

CONTENTS

Preface	v
1. Getting the program running	1
1.1 <i>The Dynamics program and hardware</i>	1
Smalldyn: a small version of Dynamics	4
1.2 <i>Getting started with Dynamics</i>	7
Using the mouse	17
Appendix: description of the interrupts	20
1.3 <i>Questions</i>	23
2. Samples of Dynamics: pictures you can make simply	27
2.1 <i>Introduction</i>	27
Example 2-1a: Plot a trajectory	29
Example 2-1b: Draw a box	29
Example 2-1c: Viewing the Parameter Menu	30
Example 2-1d: Refresh the screen and continue plotting	31
Example 2-1e: Clear the screen and continue plotting	31
Example 2-1f: Single stepping through a trajectory	34
Example 2-1g: Plot a cross at current position	34
Example 2-1h: Draw axes and print picture	35
Example 2-1i: Initializing	36
Example 2-1j: Viewing the Y Vectors	37
Example 2-1k: Find a fixed point	37
Example 2-1l: Find a period 2 orbit	38
Example 2-1m: Search for all periodic points of period 5	38
Example 2-1n: Change RHO	39
Example 2-1o: Plotting permanent crosses	42
Example 2-1p: Set storage vector y1 and initialize	42
Example 2-1q: Change X Scale or Y Scale	43

2.2 Complex pictures that are simple to make	45
Example 2-2a: Chaotic attractor	45
Example 2-2b: Computing Lyapunov exponents	48
Example 2-2c: Plotting trajectory versus time	49
Example 2-3a: Graph of iterate of one dimensional map	53
Example 2-3b: Cobweb plot of a trajectory	55
Example 2-3c: Plotting trajectory versus time	59
Example 2-4: The Henon attractor	62
Example 2-5: The first iterate of a quadrilateral	65
Example 2-6: Plotting direction field and trajectories	70
Example 2-7: Bifurcation diagram for the quadratic map	74
Example 2-8: Bifurcation diagram with bubbles	77
Example 2-9: All the Basins and Attractors	80
Example 2-10: Metamorphoses in the basin of infinity	84
Example 2-11: Search for all periodic points with period 10	89
Example 2-12: Search for all period 1 and period 2 points	91
Example 2-13: Following orbits as a parameter is varied	94
Example 2-14: The Mandelbrot set	98
Example 2-15: All the Basins and Attractors	101
Example 2-16: 3-Dimensional views on the Lorenz attractor	104
Example 2-17: Unstable manifold of a fixed point	108
Example 2-18: Stable and unstable manifolds	110
Example 2-19a: Plotting a Saddle Straddle Trajectory	112
Example 2-19b: The unstable manifold of a fixed point	115
Example 2-19c: The stable manifold of a fixed point	116
Example 2-19d: Saddle Straddle Trajectory, and manifolds	117
Example 2-20: The basin of attraction of infinity	118
Example 2-21: A trajectory on a basin boundary	122
Example 2-22: A BST trajectory for the Tinkerbell map	127
Example 2-23: Lyapunov exponent bifurcation diagram	130
Example 2-24: Chaotic parameters	133
Example 2-25: Box-counting dimension of an attractor	137
Example 2-26: Zooming in on the Tinkerbell attractor	140
Example 2-27: Period plot in the Mandelbrot set	143
Appendix	145
Command for plotting a graph	145
Commands from the Numerical Explorations Menu	145
Plotting multiple trajectories simultaneously	147

3. Screen utilities	149
3.1 <i>Basic screen features (Screen Menu SM)</i>	149
Commands for clearing the screen	150
Commands for controlling the screen	151
Level of Text output	153
Writing on pictures	154
3.2 <i>The arrow keys and boxes (BoX Menu BXM)</i>	155
3.3 <i>Initializing trajectories, plotting crosses, drawing circles and their iterates (Kruis Menu KM)</i>	161
3.4 <i>Drawing axes (AXes Menu AXM)</i>	169
3.5 <i>Windows and rescaling (Window Menu WM)</i>	173
Detailed view on the structure of an attractor	177
3.6 <i>Zooming in or zooming out (ZOOm Menu ZOOM)</i>	179
3.7 <i>Setting colors (Color Menu CM and Color Table Menu CTM)</i>	183
Color screens	183
Core copy of the picture	184
Color planes	185
Commands for erasing colors	196
4. Utilities	199
4.1 <i>Setting parameters (Parameter Menu PM)</i>	199
Changing the "When and What to plot" variables	203
4.2 <i>Setting and replacing a vector (Vector Menu VM)</i>	207
Y Vectors	209
"Own" and the coordinates of $y[]$	209
Setting vectors with the mouse	211
4.3 <i>Setting step size (Differential Equation Menu DEM)</i>	212
4.4 <i>Saving pictures and data (Disk Menu DM)</i>	219
Creating a batch file of commands	219
Commands for reading disk files	225
4.5 <i>Setting the size of the core (Size of Core Menu SCM)</i>	229
4.6 <i>Printing pictures (PriNter Menu PNM)</i>	231
Commands for specifying printer	231
Encapsulated PostScript	232
Commands for printer options	233
Text to printer	235
Printing color pictures	237
Printing pictures with any printer supported by Windows	238
Troubleshooting for printing pictures using Windows 95	240
4.7 <i>Plotting points from a file</i>	241
Creating a file of plotted points	242

