Index

ablation, 54
adiabatic deformation, 150
Almansi’s strain tensor, 77, 147
alternating tensor, 26, 28
axial vector. See pseudo vector
azimuth angle, 255
azimuthal shear, 197

base vectors, 250
basic invariants, 21
basis vectors, 12
Biot strain tensor, 78
Blatz P.J., 169
body force per unit mass, 86
bound vector, 9
Boyle’s law, 124
bulk modulus, 160, 209, 210
bulk viscosity, 125, 126, 221, 222, 239

canonical form, 23
Cartesian tensor analysis, 4
Cauchy elasticity, 153
Cauchy stress tensor. See stress tensors
Cauchy-Green tensors, 144
Cayley-Hamilton Theorem, 24, 158, 159
Chadwick P., 209
constant entropy, 202
coefficient of volume thermal expansion, 124, 213
cofactor, 29, 161
cylindrical bar, 165
decomposition, 205
decomposition of internal energy produced by deformation, 205
decomposition of the second law, 123, 208
Cauchy-Duhem inequality, 118, 207
Cauchy-Planck inequality, 120
correspondence principle, 203
correspondence relation, 203
creep function, 227, 247
current configuration, 90, 112
cylindrical bar, 165
cylindrical polar coordinates, 175, 253, 259, 264
cylindrical polar form, 257
cylindrical symmetry, 165
d'Alembert's Principle, 114
deformation fields, 168
deformation gradient tensor, 58, 59, 70, 74, 108, 152
dilatational part, 74
isochoric part, 74
density, 86
reference configuration, 99
spatial configuration, 63, 99
determinant, 20, 28, 31, 58
determinism, 138
dilatation, 58, 210, 222
Dirac delta function, 229
displacement gradient tensor, 78
displacement vector, 76
dissipation inequality, 118
dissipation potential, 223
divergence, 42
divergence of a vector, 39
divergence operation, 100
divergence theorem, 44, 45, 100, 106, 112, 118
dyadic product, 11, 16
eigenvalues, 23, 24, 34, 35, 36, 91, 163
eigenvectors, 22, 23, 24, 34, 35, 36, 91 163
energetic, 205, 218
energetic response, 202
energy equation, 115, 122
enthalpy, 136
entropic, 205, 218
entropic response, 202
entropic thermoelasticity, 215
entropy, 118, 213
entropy inequality, 207
entropy inequality for a thermoelastic solid, 207
entropy jump across a shock, 208
entropy production, 208, 222
equation of equilibrium, 111
equation of motion, 106
equilibrium thermodynamics, 114
Ericsen J.L., 168
Eringen C., 138
Euclidean linear vector space, 271
Euclidean point space, 1
Euclidean transformation, 140
Euler's Equation, 60
Eulerian coordinates. See spatial coordinates
Eulerian strain tensor. See Almansi's strain tensor
Eulerian tensors, 90
eversion of a cylindrical tube, 185
experimental results, 212
finite axial strain, 214
finite deformation elastostatics for isotropic hyperelastic solids, 168
first law of thermodynamics, 115
first order tensor fields. See vector field
Flügge W., 224
foam rubbers, 160
Fourier's law, 115, 123
fourth order tensor, 26
frame of reference, 139
free suffix, 6
fundamental equation of state, 136, 203
Galilean frame of reference, 141
Galilean transformations, 143
generalized functions, 229
Gibbs free energy, 137
Gibbs relation, 132, 135, 204
Goodier, 127
gradient operator, 263
gravitational potential energy, 115
Green A.E., 180
Green deformation tensor, 156
Green elastic, 155
Green strain rate tensor, 156
Green's strain tensor, 75, 77, 78, 156
Hadamard strain energy function, 169
Haupt P., 114
heat conduction, 220
