

Series on
Applied Mathematics
Volume 23



ORDINARY DIFFERENTIAL EQUATIONS WITH APPLICATIONS

Third Edition

Sze-Bi Hsu
Kuo-Chang Chen

 World Scientific

Series on
Applied Mathematics
Volume 23

มหาวิทยาลัยเชียงใหม่

616700428
012545216
1 22684158

p67
8400-

ORDINARY DIFFERENTIAL EQUATIONS WITH APPLICATIONS

Third Edition

Sze-Bi Hsu
Kuo-Chang Chen

National Tsing Hua University, Taiwan



 World Scientific

NEW JERSEY • LONDON • SINGAPORE • BEIJING • SHANGHAI • HONG KONG • TAIPEI • CHENNAI

Contents

<i>Preface to the First Edition</i>	v
<i>Preface to the Second Edition</i>	ix
<i>Preface to the Third Edition</i>	xi
1. INTRODUCTION	1
1.1 Where do ODEs arise	1
2. FUNDAMENTAL THEORY	11
2.1 Introduction and Preliminaries	11
2.2 Local Existence and Uniqueness of Solutions of I.V.P.	14
2.3 Continuation of Solutions	21
2.4 Continuous Dependence Properties	24
2.5 Differentiability of I.C. and Parameters	25
2.6 Differential Inequalities	28
2.7 Exercises	32
3. LINEAR SYSTEMS	39
3.1 Introduction	39
3.2 Fundamental Matrices	40
3.3 Linear Systems with Constant Coefficients	45
3.4 Two-Dimensional Linear Autonomous Systems	54
3.5 Linear Systems with Periodic Coefficients	58
3.6 Adjoint Systems	66
3.7 Exercises	70

4.	STABILITY OF NONLINEAR SYSTEMS	77
4.1	Definitions	77
4.2	Linearization	79
4.3	Saddle Point Property	88
4.4	Orbital Stability	94
4.5	Traveling Wave Solutions	102
4.6	Exercises	109
5.	METHOD OF LYAPUNOV FUNCTIONS	115
5.1	An Introduction to Dynamical Systems	115
5.2	Lyapunov Functions	121
5.3	Simple Oscillatory Phenomena	134
5.4	Gradient Vector Fields	137
5.5	Exercises	140
6.	TWO-DIMENSIONAL SYSTEMS	149
6.1	Poincaré-Bendixson Theorem	149
6.2	Levinson-Smith Theorem	160
6.3	Hopf Bifurcation	177
6.4	Exercises	186
7.	SECOND ORDER LINEAR EQUATIONS	191
7.1	Sturm's Comparison Theorem and Sturm-Liouville Boundary Value Problem	191
7.2	Distributions	199
7.3	Green's Function	201
7.4	Fredholm Alternative	208
7.5	Exercises	211
8.	THE INDEX THEORY AND BROUWER DEGREE	215
8.1	Index Theory in the Plane	215
8.2	Introduction to the Brouwer Degree in \mathbb{R}^n	223
8.3	Lienard Equation with Periodic Forcing	230
8.4	Exercises	234
9.	PERTURBATION METHODS	237
9.1	Regular Perturbation Methods	237
9.2	Singular Perturbation: Boundary Value Problem	243

9.3	Singular Perturbation: Initial Value Problem	249
9.4	Exercises	261
10.	INTRODUCTION TO MONOTONE DYNAMICAL SYSTEMS	263
10.1	Monotone Dynamical System with Applications to Cooperative Systems and Competitive Systems	263
10.2	Uniform Persistence	269
10.3	Application: Competition of Two Species in a Chemostat with Inhibition	278
10.4	Two Species Competition Models	291
10.5	Exercises	295
11.	INTRODUCTION TO HAMILTONIAN SYSTEMS	299
11.1	Definitions and Classic Examples	299
11.2	Linear Hamiltonian Systems	302
11.3	First Integrals and Poisson Bracket	310
11.4	Symplectic Transformations	316
11.5	Generating Functions and Hamilton-Jacobi's Method	322
11.6	Exercises	333
	APPENDIX A	339
	A.1	339
	A.2	342
	A.3	345
	APPENDIX B	347
	<i>Bibliography</i>	355
	<i>Index</i>	359