

Reinhold Kienzler · George Herrmann

Mechanics in Material Space

with Applications to Defect
and Fracture Mechanics



Springer

Contents

Preface	V
Introduction	1
1 Mathematical Preliminaries	13
1.1 General Remarks	13
1.2 What is a Conservation Law?	14
1.3 Trivial Conservation Laws	17
1.4 System with a Lagrangian; Noether's Method	19
1.5 System without a Lagrangian; Neutral-Action Method	42
1.6 Discussion	48
2 Linear Theory of Elasticity	51
2.1 General Remarks	51
2.2 Elements of Linear Elasticity	51
2.3 Conservation Laws of Linear Elastostatics	62
2.4 Alternative Derivations of Conservation Laws	72
3 Properties of the Eshelby Tensor	81
3.1 General Remarks	81
3.2 Physical Interpretation of the Components of the Eshelby Tensor	82
3.3 Invariants, Principal Values, Principal Directions and Extremal Values of the Eshelby Tensor	86
4 Linear Elasticity with Defects	95
4.1 General Remarks	95
4.2 Path-Independent Integrals and Energy-Release Rates	96
4.3 Example: Hole-Dislocation Interaction	100
4.4 Path-Independent Integrals of Fracture Mechanics	107

5	Inhomogeneous Elastostatics	121
5.1	General Remarks	121
5.2	Symmetry Transformations	122
5.3	The Homogeneous Case	124
5.4	The Inhomogeneous Case	124
5.5	Relation to Stress-Intensity Factors	127
5.6	Examples	128
6	Elastodynamics	133
6.1	General Remarks	133
6.2	Time t as an Additional Independent Variable	134
6.3	Convolution in Time	143
6.4	Domain-Independent Integrals	146
6.5	Energy-Release Rates	151
6.6	Wave Motion	156
7	Dissipative Systems	161
7.1	General Remarks	161
7.2	Diffusion Equation	161
7.3	Non-Linear Wave Equation	163
7.4	Viscoelasticity	165
8	Coupled Fields	173
8.1	General Remarks	173
8.2	Piezoelectricity	174
8.3	Thermoelasticity	179
8.4	Mechanics of a Porous Medium	192
9	Bars, Shafts and Beams	195
9.1	General Remarks	195
9.2	Elements of Strength-of-Materials	196
9.3	Balance and Conservation Laws for Bars and Shafts	200
9.4	Balance and Conservation Laws for Beams	203
9.5	Energy-Release Rates and Stress-Intensity Factors	205
9.6	Examples	211

10	Plates and Shells	219
10.1	General Remarks	219
10.2	Plate Theories	220
10.3	Conservation Laws for Elastostatics of Mindlin Plates	224
10.4	Reduction to the Classical Theory	229
10.5	Conservation Laws for Shells	233
Appendix A		239
	Conservation Laws for Inhomogeneous Bars under Arbitrary Axial Loading	239
Appendix B		245
B.1	Elastodynamics of Inhomogeneous Bernoulli-Euler Beams	245
B.2	Reduction to Statics	252
Appendix C		259
C.1	Elastodynamics of Inhomogeneous Mindlin Plates	259
C.2	Reduction to Statics	269
References		273
Symbol Index		281
Author Index		287
Subject Index		291