

Contents

1. Kinematics	1
1.1 Configuration and Deformation	1
1.1.1 Change of Reference Configuration	4
1.2 Strain and Rotation	4
1.3 Linear Strain Tensors	8
1.4 Motion	13
1.4.1 Material and Spatial Descriptions	14
1.5 Relative Deformation	17
1.6 Rate of Deformation	20
1.7 Change of Frame and Objective Tensors	22
1.7.1 Transformation Property of Motion	25
1.7.2 Property of Some Kinematic Quantities	26
2. Balance Laws	31
2.1 General Balance Equation	31
2.1.1 Field Equation and Jump Condition	35
2.1.2 Balance Equations in Material Coordinates	36
2.2 Conservation of Mass	38
2.3 Laws of Dynamics	41
2.3.1 Forces and Moments	42
2.3.2 Stress Tensor	43
2.3.3 Conservation of Linear and Angular Momenta	50
2.4 Conservation of Energy	51
2.5 Summary of Basic Equations	54
2.5.1 Basic Equations in Material Coordinates	56
2.5.2 Boundary Conditions of a Material Body	57
2.6 Field Equations in Arbitrary Frames	58
3. Basic Principles of Constitutive Theories	63
3.1 Constitutive Relation	63
3.2 Principle of Material Objectivity	65
3.2.1 In Referential Description	68
3.2.2 An Example: a Particular Class of Materials	70
3.3 Simple Material Bodies	72

3.4	Reduced Constitutive Relations	75
3.5	Material Symmetry	77
3.5.1	Constitutive Equation for a Simple Solid Body	81
3.5.2	Constitutive Equation for a Simple Fluid	82
3.5.3	Fluid Crystal with an Intrinsic Direction	84
3.6	Isotropic Materials	86
3.6.1	Constitutive Equation of an Isotropic Material	88
3.7	Fading Memory	89
3.7.1	Linear Viscoelasticity	90
3.7.2	Boltzmann–Volterra Theory of Viscoelasticity	92
3.7.3	Linear Viscoelasticity of Rate Type	93
3.7.4	Remark on Objectivity of Linear Elasticity	94
4.	Representation of Constitutive Functions	97
4.1	Materials of Grade n	97
4.2	Isotropic Functions	98
4.2.1	Isotropic Elastic Materials and Linear Elasticity	107
4.2.2	Reiner–Rivlin Fluids and Navier–Stokes Fluids	109
4.2.3	Elastic Fluids	111
4.3	Representation of Isotropic Functions	112
4.3.1	Isotropic Thermoelastic Solids and Viscous Heat-Conducting Fluids	118
4.4	Hemitropic Invariants	119
4.5	Anisotropic Invariants	122
4.5.1	Transverse Isotropy and Orthotropy	124
4.5.2	On Irreducibility of Invariant Sets	126
5.	Entropy Principle	129
5.1	Entropy Inequality	129
5.2	Entropy Principle	131
5.3	Thermodynamics of Elastic Materials	132
5.3.1	Linear Thermoelasticity	135
5.4	Elastic Materials with Internal Constraints	139
5.5	Stability of Equilibrium	144
5.5.1	Thermodynamic Stability Criteria	148
5.6	Phase Equilibrium	149
6.	Isotropic Elastic Solids	153
6.1	Constitutive Equations	153
6.2	Boundary Value Problems in Elasticity	155
6.3	Homogeneous Stretch	157
6.3.1	Uniaxial Stretch	158
6.3.2	Biaxial Stretch	159
6.4	Symmetric Loading of a Square Sheet	160
6.4.1	Stability of a Square Sheet	162

6.5	Simple Shear	166
6.6	Pure Shear of a Square Block	169
6.7	Finite Deformation of Spherical Shells	173
6.7.1	Eversion of a Spherical Shell	175
6.7.2	Inflation of a Spherical Shell	176
6.8	Stability of Spherical Shells	179
6.8.1	Stability under Constant Pressures	180
6.8.2	Stability for an Enclosed Spherical Shell	181
7.	Thermodynamics with Lagrange Multipliers	183
7.1	Supply-Free Bodies	183
7.2	Viscous Heat-Conducting Fluid	184
7.2.1	General Results	186
7.2.2	Navier–Stokes–Fourier Fluids	188
7.3	Method of Lagrange Multipliers	189
7.3.1	An Algebraic Problem	190
7.3.2	Local Solvability	191
7.4	Relation Between Entropy Flux and Heat Flux	194
7.4.1	Theorem of Parallel Isotropic Vector Functions	194
8.	Rational Extended Thermodynamics	199
8.1	Introduction	199
8.2	Formal Structure of System of Balance Equations	200
8.2.1	Symmetric Hyperbolic System	201
8.2.2	Galilean Invariance	204
8.3	System of Moment Equations	207
8.4	Closure Problem	213
8.4.1	Entropy Principle	214
8.4.2	Formal Procedures	216
8.5	Thirteen-Moment Theory of Viscous Heat-Conducting Fluid	217
8.5.1	Field Equations	223
8.5.2	Entropy and Entropy Flux	225
8.6	Monatomic Ideal Gases	226
8.6.1	Thirteen-Moment Theory	227
8.6.2	Constitutive Equations	228
8.7	Stationary Heat Conduction in Ideal Gases	228
8.7.1	Fourier’s Law and Heat Conduction	229
8.7.2	Heat Conduction in Thirteen-Moment Theory	229
8.7.3	Remark on Boundary Value Problems	232

A. Elementary Tensor Analysis	233
A.1 Linear Algebra	233
A.1.1 Inner Product	234
A.1.2 Dual Bases	235
A.1.3 Tensor Product	238
A.1.4 Transformation Rules for Components	243
A.1.5 Determinant and Trace	245
A.1.6 Exterior Product and Vector Product	251
A.1.7 Second-Order Tensors	254
A.1.8 Some Theorems of Linear Algebra	256
A.2 Tensor Calculus	262
A.2.1 Euclidean Point Space	262
A.2.2 Differentiation	263
A.2.3 Coordinate System	272
A.2.4 Covariant Derivatives	275
A.2.5 Other Differential Operators	277
A.2.6 Physical Components	281
A.2.7 Orthogonal Coordinate Systems	282
References	289
Index	293



<http://www.springer.com/978-3-540-43019-3>

Continuum Mechanics

Liu, I.-S.

2002, XII, 298 p., Hardcover

ISBN: 978-3-540-43019-3