

Contents

1	Oscillation Equations of a Rod with Rectilinear Axis	3
1.1	Differential Equations of Longitudinal Vibrations of a Rod	3
1.2	Differential Equations of Longitudinal Vibrations of a Rod in the Operator Form	6
1.3	Differential Equations of Torsional Vibrations	10
1.4	Differential Equations of Transverse Vibrations of a Rectilinear Rod	11
1.5	Differential Equations of Transverse Vibrations of a Rod in the Operator Form	14
1.6	Joint Longitudinal, Torsional and Transverse Vibrations of a Rod	17
1.7	Differential Equations in Displacements and Forces	18
1.8	Integral Equations of Longitudinal and Torsional Vibrations	22
1.9	Integral Equations of Transverse Vibrations of a Rod	25
1.10	Equations in Displacements with Integral Operators	28
1.11	Converting the Equations with Differential and Integral Operators to the Classical Form	30
1.12	Integral Equations of Harmonic Oscillations for an Unattached Elastic Body	37
	References	39
 Part I Equations and Methods		
2	Vibrations of a Three-Dimensional Body, Plate and Ring	41
2.1	Equations of Three-Dimensional Body Vibrations	41
2.2	Equations of Plate Vibrations	45
2.3	Equations of Ring Vibrations	50
	References	52

3	Spectral Theory	53
3.1	Forms and Frequencies of Free Oscillations	53
3.2	Representation of the Amplitude of Forced Harmonic Vibrations as a Series in the Forms of Free Oscillations.	58
3.3	Bringing Equations to the Classical Form.	61
3.4	Stationary (Periodic) and Nonstationary Elastic Vibrations	63
3.5	Oscillations with the Initial Conditions Given	63
3.6	Periodic Oscillations	66
3.7	Oscillations of a Rod Under the Action of Concentrated Force	68
3.8	Iterative Method for Determination of the First Form and Frequency of Free Elastic Oscillations	71
3.9	Determination of Higher Forms and Frequencies of Free Oscillations	75
	References	77
4	Variational and Projection Methods for Solving Vibration Theory Equations	79
4.1	Variational Principle in the Problem of Forced Harmonic Vibrations for the Displacement Equation.	80
4.2	Variational Principle in the Problem of Free Harmonic Vibrations for the Equation on Displacements Using a Differential Operator	82
4.3	Extreme Variational Principle in the Problem of Forced Harmonic Oscillations.	83
4.4	Mixed Variational Principle in the Problem of Forced Harmonic Oscillations (Principle of Reissner).	84
4.5	Variational Principle in the Problem of Forced Harmonic Vibrations for the Equation on Displacement Using an Integral Operator	86
4.6	Variational Principle in the Problem of Nonstationary Vibrations	87
4.7	Rheonomic Variation	88
4.8	Variational Method for Solving Equations of the Theory of Vibrations in Displacements.	88
4.9	Approximate Method of Solving the Problem of Harmonic Vibrations, Based on the Mixed Variational Principle	92
4.10	Formulas of the First Approximation for the First Frequency of Free Oscillations (Formulas of Rayleigh and Ritz).	94
4.11	Variational Difference Method in the Problem of Longitudinal Vibrations of a Rod (Free Oscillations)	98
4.12	Variational Difference Method (Forced Harmonic Oscillations)	102
4.13	Forced Harmonic Oscillations at the Presence of Friction.	104

4.14	Mixed Variational Principle at Complex Boundary Conditions	105
	References.	108
5	Harmonic Analysis	109
5.1	Periodic Oscillations	110
5.2	Harmonic Analysis and Spectral Method	112
5.3	Harmonic Analysis and the Variational Difference Method	114
5.4	Periodic Oscillations (Dependence of the Equation Operators on Time).	115
5.5	Nonstationary Oscillations and Harmonic Analysis.	116
5.6	Oscillations Close to Periodic.	118
	References.	122
6	Discontinuous Functions. Complicated Boundary Conditions	123
6.1	Longitudinal Vibrations of a Rectilinear Rod	123
6.2	The Spectral Method Using the Simple Homogeneous Boundary Conditions	127
6.3	Vibrations of a Three-Dimensional Body (Mixed Boundary Conditions).	134
	References.	139
7	Exact Solutions of Equations of Oscillation Theory	141
7.1	Transverse Vibrations of a Rectilinear Beam	141
7.2	Free Oscillations of a Ring of Uniform Cross-Section	155
7.3	Free Vibrations of a Circular Plate	159
7.4	Vibrations of a Rectangular Plate	168
7.5	Free Oscillations of a Spherical Shell	175
	References.	178
8	Nonlinear Periodic Oscillations.	179
8.1	Periodic Oscillations of a Thin Rod, Lying on a Nonlinear Elastic Foundation	179
8.2	The Newton-Kantorovich Method for Solving Nonlinear Operator Equations.	182
8.3	Iterative Gradient Method for Solving Operator Equations	184
8.4	Nonlinear Vibrations, Close to Periodic	187
	References.	189
 Part II Some Applied Problems		
9	Determination of Elastic Damping Characteristics of Slide Bearings.	193
9.1	The Hydrodynamic Theory of Lubrication	193
9.2	The Theory of the Oil Wedge.	196
9.3	Cylindrical Plain Bearing	200

9.4	Cylindrical Bearing (Projection Method for Solving Pressure Distribution in the Oil Film)	203
	References	208
10	Vibrations of Shafts, Blades and Disks	209
10.1	Bending Vibrations of a Rotating Shaft on Pivot Supports Under Unbalanced Centrifugal Forces	209
10.2	Bending Vibrations of an Unbalanced Rotating Shaft on Isotropic Elastic Supports	212
10.3	Bending Vibrations of an Unbalanced Rotating Shaft on Isotropic Elastic-Damping Supports	217
10.4	Bending Vibrations of an Unbalanced Rotating Shaft on Anisotropic Elastic-Damping Supports	218
10.5	Parametric Oscillations of a Shaft with Twofold Bending Stiffness	220
10.6	Vibrations of the Blade of a Steam Turbine Subject to Centrifugal Forces	222
10.7	Joint Vibrations of the Disk and Blades of a Turbine Rotor	224
	References	228
11	Stability of the Equilibrium Position of a Rotating Shaft Axis	229
11.1	Methods Used to Investigate Stability	231
	References	237
12	Vibrations of an Internal Combustion Engine	239
12.1	Statement of the Problem (Original Model of an Internal Combustion Engine)	239
12.2	The Method Used for Solution	241
	References	247
	Appendix A: The Operator Notation of Equations of the Theory of Elasticity and Boundary Conditions in Curvilinear Coordinates	249
	References	257

Theory of Elastic Oscillations

Equations and Methods

Fridman, V.

2018, XIII, 257 p. 11 illus., 3 illus. in color., Hardcover

ISBN: 978-981-10-4785-5