, 147, 198
coating-moisture absorption, 138	index ellipsoid, 266
coatings, 138	index of refraction, 37, 87, 269, 283, 293
coefficient of moisture expansion,	
298	interferogram, 360
coefficient of thermal expansion,	interferogram files, 92, 276, 289,
281, 290	374, 375
correctability, 303-307	isotropic materials, 5, 6
cut-off frequency, 49	kinematic mounting, 164
damping, 201, 245	Legendre–Fourier polynomials, 76
Delaunay triangulation, 94	lightweight mirror, 108
design optimization, 113, 116, 314,	mass density, 109, 112, 115, 117
317, 319, 322 design sensitivity, 327, 332	material coordinate system, 116,
design sensitivity, 327, 332 diffraction, 44, 58, 59, 61	157, 159
	maximum modulus, 149–151, 155, 159
diffraction-limited depth-of-focus, 45, 287	
	membrane thickness, 110, 112, 118
effective properties, 109, 119, 153,	modal analysis, 203
154, 155, 161	mode shapes, 25
elasticity, 4	model checkout, 28
electric field vector, 38, 39, 269	modulation transfer function, 48, 371
encircled energy, 47, 57, 58, 59	3/1

382 INDEX

Mohr's circle, 9	shape optimization, 116
mounts, 114, 147, 162–167, 172,	single-point model, 103
181, 188, 195, 196	sling test supports, 189
multidisciplinary design	solid optics, 104
optimization (MDO), 336	solidity ratio, 110, 118
natural frequencies, 199, 200, 354	spatial domain, 51
neutral plane, 109, 110, 112, 118,	spot diagrams, 46, 99
166, 172	stress analysis, 249
nonlinear programming, 327, 329	stress birefringence, 265, 374
nonstructural mass, 112, 119	stress-optical coefficient, 267–271,
obscuration, 57	276
optical frequency, 38	structural analysis, 21
optical path difference (OPD), 40,	surface deformation, 101, 102, 138,
290	139, 174, 175
optical path length (OPL), 40	surface effects, 137-141
optical transfer function, 51	symmetry, 24, 28
optimization, 327, 329, 332, 333,	tangency, 182-187
335–339, 351	test supports, 181, 182, 189
opto-thermal expansion coefficient,	thermal analysis, 22, 23
285	thermal-glass constant, 285, 286
orthotropic materials, 7	thermal soak, 30
phase transfer function, 53	thermal strain, 280
phase, 38	thermo-optic coefficient, 283, 284,
plane strain, 8	290
plane stress, 6, 7	thermo-optic constant, 288
point spread function (PSF), 46, 371	thermoelastic expansion, 103, 174
polarization, 38, 270, 273, 275, 276	three-dimensional element models,
principal stress, 9	105
pseudo-kinematic mounting, 164	transverse shear factor, 104
quilting, 102, 112, 334	two-dimensional models, 104
radius of curvature (ROC), 85, 97	Twyman effect, 138, 141, 145
random response, 209, 210, 352	uniaxial, 267
rays, 40	unstable mounting, 163
redundant mounting, 164	V-block, 189
resolution, 47	vibrations, 199
rigid-body error, 29, 81	wavefront, 40
rigid-body motion, 101–104, 113, 116, 163, 164	wavefront error, 40, 88, 270, 274, 276, 371, 374–376, 379
ring bonds, 161, 162	wavelength, 38
roller-chain test supports, 189, 190	X-Y polynomials, 74, 77
shape function, 17	Zernike polynomials, 1, 63, 64, 89–
shape function interpolation, 100,	91, 97, 290, 333
296	



Keith Doyle has over 25 years of experience in the field of optomechanical engineering, working on a diverse range of high-performance optical instruments specializing in the multidisciplinary analysis and integrated modeling of optical systems. He is currently a Group Leader in the Engineering Division at MIT Lincoln Laboratory. He previously served in a variety of roles including Vice President of Sigmadyne, Inc., Senior Systems Engineer at Optical Research Associates, and a Structures Engineer at Itek Optical Systems. He received his Ph.D. from the

University of Arizona in Engineering Mechanics with a minor in the Optical Sciences in 1993, and he holds a BS degree from Swarthmore College received in 1988. Dr. Doyle is an active participant in SPIE symposia, teaches short courses on optomechanics and integrated modeling, and has authored and co-authored over 30 technical papers in optomechanical engineering.



Dr. Victor Genberg PE has over 45 years of experience in the application of finite element methods to high-performance optical structures, and is a recognized expert in optomechanics. He is currently President of Sigmadyne, Inc. Prior to starting Sigmadyne, Dr. Genberg worked at Eastman Kodak for 28 years, serving as a technical specialist for commercial and military optical instruments. He is an author of SigFit, a commercially available

software product for optomechanical analysis. Dr. Genberg is also a full professor (adjunct) of Mechanical Engineering at the University of Rochester, where he teaches a variety of courses in finite elements, design, optimization, and optomechanics. He has over 50 publications. He received his Ph.D. from Case Western Reserve University in 1973.



Gregory Michels PE has worked for twenty years in optomechanical design and analysis, and is currently Vice President of Sigmadyne, Inc. He received his MS degree in Mechanical Engineering from the University of Rochester in 1994. He specializes in finite element analysis and design optimization of high-performance optical systems. Mr. Michels is also a software developer and technical support engineer for Sigmadyne's optomechanical analysis

software product, SigFit. Prior to co-founding Sigmadyne, he worked at Eastman Kodak for five years as a structural analyst on the Chandra X-Ray Observatory. Mr. Michels has authored or co-authored over 25 papers in the field of integrated optomechanical analysis and teaches short courses on finite element analysis and integrated modeling.