

Lattice Rotation in Compression	131
Texture Formation in Polycrystals	132
Approximate Calculation of $R$ -Values	133
Notes	134
References	135
Problems	135
<b>9 Dislocation Geometry and Energy .....</b>	<b>139</b>
Introduction	139
Theoretical Strength of Crystals	139
The Nature of Dislocations	141
Burgers Vectors	142
Energy of a Screw Dislocation	144
Reactions between Parallel Dislocations and Frank's Rule	146
Stress Fields around Dislocations	147
Forces on Dislocations	149
Partial Dislocations in fcc Crystals	150
Stacking Faults	151
Notes	154
References	154
Problems	156
<b>10 Dislocation Mechanics .....</b>	<b>158</b>
Introduction	158
Frank-Read Sources	158
Dislocation Pile-Ups	161
Cross-Slip	161
Dislocation Intersections	163
Climb	166
Notes	166
References	167
Problems	167
<b>11 Mechanical Twinning and Martensitic Shear .....</b>	<b>170</b>
Introduction	171
Formal Notation	171
Twinning Shear	172
Twinning in fcc Metals	173
Twinning in bcc Metals	173
Twinning in hcp Metals	175
Shapes of Twins	178
Mechanism of Twinning	179
Martensite Transformation	182
Shape Memory and Superelasticity	183

Notes	184
References	185
Problems	186
<b>12 Hardening Mechanisms in Metals</b> .....	<b>188</b>
Introduction	188
Deformation of Polycrystals	188
Texture Strengthening	190
Crystal Structure	191
Grain Size	193
Strain-Hardening	194
Solid-Solution Strengthening	195
Dispersion Strengthening	196
Yield Points and Strain-Aging	199
Dynamic Strain-Aging	201
Combined Effects	202
Notes	206
References	206
Problems	206
<b>13 Ductility and Fracture</b> .....	<b>210</b>
Introduction	210
Ductile Fracture	212
Brittle Fracture	217
Impact Energy	220
Notes	224
References	224
Problems	225
<b>14 Fracture Mechanics</b> .....	<b>227</b>
Introduction	227
Theoretical Fracture Strength	227
Stress Concentration	229
Griffith Theory	230
Orowan Theory	231
Fracture Modes	231
Irwin's Fracture Analysis	231
Plastic Zone Size	233
Thin Sheets	235
Temperature and Loading Rate	236
Metallurgical Variables	237
Fracture Mechanics in Design	237
Compact Tensile Specimens	239
Strain-Energy Release	240
The <i>J</i> -integral	241

Notes	242
References	243
Problems	243
Appendix I	245
Size and Shape of the Plastic Zone at a Crack Tip	245
<b>15 Viscoelasticity.....</b>	<b>247</b>
Introduction	247
Rheological Models	247
Series Combination of a Spring and Dashpot	248
Parallel Combination of a Spring and Dashpot	249
Combined Parallel-Series Model	250
More Complex Models	251
Damping	251
Natural Decay	253
Elastic Modulus – Relaxed Versus Unrelaxed	254
Thermoelastic Effect	255
Snoek Effect in bcc Metals	256
Other Damping Mechanisms	257
References	258
Notes	258
Problems	259
<b>16 Creep and Stress Rupture.....</b>	<b>262</b>
Introduction	262
Creep Mechanisms	262
Temperature Dependence of Creep	266
Deformation Mechanism Maps	267
Cavitation	268
Rupture Versus Creep	269
Extrapolation Schemes	270
Alloys for High-Temperature Use	273
Notes	275
References	275
Problems	276
<b>17 Fatigue.....</b>	<b>279</b>
Introduction	279
Surface Observations	279
Nomenclature	281
S-N Curves	282

Effect of Mean Stress	283
The Palmgren–Miner Rule	285
Stress Concentration	286
Surfaces	288
Design Estimates	290
Metallurgical Variables	291
Strains to Failure	291
Crack Propagation	294
Cyclic Stress–Strain Behavior	296
Temperature and Cycling Rate	
Effects	297
Fatigue of Polymers	300
Fatigue Testing	302
Design Considerations	302
Summary	303
Notes	303
References	304
Problems	304
<b>18 Residual Stresses</b> .....	<b>308</b>
Introduction	308
Small-Scale Stresses	308
Bauschinger Effect	311
Nonuniform Cooling	312
Nonuniform Material	313
Stresses from Welding	313
Stresses from Mechanical Working	314
Consequences of Residual Stresses	316
Measurement of Residual Stresses	317
Relief of Residual Stresses	319
Notes	321
References	321
Problems	321
<b>19 Ceramics and Glasses</b> .....	<b>324</b>
Introduction	324
Elastic Properties	324
Slip Systems	325
Hardness	326
Weibull Analysis	326
Testing	329
Porosity	329
High-Temperature Behavior	331
Fracture Toughness	331
Toughening of Ceramics	334

Fatigue	335
Silicate Glasses	335
Strength of Glasses	338
Thermally Induced Stresses	339
Delayed Fracture	340
Glassy Metals	341
Notes	342
References	343
Problems	343
<b>20 Polymers .....</b>	<b>345</b>
Introduction	345
Elastic Behavior	345
Rubber Elasticity	350
Damping	353
Yielding	353
Effect of Strain Rate	356
Effect of Pressure	356
Crazing	361
Yielding of Fibers in Compression	363
Fracture	364
Deformation Mechanism Maps	366
Shape-Memory Effect	367
References	368
Notes	368
Problems	370
<b>21 Composites .....</b>	<b>372</b>
Introduction	372
Fiber-Reinforced Composites	372
Elastic Properties of Fiber-Reinforced Composites	372
Strength of Fiber-Reinforced Composites	376
Volume Fraction of Fibers	377
Orientation Dependence of Strength	378
Fiber Length	379
Failures with Discontinuous Fibers	381
Failure under Compression	382
Typical Properties	383
Particulate Composites	384
Brick-Wall Model	385
Lamellar Composites	387
Notes	388
References	389
Problems	389

<b>22 Mechanical Working</b> .....	<b>392</b>
Introduction	392
Bulk-Forming Energy Balance	392
Deformation Zone Geometry	396
Friction in Bulk Forming	399
Formability	400
Deep Drawing	401
Stamping	403
Notes	407
References	409
Problems	409
<i>Appendix A</i> .....	413
<i>Appendix B</i> .....	418
<i>Index</i> .....	421