heat conduction tensor, 115, 123
heat flux vector, 115, 123, 138
Helmholtz free energy, 119, 131, 155, 202
hereditary integral, 233
Hill R., 104
Holzapfel G.A., 215
homogeneous deformation, 168
Hooke’s law, 127
  generalized, 127
Hunter S.C., 240
hydrostatic state of stress, 92, 95
hyperelastic solid, 155, 156, 160, 162
hyperelastic stress-deformation relations, 170
hyperelasticity, 157
hysteresis effects, 208, 220
  ideal inviscid fluid, 123
  ideal rubber, 212
  impact modulus, 227, 232
  improper orthogonal tensor, 32
  incompressibility, 58, 160
  incompressible fluid, 122
  incompressible Hyperelastic solid, 160
  incompressible isotropic models, 210
  incompressible materials, 160
  incompressible solid, 210
  inertia tensor of the element, 69
  inertial frame of reference, 143
  infinitesimal rotation, 80
  infinitesimal rotation tensor, 80
  infinitesimal strain tensor, 78, 80, 160
  inner product, 5, 17
  internal energy, 124, 131, 155, 202, 212
  internal variable, 231, 238
  invariants, 158, 223
  inverse, 30, 59
  inverse methods, 168
  inversion effect, 218
  inviscid fluids, 220
  isentropic deformation, 155
  isentropic process, 120
  isentropic simple tension, 213, 214, 216, 217
  isentropic strain energy, 202
  isochoric deformation, 160, 210
  isochoric flow, 124, 125
  isochoric motions, 58
  isothermal, 150
  isothermal deformation, 155, 213
  isothermal moduli, 131
  isothermal shear, 210
  isothermal simple tension, 212, 213
  isothermal strain energy, 202
  isotropic elastic solid, 157
  isotropic state of stress. See hydrostatic state of stress
isotropic tensor, 24, 28
isotropy, 153, 154, 160
  Jacobian of the transformation, 58
  Jaumann rate, 145
  Joule heating, 116
Kelvin-Voigt element, 246
Kelvin-Voigt viscoelastic solid, 225, 228, 239
Kestin J., 202
Killing’s theorem, 67
kinematically admissible virtual displacement field, 110
kinetic energy, 106, 155
Ko W.L., 169
Kronecker delta, 6, 17, 91
Lagrangian configuration. See reference configuration
Lagrangian multiplier, 93, 126, 160, 162, 180, 222
Lagrangian strain, 76
Lagrangian strain rate, 109
Lagrangian strain tensor, 204
Lamé’s constants, 129
Laplace expansion, 28
Laplace transform, 236, 246
Laplacian operator, 261
laws of thermodynamics, 121
left Cauchy strain tensor, 75
left Cauchy-Green strain tensor, 172
left polar decompositions, 36
left stretch tensor, 72, 165
Legendre transformation, 131, 132, 135, 137, 203
Leibniz’s rule, 62
Lighthill M.J., 230
linear theory of elasticity, 150
linear thermoelasticity, 130
linear vector spaces, 269
linear viscoelastic medium, 224
linearly independent system, 270
local action, 138
logarithmic strain tensors, 78
Love A.E.H., 127
Malvern L.E., 111
mass point, 50
Index

material configuration. See reference configuration 275
material description, 50, 53, 77
material frame indifference, 138
material lines, 59
material objectivity, 167
material surface, 54, 59
material symmetry, 153
material volume, 59, 63
Mathematica, 24, 35, 37
matrix, 2
matrix multiplication, 1
Maxwell fluid, 225
mechanical compressibility, 210
mechanical dissipation, 243
mechanically incompressible fluid, 160
mechanically incompressible solid, 160
metric tensor, 252
modified deformation gradient tensor, 74
