

Contents

	<i>Preface</i>	<i>page</i>	<i>ix</i>
1	Introduction	1	1
	1.1 Reciprocity	1	1
	1.2 Static reciprocity for an elastic body subjected to concentrated loads	4	4
	1.3 Static reciprocity for distributed body forces and surface loads	5	5
	1.4 The wave equation in one dimension	6	6
	1.5 Use of a virtual wave in reciprocity considerations	7	7
	1.6 Synopsis	9	9
2	Some elastodynamic theory	13	13
	2.1 Introduction	13	13
	2.2 Linear elastodynamics	14	14
	2.3 One-dimensional problems	20	20
	2.4 Two-dimensional problems	21	21
	2.5 Linearly viscoelastic solid	23	23
	2.6 Acoustic medium	25	25
	2.7 Governing equations for linear elasticity in cylindrical coordinates	28	28
3	Wave motion in an unbounded elastic solid	30	30
	3.1 Introduction	30	30
	3.2 Plane waves	31	31
	3.3 Flux of energy in plane time-harmonic waves	33	33
	3.4 Reflection of time-harmonic plane waves at a free surface	35	35
	3.5 Energy partition	40	40
	3.6 Solving the wave equation for polar symmetry	40	40
	3.7 The Helmholtz decomposition	42	42
	3.8 Displacement potentials	44	44
	3.9 Wave motion generated by a point load	45	45

vi	<i>Contents</i>	
	3.10 Expressions for the far field	50
	3.11 Wave motion generated by a line load	52
4	Reciprocity in acoustics	55
	4.1 Introduction	55
	4.2 Reciprocity in the frequency domain	57
	4.3 Reciprocity in the Laplace transform domain	58
	4.4 Reciprocity in the presence of a compact inhomogeneity	60
	4.5 Direct reciprocity for the wave equation	61
	4.6 Other reciprocity theorems	62
	4.7 Reciprocity between source solutions	64
	4.8 Distribution of sources	65
	4.9 Inverse problem for scattering by a compact inhomogeneity	65
5	Reciprocity in one-dimensional elastodynamics	70
	5.1 Introduction	70
	5.2 Reciprocity for the Bernoulli–Euler beam	71
	5.3 Waves in a Bernoulli–Euler beam due to a time-harmonic force	73
	5.4 Forced vibrations of a simply supported beam	74
	5.5 Reciprocity for wave motion in one-dimensional strain	77
	5.6 The effect of an interface	79
	5.7 Use of reciprocity to determine the reflection coefficient	81
	5.8 Reciprocity of two one-dimensional solutions for concentrated forces	82
	5.9 An inverse problem	84
	5.10 Comparison of Born approximation with exact solution	85
6	Reciprocity in two- and three-dimensional elastodynamics	90
	6.1 Introduction	90
	6.2 Reciprocity theorems	91
	6.3 Reciprocity in the time domain	92
	6.4 Reciprocity in a two-material body	94
	6.5 Reciprocity theorems for linearly viscoelastic solids	94
	6.6 Anti-plane line load in an unbounded elastic solid	95
	6.7 Anti-plane surface waves	99
	6.8 The wave equation with polar symmetry	104
	6.9 Reciprocity for waves reflected from a free surface	105
	6.10 Reciprocity for fields generated by point loads in a bounded body	107
	6.11 Reciprocity for point loads in an unbounded body	108
	6.12 Distribution of body forces	109

	<i>Contents</i>	vii
6.13	Domain integral equation for scattering by an inclusion	110
6.14	Examples from the technical literature	112
7	Wave motion guided by a carrier wave	116
7.1	Introduction	116
7.2	Guided wave motion	117
7.3	Rayleigh surface waves	119
7.4	Carrier waves	122
7.5	Equivoluminal waves in an elastic layer	124
7.6	Lamb waves	127
8	Computation of surface waves by reciprocity considerations	132
8.1	Introduction	132
8.2	Surface waves generated by a line load	132
8.3	Surface waves generated by a sub-surface point load	135
8.4	Application of elastodynamic reciprocity in cylindrical coordinates	138
8.5	Surface wave motion generated by a vertical force $P$	141
8.6	Check of calculated surface-wave amplitude	142
9	Reciprocity considerations for an elastic layer	145
9.1	Introduction	145
9.2	Two-dimensional horizontally polarized transverse waves	146
9.3	Equivoluminal wave modes	148
9.4	Lamb waves in plane strain	149
9.5	Lamb waves in polar coordinates	152
10	Forced motion of an elastic layer	157
10.1	Introduction	157
10.2	Elastic layer subjected to a time-harmonic anti-plane line load	159
10.3	Response to a line load normal to the plate faces	162
10.4	Response to a point load parallel to the plate faces	164
10.5	Summary of solutions	168
10.6	Comparison with plane-stress solution	170
10.7	Comparison with plate theory for the normal-point-load problem	172
11	Integral representations and integral equations	175
11.1	Introduction	175
11.2	Radiation of anti-plane shear waves from a cavity	176
11.3	Integral representation in three dimensions	181

viii	<i>Contents</i>	
	11.4 Integral equation	185
	11.5 Scattering by a crack	188
	11.6 Reciprocity relations	191
	11.7 Kirchhoff approximation for scattering by a crack	194
	11.8 Reciprocity considerations for a diffraction problem	196
12	Scattering in waveguides and bounded bodies	199
	12.1 Introduction	199
	12.2 Interaction of an incident wave with a defect in a layer	200
	12.3 Thin film on an inhomogeneous substrate	208
	12.4 Scattering by a disbond	210
	12.5 Interaction of a Rayleigh surface wave with a crack	212
	12.6 Scattering matrix	214
	12.7 Transducer response to scattering by a flaw	216
13	Reciprocity for coupled acousto-elastic systems	220
	13.1 Introduction	220
	13.2 Reciprocity for configurationally coupled systems	221
	13.3 Reciprocity between source solutions	223
	13.4 Scattering by a flaw in a submerged solid body	223
	13.5 Reciprocity for free-field sources and sources located on rigid baffles	225
	13.6 Interaction of sound and structural vibrations	228
	13.7 Reciprocity for free-field sources and sources located on elastic baffles	231
14	Reciprocity for piezoelectric systems	233
	14.1 Introduction	233
	14.2 Piezoelectricity	234
	14.3 Governing equations	235
	14.4 Reciprocity theorem for a piezoelectric solid	236
	14.5 Application to scattering by a flaw	238
	14.6 Reflection by the bottom surface of an elastic layer	241
	14.7 Reflection and transmission by a fatigue crack	243
	<i>References</i>	247
	<i>Index of cited names</i>	251
	<i>Subject index</i>	253