
Contents

Introduction	9
1. Basic properties and definitions	12
1.1. Non-linear vibration, non-linear characteristics and basic definitions	12
1.2. Some examples of excited and self-excited systems	17
1.3. Basic features of excited systems	26
1.4. Basic features of self-excited systems	29
1.5. Stability	31
2. Methods of solution	35
2.1. The harmonic balance method	35
2.2. The Van der Pol method	38
2.3. The integral equation method	41
2.4. Stability conditions	44
2.5. The averaging method	46
3. Auxiliary curves for analysis of non-linear systems	48
3.1. Characteristic features of auxiliary curves, particularly the backbone curves and the limit envelopes	48
3.2. Use of auxiliary curves for preliminary analysis	57
3.3. Use of auxiliary curves for preliminary analysis of parametrically excited systems	59
3.4. Auxiliary curves of higher-order systems	64
3.5. Use of auxiliary curves in analysis of systems with several degrees of freedom	71
3.6. Identification of damping	74
4. Analysis in the phase plane	77
4.1. Fundamental considerations	77
4.2. Practical solution of the phase portraits	90
4.3. Examples of systems of group (b)	91
4.4. Examples of systems of group (c)	96
4.5. An example of a system of group (a)	99
5. Forced, parametric and self-excited vibrations	112
5.1. Amplitude equations	112
5.2. Resonance curves, extremal amplitudes, and stability	117
5.3. Non-linear damping	124
5.4. Forced and self-excited vibrations	129
5.5. Parametric and self-excited vibrations	138
5.6. Forced, parametric and self-excited vibrations	141
5.7. Non-linear parametric excitation. Harmonic resonance	146
5.8. Non-linear parametric excitation. Subharmonic resonance	152

6.	Vibrations of systems with many degrees of freedom	154
6.1.	Single and combination resonances	154
6.2.	Stability of vibrations with many degrees of freedom	162
6.3.	Vibrations in one-stage gear drives	166
6.4.	Torsional gear resonance	170
6.5.	Combination gear resonances	173
6.6.	Internal resonances in gear drives	178
6.7.	Torsional vibrations in N -stage gear drives	184
6.8.	Strong coupling between gear stages	193
6.9.	Application of computer algebra	196
7.	Investigation of stability in the large	199
7.1.	Fundamental considerations	199
7.2.	Methods of investigating stability in the large for disturbances in the initial conditions	201
7.3.	Investigation of stability in the large for not-fully determined disturbances	206
7.4.	Examples of investigations concerning stability in the large for disturbances in the initial conditions	212
7.5.	Investigation of stability in the large for other types of disturbances	232
7.6.	Other applications of the results	235
7.7.	Examples	236
8.	Analysis of some excited systems	247
8.1.	Duffing system with a softening characteristic	247
8.2.	Some special cases of kinematic (inertial) excitation	256
8.3.	Parametric vibration of a mine cage	270
9.	Quenching of self-excited vibration	278
9.1.	Basic considerations and methods of solution	278
9.2.	Two-mass systems with two degrees of freedom	282
9.3.	Chain systems with several masses	302
9.4.	Example of a rotor system	313
10.	Vibration systems with narrow-band random excitation	323
10.1.	Application of the quasi-static method	323
10.2.	Application of the integral equation method. Probability densities	326
11.	Vibration systems with broad-band random excitation	336
11.1.	The amplitude probability density	336
11.2.	Statistical properties of the vibrations	343
11.3.	Non-stationary probability density, transition probability density and two-dimensional probability density	353
12.	Systems with autoparametric coupling	362
12.1.	Basic properties	362
12.2.	Internal resonance	370
12.3.	Narrow-band random excitation	375
12.4.	Broad-band random excitation	380
12.5.	Fokker Planck Kolmogorov equation	384
12.6.	Behaviour of the solution	391
12.7.	Application of computer algebra	400
Appendix		401
Bibliography		405
Index		415