modified entropic elasticity, 218
Mooney-Rivlin material, 179
Mooney-Rivlin solid, 197
Mooney-Rivlin strain energy function, 166, 178
Müller I., 124
mutually orthogonal, 21, 22
natural reference configuration, 50
Navier-Stokes equation, 126
negative definite, 34
negative definite tensors, 36
neohookean elastic solid, 167
neo-Hookean solid, 188
neo-Hookean strain energy function, 169
Newton’s second law, 86
Newtonian viscous fluid, 125, 220, 239
nominal stress, 98, 112, 162
nominal stress tensor, 98
non-ideal rubbers, 209
non-newtonian viscous fluid, 223
non-singular second order tensor, 35
normal component, 85
normal stress, 89, 93
normalized eigenvectors, 21
numerical results, 217

objectivity, 151
oblique Cartesian coordinate system, 4
observer, 139, 140
octahedral plane, 96

octahedral shearing stress, 96
Ogden R.W., 102, 104, 174, 175, 189
Oldroyd J.G., 146
orthogonal curvilinear coordinate systems, 249, 258
orthogonal tensor, 32, 33, 36, 71
orthogonal transformations, 9, 15
orthogonality, 252
orthonormal, 6
parallelogram rule, 5
particle, 50
particle path, 52
partly energetic, 209
Pearson C.E., 95
perfectly elastic solid, 119
physical components, 253, 256
piezotropic model, 208
plane deformation, 171
Poisson’s ratio, 169
polar decomposition theorem, 35, 70
polar media, 85
polar vector, 1, 10
polymers, 209
positive definite second order tensor, 21, 32, 33, 34, 35, 36
positive semidefinite, 33, 34
potential energy, 116
Poynting effect, 172, 179
principal axes, 34, 67
principal components, 164
principal directions, 91
principal invariants, 163, 173
principal stretches, 91, 92, 93
principal stresses, 71, 72, 163, 210
modified stretches, 74
principle of local state, 114, 202, 243
principle of virtual work, 164
proper orthogonal tensor, 32, 71, 152, 154
pseudo scalar, 10
pseudo vector, 10
pure bending of an hyperelastic plate, 189
pure dilatation, 125, 130
pure hydrostatic stress, 95
pure shear stress, 94, 95
radiation, 116
rate of change of momentum of the body, 86
rate of deformation, 107, 113
rate of deformation tensor, 65, 67, 77, 159
rate of entropy production per unit mass, 208
rate of heat supply, 115, 123
rectangular Cartesian coordinate system, 1, 2, 3, 6
reference configuration, 50, 108, 112, 117
referential description, 50, 53
referential heat flux, 207
Reiner-Rivlin fluid, 223
relation between the velocity gradient and the deformation gradient tensor, 65
relative description, 51
relaxation function, 226, 232, 246
relaxation modulus, 224, 227, 246
relaxation time, 226, 237, 246
resultant moment acting on a body, 86
right Cauchy Green deformation tensor, 75, 152, 157, 204
right polar decompositions, 36
right stretch tensor, 72, 165
rigid body, 122
rigid body mechanics, 122
rigid body motion, 122
rigid motion, 121
Rivlin R.S., 189
rotation, 151
rate of deformation, 107, 113
rubber-like materials, 160
rubber-like solids, 210
scalar, 1, 2, 17
scalar differential operator, 40
scalar field, 38
scalar function, 223
scalar invariants, 9, 21
scalar product, 5, 32
Schlichting H., 222
second law of thermodynamics, 117, 124
second order tensor field, 38
shear and bulk relaxation functions, 234
shear deformation, 222
shear modulus, 160, 209
shear modulus for infinitesimal deformation, 169
shear viscosity, 221