5. Lyapunov exponents	243
5.1 Introduction and the methods	243
Computation of Lyapunov exponents: the numerical method	244
Lyapunov dimension	245
Plotting of Lyapunov exponents versus time or parameter	246
5.2 Lyapunov Menu LM	255
Commands for Lyapunov exponents	255
5.3 Examples	260
5.4 Exercises	264
5.5 References related to Dynamics	266
 6. Bifurcation diagrams	267
6.1 Introduction and the methods	267
Initializing one or more trajectories for each parameter value	273
Coexistence of attractors	274
Plotting of Lyapunov exponents versus a parameter	275
6.2 BIFurcation diagram Menu BIFM	280
6.3 Examples	289
6.4 Exercises	303
6.5 References related to Dynamics	310
 7. Basins of attraction	313
7.1 Introduction and the methods	313
Computation of basins: the BA method	314
Diverging trajectories	317
BA for Bifurcation Diagrams	317
Plotting of basins in higher dimensions	317
Many basins and too few colors?	318
Blow-ups: when BA cannot be used	318
Computation of basins: the BAS method	319
Plotting of basins in higher dimensions	323
BAS Plotting scheme	324
Basin picture resolution	326
Numerical method for computing Newton basins	328
Numerical methods in parameter space	329
7.2 Basin of attraction Menu BM	333
Commands for computation of basins (BA method)	338
Commands for computation of basins (BAS method)	341
Commands for basin picture resolutions	346
Commands for color schemes for plotting basins	348
7.3 Examples	353
7.4 Exercises	368
7.5 References related to Dynamics	372

8. Straddle trajectories	379
8.1 <i>Introduction and the methods</i>	379
Basin boundary Straddle Trajectories	382
Saddle Straddle Trajectories	387
Accessible straddle trajectories	389
Lyapunov exponents and other trajectory tools	392
8.2 <i>Straddle Trajectory Menu STM</i>	393
Commands for straddle options	398
8.3 <i>Examples</i>	403
8.4 <i>Exercises</i>	409
8.5 <i>References related to Dynamics</i>	412
9. Unstable and stable manifolds	413
9.1 <i>Introduction and the method</i>	413
The method for computation of the manifolds	416
9.2 <i>Unstable and stable manifold Menu UM</i>	418
The role of the number of screen diameters SD	419
Hint: Drawing manifolds slowly	425
9.3 <i>Examples</i>	428
9.4 <i>Exercises</i>	432
9.5 <i>References related to Dynamics</i>	436
10. Finding periodic orbits	441
10.1 <i>Introduction and the methods</i>	441
Interactively finding periodic orbits	441
Randomly finding periodic orbits	442
The Quasi-Newton method	442
Newton's method: how it is done	443
10.2 <i>Periodic Orbit Menu POM</i>	449
10.3 <i>Examples</i>	452
10.4 <i>Exercises</i>	460
11. Following periodic orbits	461
11.1 <i>Introduction and the method</i>	461
Colors and orbit index	462
Bifurcation and the orbit index	463
Numerical method for following periodic orbits	464
11.2 <i>Follow Orbit Menu FOM</i>	467
Commands for following periodic orbits	467
11.3 <i>Examples</i>	469
11.4 <i>Exercises</i>	474
11.5 <i>References related to Dynamics</i>	476

12. Dimension	477
<i>12.1 Introduction and the methods</i>	477
Method for the computation of the box-counting dimension	480
Method for the computation of the correlation dimension	481
<i>12.2 Dimension Menu DIM</i>	483
Commands for computing dimensions	483
<i>12.3 Examples</i>	485
<i>12.4 Exercises</i>	486
<i>12.5 References related to Dynamics</i>	488
13. Adding your OWN process to Dynamics	491
<i>13.1 Introduction</i>	491
<i>13.2 Adding a new map</i>	492
<i>13.3 Adding a new differential equation</i>	508
<i>13.4 Storing pictures of an OWN-process</i>	517
14. Dynamics on Unix systems	
<i>by Brian R. Hunt and Eric J. Kostelich</i>	519
15. Appendix	529
<i>15.1 The map Q</i>	529
<i>15.2 List of menu commands</i>	531
<i>15.3 Tables of the Figures</i>	543
References	553
Index	563