## CONTENTS

OF THE STATE OF A STATE AND A STATE OF THE S

The second secon

The second secon

The same of the sa

	Preface	ix
1.	Introducing Iterated Functions  1.1 Iterated Functions	
	1.1 Iteratea Functions 1.2 Thinking Globally	5
	1.3 Stability: Attractors and Repellors	7
	1.4 Another Example	9
	1.5 One More Example	10
	1.6 Determinism	14
	1.7 Summary	15
2.	Introducing Differential Equations	
	2.1 Newton's Law of Cooling	17
	2.2 Exact Solutions	21
	2.3 Calculus Puzzles	22
	2.4 Qualitative Solutions	24
	2.5 Numerical Solutions	27
	2.6 Putting It All Together	32
	2.7 More about Numerical Solutions	35
	2.8 Notes on Terminology and Notation	36
	29 Existence and Uniqueness of Solutions	39

	2.10	Determinism and Differential Equations	40		
	2.11	Iterated Functions vs. Differential Equations	42		
	2.12	Further Reading	44		
3.	Interlude: Mathematical Models				
	and	and the Newtonian Worldview			
	3.1	Why Isn't This the End of the Book?	45		
	3.2	Newton's Mechanistic World	46		
	3.3	Laplacian Determinism and the Aspirations			
		of Science	47		
	3.4	Styles of Mathematical Models	50		
	3.5	Levels of Models	54		
	3.6	Pluralistic View of Mathematical Models	59		
	3.7	Further Reading	61		
4.	Cha	os I: The Butterfly Effect	62		
	4.1	The Logistic Equation	62		
	4.2	Periodic Behavior	67		
	4.3	Aperiodic Behavior	70		
Ä.	4.4	The Butterfly Effect	74		
	4.5	The Butterfly Effect Defined	80		
	4.6	Chaos Defined	83		
	4.7	Lyapunov Exponents	85		
5.	Chaos II: Deterministic Randomness				
	5.1	Symbolic Dynamics	91		
	5.2	As Random as a Coin Toss	93		
	5.3	Deterministic Sources of Randomness	95		
	5.4	Implications of the Butterfly Effect	99		
	5.5	Further Reading	104		
6.	Bifu	rcations: Sudden Transitions	106		
	6.1	Logistic Differential Equation	106		
	6.2	Logistic Equation with Harvest	109		
	6.3	Bifurcations and Bifurcation Diagrams	113		
	6.4	General Remarks on Bifurcations	119		

		Contents	Vi
	6.5	Catastrophes and Tipping Points	120
	6.6	Hysteresis	123
	6.7	Further Reading	128
7.	Universality in Chaos		129
	7.1	Logistic Equation Bifurcation Diagram	129
	7.2	Exploring the Bifurcation Diagram	137
	7.3	Some Words about Emergence	141
	7.4	The Period-Doubling Route to Chaos	143
	7.5	Universality in Maps	145
	7.6	Universality in Physics	149
	7.7	Renormalization	151
	7.8	Phase Transitions, Critical Phenomena,	
		and Power Laws	159
	7.9	Conclusion: Lessons and Limits to Universality	165
	7.10	Further Reading	169
8.	Higher-Dimensional Systems and Phase Space		170
	8.1	A Quick Review of One-Dimensional	
		Differential Equations	170
	8.2	Lotka-Volterra Differential Equations	172
	8.3	The Phase Plane	176
	8.4	Phase Planes in General	181
	8.5	The Rössler Equations and Phase Space	183
	8.6	Further Reading	188
9.	Strange Attractors		
	9.1	Chaos in Three Dimensions	190
	9.2	The Rössler Attractor	195
	9.3	Strange Attractors	201
	9.4	Back to 1D: The Lorenz Map	203
	9.5	Stretching and Folding	207
	9.6	Poincaré Maps	210
	9.7	Delay Coordinates and Phase Space	
		Reconstruction	212

- .

	9.8	Determinism vs. Noise	219
	9.9	Further Reading	221
10.	Con	nclusion	223
	10.1	Summary	223
	10.2	Complex Systems	225
	10.3	Emergence(?)	227
	10.4	But Not Everything Is Simple	229
	10.5	Further Reading	230
	10.6	Farewell	230
	Bibl	liography	231
	Inde	ex	243

CTF-5 Zhr Zhareniy Nyer-sakhlanji hitumetika wendal-adaa 5,880

CHB.3 The Phase Plane

108.6 Parther Kerding

пописты Анингоп

community symmetry, ETG, 12