shearing stress, 89
shearing stress on the element, 87
shock wave propagation, 220
shock waves, 208
simple materials, 138
simple shear, 125, 165, 171
simple shear deformation, 170
simple tension, 172, 212
simple tension of the neo-Hookean solid, 174
Sokolnikov I.S., 127, 128
spatial configuration, 51, 84, 90, 111, 113, 118, 154
spatial description, 51, 53
spatial form of continuity equation, 63
spatial heat flux, 207
specific enthalpy, 203
specific Gibbs free energy, 203
specific heat, 122, 133
specific heat at constant deformation, 209
specific Helmholtz free energy, 203
specific internal energy, 115, 203
specific strain energy, 156
spectral decomposition, 163
spectral form, 24, 34
spherical polar coordinates, 180, 254, 259, 264, 265
spherical polar form, 257
spherical symmetry, 165
spin tensor, 65, 70, 107, 148
spring-dashpot models, 224
square matrices, 13
square root of a second order tensor, 35, 36
simple shear, 125, 165, 171
spin tensor, 65, 70, 107, 148
standard material, 247
standard model, 230, 239
statically admissible stress, 112
statically admissible stress field, 110, 113
stationary values, 93
statistical theory of rubber elasticity, 212
steady flow, 52, 54
stiffness tensor, 127
Stokes’ hypothesis, 126, 222
Stokes’ theorem, 44
Stokesian fluid, 223
stored energy, 155
<table>
<thead>
<tr>
<th>Term</th>
<th>Page(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>stored energy function</td>
<td>155</td>
</tr>
<tr>
<td>strain energy</td>
<td>239</td>
</tr>
<tr>
<td>strain energy function</td>
<td>156, 157, 159</td>
</tr>
<tr>
<td>strain energy rate</td>
<td>159</td>
</tr>
<tr>
<td>strain rate tensor</td>
<td>78, 80</td>
</tr>
<tr>
<td>stream line</td>
<td>52</td>
</tr>
<tr>
<td>stress boundary conditions</td>
<td>162</td>
</tr>
<tr>
<td>stress discontinuities</td>
<td>110</td>
</tr>
<tr>
<td>stress power</td>
<td>155, 159, 221</td>
</tr>
<tr>
<td>stress relaxation</td>
<td>224</td>
</tr>
<tr>
<td>stress tensor</td>
<td></td>
</tr>
<tr>
<td>Biot</td>
<td>101, 164, 214</td>
</tr>
<tr>
<td>Cauchy</td>
<td>2, 90, 91, 106, 150, 153, 158, 160, 164</td>
</tr>
<tr>
<td>deviatoric part</td>
<td>95</td>
</tr>
<tr>
<td>isotropic part</td>
<td>95</td>
</tr>
<tr>
<td>first Piola-Kirchhoff</td>
<td>107</td>
</tr>
<tr>
<td>nominal</td>
<td>107, 212</td>
</tr>
<tr>
<td>second Piola-Kirchhoff</td>
<td>100, 107, 153, 156, 158, 203</td>
</tr>
<tr>
<td>stress vector</td>
<td>2, 84, 85</td>
</tr>
<tr>
<td>strictly entropic elasticity</td>
<td>209, 212, 213, 215</td>
</tr>
<tr>
<td>substitution property</td>
<td>17, 91</td>
</tr>
<tr>
<td>suffix notation</td>
<td>4, 18</td>
</tr>
<tr>
<td>summation convention</td>
<td>35</td>
</tr>
<tr>
<td>superposition principle</td>
<td>227</td>
</tr>
<tr>
<td>surface traction</td>
<td>85</td>
</tr>
<tr>
<td>symbolic form</td>
<td>12</td>
</tr>
<tr>
<td>symbolic notation</td>
<td>4, 17</td>
</tr>
<tr>
<td>symmetric part of the displacement</td>
<td></td>
</tr>
<tr>
<td>gradient tensor</td>
<td>80</td>
</tr>
<tr>
<td>symmetric second order tensor</td>
<td>34</td>
</tr>
<tr>
<td>symmetry group</td>
<td>154</td>
</tr>
<tr>
<td>symmetry transformation</td>
<td>154</td>
</tr>
<tr>
<td>Tanner R.I.</td>
<td>220</td>
</tr>
<tr>
<td>telescopic shear of the neo-Hookean</td>
<td>200</td>
