



# Chapter Index

<b>Wordfinder .....</b>	XIV
<b>Chapter 1 Preparing for a Journey Through Deterministic Chaos and Complex Systems .....</b>	1
Section 1.1 Deterministic Chaos? .....	3
Section 1.2 Complexity and the Failure of Reductionism .....	8
Section 1.3 Pure Mathematics and Crazy Numbers .....	12
Section 1.4 What is the Point of Geometry? .....	18
Section 1.5 Painting a Rainbow by Tracking Vanishing Pixels in Linespace	25
Section 1.6 Beware of Averages! .....	36
Section 1.7 Noisy Telephone Lines and Cantorian Dusts .....	45
Section 1.8 Monte Carlo Explorations with a Cluster of Drunks .....	50
Section 1.9 Empirical Facts and General Truths .....	60
Section 1.10 Escape From Time Space Into Phase Space .....	64
Exercises .....	71
References .....	77
<b>Chapter 2 Mandelbrot Sets, Julia Lace and Fatou Dusts .....</b>	79
Section 2.1 A Three-fold Path to Geometric Understanding .....	81
Section 2.2 The Mandelbrot Set – A Prison for Restless Pixels .....	85
Section 2.3 Julia Lace and Fatou Dusts .....	103
References .....	105
<b>Chapter 3 The Normal Distribution of Drunks .....</b>	107
Section 3.1 Can Tumbling Coins Tell Us Anything About Staggering Drunks? .....	109
Section 3.2 Seductive (Often Meaningless) Patterns in Random Time Sequences .....	112
Section 3.3 Technical Names for the Bell Curve .....	114
Section 3.4 Mathematical Description of the Structure of the Gaussian Probability Curve .....	115
Section 3.5 Stretching Data Mathematically with Gaussian Probability Graph Paper .....	120
Section 3.6 When are we Likely to Encounter Gaussian Probability Distribution in Stochastic Systems? .....	124
Section 3.7 Gaussianly Scattered Drunks .....	126
Section 3.8 Gaussian Variations in the Structure of Powder Mixtures .....	127

Section 3.9	Using The Gaussian Probability Curve to Characterize Uncertainty in Experimental Data .....	133
Section 3.10	The Power of Self-cancelling Errors to Improve Experimentally Based Estimates of a Physical Quantity .....	137
Section 3.11	Using Dot Counting to Estimate Irregular Areas .....	140
Section 3.12	Finding the Percentage of a Given Material in an Ore .....	145
Section 3.13	Aperture Size Distribution in a Woven Wire Sieve .....	147
Section 3.14	Characterizing The Weight Variation in a Population of Candy Covered Chocolate Buttons .....	150
Section 3.15	Buffon's Needle – A Surprising Pattern of Events .....	155
Section 3.16	Exploiting the Efficiency of Antithetic Variates to Improve the Efficiency of the Estimates of $\pi$ by Buffon's Needle Experiments .....	158
Section 3.17	How Much Work is Needed to Improve One's Confidence in an Average Value? .....	163
Exercises	.....	167
References	.....	175

**Chapter 4 The Rare Events of Cooperative Chaos .....** 177

Section 4.1	“Double or Quits” – A Desperate Gamble .....	179
Section 4.2	The Surprise of a (Half) Lifetime! .....	184
Section 4.3	Making Things Normal Again with Logarithms .....	189
Section 4.4	How Long is a Game of Snakes and Ladders? .....	193
Exercises	.....	201
References	.....	206

**Chapter 5 Prussian Horses and Fishy Statistics .....** 207

Section 5.1	Death Rates from Horse Kicks in the Prussian Cavalry .....	209
Section 5.2	Using Poisson Graph Paper in the Assessment of Dust Deposition Density in Air Pollution Studies .....	213
Section 5.3	Stingy with the Yellow Buttons? .....	215
Section 5.4	Using Poisson Trackers to Monitor Chaos in a Powder Mixer	220
Section 5.5	Segregated and Tumbled Jelly Beans .....	223
Section 5.6	A Cautionary Tale of Tails .....	226
Exercises	.....	227
References	.....	229

**Chapter 6 Rubber Number Logic and the Swinging Mouse .....** 231

Section 6.1	The Dimensions of Reality .....	233
Section 6.2	Topolgy, Topography & Stretched Relationships .....	238

