

Table of Contents

Preface I

1	Introduction and outline	1
2	Introduction	3
2.1	Fundamental quantities and their units	3
2.2	D'ALEMBERT's principle, law of conservation of momentum	4
2.3	Energy conservation	11
2.4	Area and mass moments of inertia	13
2.5	Complex representation of harmonic vibration	20
2.6	Frequency analysis	23
2.7	Classification of dynamic processes, fundamentals of random vibration theory	32
3	Single-degree-of-freedom systems	39
3.1	Free, undamped vibrations	39
3.2	Forced vibrations without damping	43
3.3	Damped free and forced vibrations	45
3.4	Direct Integration of the differential equation of motion	51
3.5	Frequency domain methods	54
3.6	Harmonic excitation, vibration isolation for harmonic loads	61
3.7	SDOF system with material non-linearity	66
4	Systems with several degrees of freedom	74
4.1	General	74
4.2	Fundamental equations and discretisation for viscoelastic continua	74
4.3	Substructuring techniques, static condensation	83
4.4	Lumped-mass multi-degree-of-freedom systems	89
4.5	Modal analysis for lumped-mass systems	92
4.6	Solving the linear eigenvalue problem	103
4.7	The linear viscous damping model	107
4.8	Direct integration methods	112
4.9	Frequency domain methods	117
5	Systems with distributed mass and stiffness properties	121
5.1	General	121
5.2	Longitudinal vibration of straight bars	122
5.3	Torsional vibration of straight bars	124
5.4	Flexural vibration of EULER-BERNOULLI beams	125
5.5	Flexural vibration considering axial forces (2 nd order theory)	128
5.6	Flexural vibration of the TIMOSHENKO beam	130
5.7	Programming aspects	134
5.8	Examples	137
6	Bell tower response to bell-induced forces	145
6.1	Analytical preliminaries	145
6.2	Experimental investigations	151
6.3	Examples	155

7	Structural response to earthquakes	157
7.1	Seismological background	157
7.2	Characteristic functions for describing ground motions	162
7.2.1	Time domain parameters	166
7.2.2	Frequency domain parameters	169
7.3	Site-dependent elastic response spectra	177
7.4	The generation of artificial accelerograms	181
7.5	Determination of seismic structural response	189
7.5.1	Introductory remarks	189
7.5.2	Modal analysis-response spectrum approach	192
7.5.3	Equivalent static loads, simplified response spectrum approach	197
7.5.4	Direct integration solution	198
7.6	Three-dimensional building models for seismic analyses	202
7.6.1	Introduction	202
7.6.2	Lateral stiffness matrices for different wall types	211
7.7	Seismic design according to DIN 4149	221
7.8	Seismic design according to Eurocode	8 224
7.8.1	Theoretical background	224
7.8.2	Example	233
7.8.2.1	Description of the building	233
7.8.2.2	Materials	233
7.8.2.3	Structural model and equivalent seismic forces	235
7.8.2.4	Design forces and verifications	240
8	Examples and special topics	243
8.1	Non-linear behaviour of seismically excited reinforced concrete buildings	243
8.2	Seismic investigation of the towers of Cologne cathedral	256
8.3	Natural frequencies and mode shapes of a refinery vessel	260
9	Fluid containers subject to seismic loading	264
9.1	General	264
9.2	HOUSNER's approximate method	266
9.2.1	Assumptions	266
9.2.2	Formulas for ground-supported tanks	269
9.2.2.1	Squat ground-supported tanks	270
9.2.2.2	Slender ground-supported tanks	273
9.2.3	Formulas for elevated tanks	278
9.3	Numerical analysis of the structure-fluid interaction problem	287
References		290
Computer programs		297
Program descriptions		298
Index		337