

The structure of materials	p. 1
Atomic structure and the chemical bond	p. 1
Metals	p. 5
Metallic bond	p. 5
Crystal structures	p. 7
Polycrystalline metals	p. 14
Ceramics	p. 15
Covalents bond	p. 16
Ionic bond	p. 18
Dipole bond	p. 19
Van der Waals bond	p. 19
Hydrogen bond	p. 20
The crystal structure of ceramics	p. 21
Amorphous ceramics	p. 22
Polymers	p. 23
The chemical structure of polymers	p. 24
The structure of polymers	p. 25
Elasticity	p. 31
Deformation modes	p. 31
Stress and strain	p. 32
Stress	p. 32
Strain	p. 34
Atomic interactions	p. 37
Hooke's law	p. 39
Elastic strain energy	p. 42
Elastic deformation under multiaxial loads	p. 43
Isotropic material	p. 46
Cubic lattice	p. 50
Orthorhombic crystals and orthotropic elasticity	p. 53
Transversally isotropic elasticity	p. 54
Other crystal lattices	p. 55
Examples	p. 55
Isotropy and anisotropy of macroscopic components	p. 57
Temperature dependence of Young's modulus	p. 60
Plasticity and failure	p. 63
Nominal and true strain	p. 64
Stress-strain diagrams	p. 68
Types of stress-strain diagrams	p. 68
Analysis of a stress-strain diagram	p. 73
Approximation of the stress-strain curve	p. 81
Plasticity theory	p. 83

Yield criteria	p. 84
Yield criteria of metals	p. 86
Yield criteria of polymers	p. 92
Flow rules	p. 93
Hardening	p. 97
Application of a yield criterion, flow rule, and hardening rule	p. 103
Hardness	p. 107
Scratch tests	p. 108
Indentation tests	p. 108
Rebound tests	p. 110
Material failure	p. 110
Shear fracture	p. 111
Cleavage fracture	p. 114
Fracture criteria	p. 116
Notches	p. 119
Stress concentration factor	p. 119
Neuber's rule	p. 122
Tensile testing of notched specimens	p. 125
Fracture mechanics	p. 129
Introduction to fracture mechanics	p. 129
Definitions	p. 129
Linear-elastic fracture mechanics	p. 131
The stress field near a crack tip	p. 131
The energy balance of crack propagation	p. 134
Dimensioning pre-cracked components under static loads	p. 142
Fracture parameters of different materials	p. 144
Material behaviour during crack propagation	p. 146
Subcritical crack propagation	p. 150
Measuring fracture parameters	p. 152
Elastic-plastic fracture mechanics	p. 158
Crack tip opening displacement (CTOD)	p. 158
J integral	p. 159
Material behaviour during crack propagation	p. 161
Measuring elastic-plastic fracture mechanics parameters	p. 163
Mechanical behaviour of metals	p. 165
Theoretical strength	p. 165
Dislocations	p. 166
Types of dislocations	p. 166
The stress field of a dislocation	p. 168
Dislocation movement	p. 170
Slip systems	p. 173

The critical resolved shear stress	p. 178
Taylor factor	p. 182
Dislocation interaction	p. 184
Generation, multiplication and annihilation of dislocations	p. 185
Forces acting on dislocations	p. 187
Overcoming obstacles	p. 189
Athermal processes	p. 190
Thermally activated processes	p. 193
Ductile-brittle transition	p. 196
Climb	p. 196
Intersection of dislocations	p. 197
Strengthening mechanisms	p. 198
Work hardening	p. 198
Grain boundary strengthening	p. 200
Solid solution hardening	p. 203
Particle strengthening	p. 209
Hardening of steels	p. 218
Mechanical twinning	p. 223
Mechanical behaviour of ceramics	p. 227
Manufacturing ceramics	p. 228
Mechanisms of crack propagation	p. 229
Crack deflection	p. 230
Crack bridging	p. 230
Microcrack formation and crack branching	p. 231
Stress-induced phase transformations	p. 232
Stable crack growth	p. 234
Subcritical crack growth in ceramics	p. 234
Statistical fracture mechanics	p. 236
Weibull statistics	p. 236
Weibull statistics for subcritical crack growth	p. 242
Measuring the parameters [σ_0] and m	p. 243
Proof test	p. 246
Strengthening ceramics	p. 248
Reducing defect size	p. 249
Crack deflection	p. 249
Microcracks	p. 251
Transformation toughening	p. 252
Adding ductile particles	p. 255
Mechanical behaviour of polymers	p. 257
Physical properties of polymers	p. 257
Relaxation processes	p. 257