Section 6.3	Stokes' Law Versus Galileo .....	244
Section 6.4	Rubber Number Logic for Studying the Flow of Viscous Fluid Through Pipes .....	253
Section 6.5	Dimensionless Numbers as Indicators of Similar Structure and Behavior .....	256
Exercises	.....	262
References	.....	265
<b>Chapter 7</b>	<b>Congregating Drunks, Soot and Other Pigments .....</b>	<b>267</b>
Section 7.1	Congregating Drunks Create Surprising Patterns! .....	269
Section 7.2	Characterizing the Structure of Fractal Agglomerates .....	275
Section 7.3	Fractal Fingers Generated by Electrolytic Deposition .....	282
Section 7.4	Creating Fractal Fingers of Moving Fluid in a Hele–Shaw Cell .....	287
Exercises	.....	289
References	.....	304
<b>Chapter 8</b>	<b>Infinite Coastlines and Other Wiggly Lines .....</b>	<b>305</b>
Section 8.1	Easy Questions and Impossible Answers .....	307
Section 8.2	Beware! Richardson Plots May Have More Than One Straight Line Data Relationship Lurking in the Scatter of the Data Points	311
Section 8.3	Characterizing Profiles Which Manifest Various Fractal Structures Around Their Perimeter .....	314
Section 8.4	Estimating Fractal Dimensions by Penny Plating Procedures ..	324
Section 8.5	Mosaic Amalgamation – Another Variation of the Minkowski Sausage Method for Characterizing Rugged Curves .....	331
Section 8.6	Fractal Rabbits and Manitoulin Island .....	334
Section 8.7	How to Tell a Vulcan from Another Carbon Black .....	340
Section 8.8	Putting Fractal Dimensions to Work in Applied Science .....	344
Section 8.9	More Ideas for Putting Fractals to Work .....	359
Exercises	.....	363
References	.....	383
<b>Chapter 9</b>	<b>Invisible Carpets, Swiss Cheese and a Slice of Bread .....</b>	<b>387</b>
Section 9.1	Fractalicious Bread and Cheese .....	389
Section 9.2	Exploring the Fractal Structure of Felts and Filters .....	403
Section 9.3	Characterizing the Porous Nature of Bone and Sandstone .....	408
Exercises	.....	411
References	.....	415

<b>Chapter 10 A New Wrinkle on Surface Fractals .....</b>	417
Section 10.1 Characterizing Canyons and the Effect of Sunshine .....	419
Section 10.2 Simulating Passoja's Method for Studying the Roughness of Metal Fractures .....	425
Section 10.3 How Many Islands are there in a Lake? .....	427
Exercises .....	434
References .....	436
<b>Chapter 11 Zipf's Law and the Surprising Patterns of Word Occurrences .....</b>	437
Section 11.1 Hyperbolic Word Frequencies .....	439
Section 11.2 The Size Distribution of Population Centers .....	443
Section 11.3 Beware of Procrustean Thinking .....	445
Section 11.4 Levy Flights – A Generalized Theory of Brownian Motion ..	450
References .....	461
<b>Chapter 12 Climbing Fig Trees to Discover Fascinating Numbers ...</b>	463
Section 12.1 Magic Numbers for Communicating with Space Aliens? .....	465
Section 12.2 Population Ecology – Malthus Modified .....	466
Section 12.3 Climbing Attractor Fig Trees by Means of Parabolic Cobwebs	477
Exercises .....	482
References .....	482
<b>Chapter 13 Coincidences, Clusters and Catastrophes .....</b>	483
Section 13.1 Strange Coincidences and Significant Clusters .....	485
Section 13.2 Simulating Significant and Nonsignificant Patterns of Accidents and Diseases .....	487
Section 13.3 The Importance of Understanding Coincidences and Clustering in Fine Particle Science .....	499
Section 13.4 The Catastrophic Behavior of Dripping Taps and Tumbling Rocks .....	515
Section 13.5 Avalanches and Earthquakes .....	528
Exercises .....	530
References .....	532
<b>Chapter 14 Mathematical Watersheds and Rooting Around in Drainage Basins .....</b>	535
Section 14.1 The Concepts of Fluxions .....	537
Section 14.2 Using Newton's Method for Discovering the Roots of Equations .....	543
References .....	552

<b>Chapter 15 Fourier Analysis, Fractal Dimension and Formation Dynamics .....</b>	553
Section 15.1 Hot Rocks and Musical Notes .....	555
Section 15.2 Harmonious Rocks and Fractal Profiles .....	561
Section 15.3 Fourier Analysis, Fractal Structure and Fortune Hunting .....	569
References .....	574
<b>Author Index .....</b>	575
<b>Subject Index .....</b>	579