

Contents

Preface	vii
1. Vibrations of elastic structures	1
1.1 Introduction	1
1.2 Elastodynamic linearized equations	2
1.3 Variational formulation of the response to given forces	3
1.4 Discretization: Ritz-Galerkin and finite element methods	5
1.5 Harmonic response to forces	7
1.6 Vibrational eigenmodes	7
1.7 Axisymmetric structures	13
1.8 Systems dependent on one parameter	14
1.9 Harmonic response to prescribed forces and displacements	18
1.10 Modal analysis of the response to forces	22
1.11 $(u_\Sigma, \{q_\alpha\})$ reduced matrix model of a substructure	23
1.12 Modal analysis of the response to prescribed displacements	29
2. Linearized equations of small movements of inviscid fluids	31
2.1 Introduction	31
2.2 Linearized dynamic equations	31
2.3 Potential of displacements φ	37
2.4 (p, φ) general equations	39
3. Sloshing modes	41
3.1 Introduction	41
3.2 Harmonic response to a wall displacement u_N	41
3.3 Variational formulation in terms of φ for sloshing modes	45
3.4 Spectral problem discretized by finite elements	51
3.5 Axisymmetric reservoirs	53
3.6 Formulation in terms of $\varphi _\Gamma = f$	53
3.7 Comparison of eigenfrequencies	56
3.8 Modal analysis of the vibratory response of the liquid	59
3.9 Impedance operator of the liquid	63
3.10 Open problems	69
4. Sloshing under surface tension	71
4.1 Introduction	71
4.2 Review of capillarity theory	71
4.3 Linearized free surface and contact angle conditions	77
4.4 Harmonic response to a wall displacement u_N of the wall	80
4.5 (η, φ) sloshing modes formulation	83
4.6 Spectral problem discretized by finite elements	85
4.7 η symmetric formulation and added mass	88
4.8 Comparison of eigenfrequencies	90

4.9	Modal analysis of the vibratory response of the liquid	92
4.10	Open problems	94
5.	Hydroelastic vibrations	95
5.1	Introduction	95
5.2	Variational formulation in terms of (u, φ)	96
5.3	Spectral problem discretized by finite elements	99
5.4	Formulation of the spectral problem in u : added mass	101
5.5	Axisymmetric structures	106
5.6	Comparison of eigenfrequencies	107
5.7	Open problems	110
6.	Hydroelastic vibrations under gravity	113
6.1	Introduction	113
6.2	Structure subject to a pressure field and to gravity	114
6.3	(u, φ) unsymmetric formulation	122
6.4	Symmetric variational formulation in (u, η) and added mass	123
6.5	Conclusion and open problems	130
7.	Acoustic cavity modes	131
7.1	Introduction	131
7.2	Harmonic response to a wall displacement u_N	131
7.3	φ variational formulation of the spectral problem and discretization	135
7.4	Modal analysis of the vibratory response of a fluid	140
7.5	Impedance operator of the fluid	142
7.6	Case of a compressible fluid with a free surface	145
8.	Structural-acoustic vibrations	149
8.1	Introduction	149
8.2	Unsymmetric (u, p) variational formulation	150
8.3	Basic (u, p, φ) equations	154
8.4	Symmetric formulation in (u, p, φ) with mass coupling	155
8.5	Mass coupling formulation without unwanted zero eigenvalue	164
8.6	Condensed formulation in (u, p) and continuum-based added mass operator	167
8.7	(u, p, φ) symmetric formulation with stiffness coupling	170
8.8	Symmetric formulation in (u, γ, p)	172
8.9	Conclusion and open problems	173
9.	Modal reduction in fluid-structure interaction	175
9.1	Introduction	175
9.2	Hydroelastic vibrations in the presence of gravity	176
9.3	Structural-acoustic vibrations	186
9.4	Conclusion and open problems	197
	Bibliography	201
	Index	211