

CONTENTS

PREFACE	xiii
ACKNOWLEDGMENTS	xvii
1 GETTING STARTED	1
2 INTRODUCTION TO PYTHON	7
2.1 The Basic Elements of Python.....	9
2.1.1 Objects, Expressions, and Numerical Types.....	9
2.1.2 Variables and Assignment	12
2.1.3 Python IDE's	14
2.2 Branching Programs.....	15
2.3 Strings and Input	18
2.3.1 Input.....	20
2.3.2 A Digression About Character Encoding	21
2.4 Iteration	22
3 SOME SIMPLE NUMERICAL PROGRAMS	25
3.1 Exhaustive Enumeration.....	25
3.2 For Loops.....	27
3.3 Approximate Solutions and Bisection Search	30
3.4 A Few Words About Using Floats.....	34
3.5 Newton-Raphson	37
4 FUNCTIONS, SCOPING, AND ABSTRACTION	39
4.1 Functions and Scoping.....	40
4.1.1 Function Definitions	40
4.1.2 Keyword Arguments and Default Values.....	42
4.1.3 Scoping.....	43
4.2 Specifications.....	47
4.3 Recursion.....	50
4.3.1 Fibonacci Numbers	52
4.3.2 Palindromes.....	54
4.4 Global Variables.....	57
4.5 Modules	59
4.6 Files	61

STRUCTURED TYPES, MUTABILITY, AND HIGHER-ORDER

FUNCTIONS	65
5.1 Tuples.....	65
5.1.1 Sequences and Multiple Assignment.....	67
5.2 Ranges.....	67
5.3 Lists and Mutability.....	68
5.3.1 Cloning.....	73
5.3.2 List Comprehension.....	74
5.4 Functions as Objects.....	75
5.5 Strings, Tuples, Ranges, and Lists.....	77
5.6 Dictionaries.....	79

TESTING AND DEBUGGING.....85

6.1 Testing.....	86
6.1.1 Black-Box Testing.....	87
6.1.2 Glass-box Testing.....	88
6.1.3 Conducting Tests.....	90
6.2 Debugging.....	92
6.2.1 Learning to Debug.....	94
6.2.2 Designing the Experiment.....	95
6.2.3 When the Going Gets Tough.....	98
6.2.4 When You Have Found “The” Bug.....	99

EXCEPTIONS AND ASSERTIONS.....101

7.1 Handling Exceptions.....	101
7.2 Exceptions as a Control Flow Mechanism.....	105
7.3 Assertions.....	108

CLASSES AND OBJECT-ORIENTED PROGRAMMING.....109

8.1 Abstract Data Types and Classes.....	109
8.1.1 Designing Programs Using Abstract Data Types.....	114
8.1.2 Using Classes to Keep Track of Students and Faculty.....	115
8.2 Inheritance.....	118
8.2.1 Multiple Levels of Inheritance.....	121
8.2.2 The Substitution Principle.....	123
8.3 Encapsulation and Information Hiding.....	123
8.3.1 Generators.....	128
8.4 Mortgages, an Extended Example.....	130

A SIMPLISTIC INTRODUCTION TO ALGORITHMIC COMPLEXITY..135

9.1 Thinking About Computational Complexity.....	135
9.2 Asymptotic Notation.....	139

9.3 Some Important Complexity Classes.....	141
9.3.1 Constant Complexity.....	141
9.3.2 Logarithmic Complexity.....	141
9.3.3 Linear Complexity.....	142
9.3.4 Log-Linear Complexity.....	144
9.3.5 Polynomial Complexity.....	144
9.3.6 Exponential Complexity.....	145
9.3.7 Comparisons of Complexity Classes.....	147

10 SOME SIMPLE ALGORITHMS AND DATA STRUCTURES.....151

10.1 Search Algorithms.....	152
10.1.1 Linear Search and Using Indirection to Access Elements.....	153
10.1.2 Binary Search and Exploiting Assumptions.....	154
10.2 Sorting Algorithms.....	158
10.2.1 Merge Sort.....	159
10.2.2 Exploiting Functions as Parameters.....	162
10.2.3 Sorting in Python.....	162
10.3 Hash Tables.....	164