</tr>
<tr>
<td>solid</td>
<td></td>
</tr>
<tr>
<td>temperature</td>
<td>121</td>
</tr>
<tr>
<td>tensor</td>
<td>2</td>
</tr>
<tr>
<td>first order. See vector</td>
<td></td>
</tr>
<tr>
<td>fourth order</td>
<td>25</td>
</tr>
<tr>
<td>higher order</td>
<td>2</td>
</tr>
<tr>
<td>second order</td>
<td>1, 12, 13, 34, 42</td>
</tr>
<tr>
<td>antisymmetric part</td>
<td>14</td>
</tr>
<tr>
<td>deviatoric part</td>
<td>18</td>
</tr>
<tr>
<td>isotropic part</td>
<td>18</td>
</tr>
<tr>
<td>symmetric part</td>
<td>13, 14, 22, 33, 34, 91</td>
</tr>
<tr>
<td>third order</td>
<td>25</td>
</tr>
<tr>
<td>tensor addition</td>
<td>19</td>
</tr>
<tr>
<td>tensor character</td>
<td>19</td>
</tr>
<tr>
<td>tensor contraction</td>
<td>19</td>
</tr>
<tr>
<td>tensor field</td>
<td>38</td>
</tr>
<tr>
<td>tensor multiplication</td>
<td>18, 19</td>
</tr>
<tr>
<td>tensor product</td>
<td>11, 25</td>
</tr>
<tr>
<td>tensor transformation rule</td>
<td>18</td>
</tr>
<tr>
<td>thermal equation of state</td>
<td>122</td>
</tr>
<tr>
<td>thermal strain</td>
<td>130</td>
</tr>
<tr>
<td>thermal wave speed</td>
<td>115</td>
</tr>
<tr>
<td>thermodynamic potentials</td>
<td>202</td>
</tr>
<tr>
<td>thermodynamic pressure</td>
<td>125, 221, 222</td>
</tr>
<tr>
<td>thermodynamic properties</td>
<td>131</td>
</tr>
<tr>
<td>thermodynamics of irreversible</td>
<td></td>
</tr>
<tr>
<td>processes</td>
<td>114</td>
</tr>
<tr>
<td>thermoelastic inversion effect</td>
<td>215</td>
</tr>
<tr>
<td>thermoelastic potentials</td>
<td>131</td>
</tr>
<tr>
<td>third invariant</td>
<td>29</td>
</tr>
<tr>
<td>third order isotropic tensor</td>
<td>26</td>
</tr>
<tr>
<td>Thurston R.N.</td>
<td>240</td>
</tr>
<tr>
<td>Timoshenko S.,</td>
<td>127</td>
</tr>
<tr>
<td>trace</td>
<td>17</td>
</tr>
<tr>
<td>transformation matrix</td>
<td>7, 15</td>
</tr>
<tr>
<td>transformation rules for base vectors</td>
<td>8</td>
</tr>
<tr>
<td>transport equation</td>
<td>63</td>
</tr>
<tr>
<td>transport properties</td>
<td>126</td>
</tr>
<tr>
<td>transpose</td>
<td>13</td>
</tr>
<tr>
<td>Treves yield condition</td>
<td>94, 98</td>
</tr>
<tr>
<td>triple scalar product</td>
<td>28</td>
</tr>
<tr>
<td>true scalar</td>
<td>10</td>
</tr>
<tr>
<td>Truesdell C.A.</td>
<td>168</td>
</tr>
<tr>
<td>unit base vectors</td>
<td>7</td>
</tr>
<tr>
<td>unit step function</td>
<td>226, 229</td>
</tr>
<tr>
<td>valanis-Landel hypothesis</td>
<td>165</td>
</tr>
<tr>
<td>vector</td>
<td>1, 3, 9, 12</td>
</tr>
<tr>
<td>vector field</td>
<td>38, 41</td>
</tr>
<tr>
<td>vector gradient</td>
<td>39, 41</td>
</tr>
<tr>
<td>vector magnitude</td>
<td>9</td>
</tr>
<tr>
<td>velocity</td>
<td>2, 54</td>
</tr>
<tr>
<td>velocity gradient tensor</td>
<td>64</td>
</tr>
<tr>
<td>virtual displacements</td>
<td>110</td>
</tr>
<tr>
<td>virtual work</td>
<td>110</td>
</tr>
<tr>
<td>viscoelastic</td>
<td>237</td>
</tr>
<tr>
<td>viscosity coefficient</td>
<td>125, 238</td>
</tr>
<tr>
<td>viscous fluid</td>
<td>124</td>
</tr>
<tr>
<td>Voigt matrix</td>
<td>130</td>
</tr>
</tbody>
</table>
volume coefficient of thermal expansion, 160, 209, 210, 215, 216, 240
volume thermal expansion, 160
von Mises yield criterion, 97
vorticity vector, 67

White F.M., 126
Whitham, 220
Zerna W., 168, 180
zeroth order tensor field. See scalar field