

Contents

Preface	vii
1 Introduction	1
1.1 Existence, Uniqueness and Analytic Properties of Solutions	2
1.2 Linear Systems	10
1.3 Dynamical Systems	16
1.4 Stability	20
1.5 Liapunov's Direct Method	33
1.6 Problems	42
2 Periodic Solutions of Linear Systems	45
2.1 Linear Systems with Constant Coefficients	45
2.2 Homogeneous Linear Systems with Periodic Coefficients . .	52
2.3 Forced Linear Oscillations	60
2.4 Stability of Linear Systems	66
2.5 Hill's and Mathieu's Equations	71
2.6 Problems	82
3 Autonomous Systems in the Plane	83
3.1 The Poincaré-Bendixson Theory	84
3.2 Liénard's Equation	97
3.3 Duffing's Equation	108
3.4 The Lotka-Volterra Predator-Prey Model and Generalizations	114

3.5	The Poincaré Index and Non-existence of Cycles	122
3.6	Hilbert's Sixteenth Problem	141
3.7	Problems	149
4	Periodic Solutions of Periodic Systems	151
4.1	Existence of Periodic Solutions	152
4.2	Stability and Isolation of Periodic Solutions	161
4.3	Periodically Forced Liénard and Duffing Equations	171
4.4	Two Competing Species in a Periodically Changing Environment	183
4.5	Applications in Higher Dimensions	194
4.6	Problems	202
5	Autonomous Systems of Arbitrary Dimension	205
5.1	Orbital Stability	206
5.2	Poincaré Map, Isolation and Isochronism	219
5.3	D-periodic Solutions of Cylindrical Systems	234
5.4	Existence of Periodic Solutions	250
5.5	Competitive and Cooperative Systems, Existence in Dimension Three	274
5.6	Invariant and Integral Manifolds of Periodic Solutions	290
5.7	Problems	299
6	Perturbations	301
6.1	Periodic Perturbations of Periodic Systems	302
6.2	Controllably Periodic Perturbations of Autonomous Systems	314
6.3	The Stability of Perturbed Periodic Solutions	341
6.4	Controllably Periodic Perturbations of Van der Pol's Equation	353
6.5	Averaging	361
6.6	Singular Perturbations and Relaxation Oscillations	371
6.7	Aperiodic Perturbations	381
6.8	Problems	396
7	Bifurcations	399
7.1	Structural Stability and Bifurcations	400
7.2	The Andronov-Hopf Bifurcation	411
7.3	A Predator-Prey Model with Memory	439
7.4	Zip Bifurcation in Competitive Systems	457
7.5	Functional Differential Equations	476
7.6	Through Periodic Motions to Chaos	491
7.7	Problems	501

Appendix	503
A1 Matrices	503
A2 Topological Degree and Fixed Point Theorems	519
A3 Invariant Manifolds	531
References	545
Symbols	569
Index	571