Glass transition temperature	p. 260
Melting temperature	p. 261
Time-dependent deformation of polymers	p. 263
Phenomenological description of time-dependence	p. 263
Time-dependence and thermal activation	p. 266
Elastic properties of polymers	p. 269
Elastic properties of thermoplastics	p. 269
Elastic properties of elastomers and duromers	p. 273
Plastic behaviour	p. 274
Amorphous thermoplastics	p. 275
Semi-crystalline thermoplastics	p. 281
Increasing the thermal stability	p. 284
Increasing the glass and the melting temperature	p. 284
Increasing the crystallinity	p. 287
Increasing strength and stiffness	p. 289
Increasing the ductility	p. 290
Environmental effects	p. 292
Mechanical behaviour of fibre reinforced composites	p. 295
Strengthening methods	p. 296
Classifying by particle geometry	p. 296
Classifying by matrix systems	p. 299
Elasticity of fibre composites	p. 300
Loading in parallel to the fibres	p. 301
Loading perpendicular to the fibres	p. 301
The anisotropy in general	p. 302
Plasticity and fracture of composites	p. 303
Tensile loading with continuous fibres	p. 303
Load transfer between matrix and fibre	p. 305
Crack propagation in fibre composites	p. 308
Statistics of composite failure	p. 312
Failure under compressive loads	p. 313
Matrix-dominated failure and arbitrary loads	p. 315
Examples of composites	p. 315
Polymer matrix composites	p. 315
Metal matrix composites	p. 321
Ceramic matrix composites	p. 323
Biological composites	p. 325
Fatigue	p. 333
Types of loads	p. 333
Fatigue failure of metals	p. 337
Crack initiation	p. 338

Crack propagation (stage II)	p. 342
Final fracture	p. 344
Fatigue of ceramics	p. 345
Fatigue of polymers	p. 346
Thermal fatigue	p. 346
Mechanical fatigue	p. 347
Fatigue of fibre composites	p. 347
Phenomenological description of the fatigue strength	p. 349
Fatigue crack growth	p. 349
Stress-cycle diagrams (S-N diagrams)	p. 357
The role of mean stress	p. 366
Fatigue assessment with variable amplitude loading	p. 368
Cyclic stress-strain behaviour	p. 369
Kitagawa diagram	p. 373
Fatigue of notched specimens	p. 375
Creep	p. 383
Phenomenology of creep	p. 383
Creep mechanisms	p. 388
Stages of creep	p. 388
Dislocation creep	p. 389
Diffusion creep	p. 393
Grain boundary sliding	p. 396
Deformation mechanism maps	p. 396
Creep fracture	p. 400
Increasing the creep resistance	p. 401
Exercises	p. 407
Packing density of crystals	p. 407
Macromolecules	p. 407
Interaction between two atoms	p. 407
Bulk modulus	p. 408
Relation between the elastic constants	p. 408
Candy catapult	p. 409
True strain	p. 410
Interest calculation	p. 410
Large deformations	p. 410
Yield criteria	p. 410
Yield criteria of polymers	p. 411
Design of a notched shaft	p. 411
Estimating the fracture toughness K_{Ic}	p. 412
Determination of the fracture toughness K_{Ic}	p. 412
Static design of a tube	p. 413

Theoretical strength	p. 414
Estimating the dislocation density	p. 414
Thermally activated dislocation generation	p. 414
Work hardening	p. 415
Grain boundary strengthening	p. 415
Precipitation hardening	p. 415
Weibull statistics	p. 415
Design of a fluid tank	p. 416
Subcritical crack growth of a ceramic component	p. 417
Mechanical models of viscoelastic polymers	p. 417
Elastic damping	p. 418
Eyring plot	p. 418
Elasticity of fibre composites	p. 419
Properties of a polymer matrix composite	p. 419
Estimating the number of cycles to failure	p. 419
Miner's rule	p. 420
Larson-Miller parameter	p. 421
Creep deformation	p. 421
Relaxation of thermal stresses by creep	p. 421
Solution	p. 423
Using tensors	p. 451
Introduction	p. 451
The order of a tensor	p. 451
Tensor notations	p. 452
Tensor operations and Einstein summation convention	p. 453
Coordinate transformations	p. 456
Important constants and tensor operations	p. 457
Invariants	p. 458
Derivations of tensor fields	p. 459
Miller and Miller-Bravais indices	p. 461
Miller indices	p. 461
Miller-Bravais indices	p. 462
A crash course in thermodynamics	p. 465
Thermal activation	p. 465
Free energy and free enthalpy	p. 466
Phase transformations and phase diagrams	p. 468
The J integral	p. 473
Discontinuities, singularities, and Gauss' theorem	p. 473
Energy-momentum tensor	p. 475
J integral	p. 476
J integral at a crack tip	p. 479

Plasticity at the crack tip	p. 481
Energy interpretation of the J integral	p. 482
References	p. 485
List of symbols	p. 493
Index	p. 499

Table of Contents provided by Blackwell's Book Services and R.R. Bowker. Used with permission.