11 PLOTTING AND MORE ABOUT CLASSES.....169

11.1 Plotting Using PyLab.....	169
11.2 Plotting Mortgages, an Extended Example.....	175

12 KNAPSACK AND GRAPH OPTIMIZATION PROBLEMS.....183

12.1 Knapsack Problems.....	184
12.1.1 Greedy Algorithms.....	184
12.1.2 An Optimal Solution to the 0/1 Knapsack Problem.....	188
12.2 Graph Optimization Problems.....	190
12.2.1 Some Classic Graph-Theoretic Problems.....	195
12.2.2 Shortest Path: Depth-First Search and Breadth-First Search.....	196

13 DYNAMIC PROGRAMMING.....203

13.1 Fibonacci Sequences, Revisited.....	203
13.2 Dynamic Programming and the 0/1 Knapsack Problem.....	205
13.3 Dynamic Programming and Divide-and-Conquer.....	213

14 RANDOM WALKS AND MORE ABOUT DATA VISUALIZATION.....215

14.1 Random Walks.....	216
14.2 The Drunkard’s Walk.....	217
14.3 Biased Random Walks.....	224
14.4 Treacherous Fields.....	231

5 STOCHASTIC PROGRAMS, PROBABILITY, AND

DISTRIBUTIONS	235
15.1 Stochastic Programs	236
15.2 Calculating Simple Probabilities	238
15.3 Inferential Statistics	239
15.4 Distributions	254
15.4.1 Probability Distributions	256
15.4.2 Normal Distributions	258
15.4.3 Continuous and Discrete Uniform Distributions	263
15.4.4 Binomial and Multinomial Distributions	264
15.4.5 Exponential and Geometric Distributions	265
15.4.6 Benford's Distribution	269
15.5 Hashing and Collisions	269
15.6 How Often Does the Better Team Win?	272
MONTE CARLO SIMULATION	275
16.1 Pascal's Problem	276
16.2 Pass or Don't Pass?	277
16.3 Using Table Lookup to Improve Performance	282
16.4 Finding π	283
16.5 Some Closing Remarks About Simulation Models	288
SAMPLING AND CONFIDENCE INTERVALS	291
17.1 Sampling the Boston Marathon	292
17.2 The Central Limit Theorem	298
17.3 Standard Error of the Mean	302
UNDERSTANDING EXPERIMENTAL DATA	305
18.1 The Behavior of Springs	305
18.1.1 Using Linear Regression to Find a Fit	309
18.2 The Behavior of Projectiles	314
18.2.1 Coefficient of Determination	317
18.2.2 Using a Computational Model	319
18.3 Fitting Exponentially Distributed Data	320
18.4 When Theory Is Missing	324
RANDOMIZED TRIALS AND HYPOTHESIS CHECKING	327
19.1 Checking Significance	328
19.2 Beware of P-values	334
19.3 One-tail and One-sample Tests	336
19.4 Significant or Not?	338
19.5 Which N?	340

19.6 Multiple Hypotheses	342
20 CONDITIONAL PROBABILITY AND BAYESIAN STATISTICS	345
20.1 Conditional Probabilities	346
20.2 Bayes' Theorem	348
20.3 Bayesian Updating	350
21 LIES, DAMNED LIES, AND STATISTICS	355
21.1 Garbage In Garbage Out (GIGO)	355
21.2 Tests Are Imperfect	356
21.3 Pictures Can Be Deceiving	357
21.4 Cum Hoc Ergo Propter Hoc	359
21.5 Statistical Measures Don't Tell the Whole Story	361
21.6 Sampling Bias	362
21.7 Context Matters	363
21.8 Beware of Extrapolation	364
21.9 The Texas Sharpshooter Fallacy	364
21.10 Percentages Can Confuse	367
21.11 Statistically Significant Differences Can Be Insignificant	368
21.12 The Regressive Fallacy	369
21.13 Just Beware	370
22 A QUICK LOOK AT MACHINE LEARNING	371
22.1 Feature Vectors	374
22.2 Distance Metrics	377
23 CLUSTERING	383
23.1 Class Cluster	385
23.2 K-means Clustering	387
23.3 A Contrived Example	390
23.4 A Less Contrived Example	395
24 CLASSIFICATION METHODS	403
24.1 Evaluating Classifiers	403
24.2 Predicting the Gender of Runners	408
24.3 K-nearest Neighbors	408
24.4 Regression-based Classifiers	415
24.5 Surviving the Titanic	425
24.6 Wrapping Up	430
PYTHON 3.5 QUICK REFERENCE	431
INDEX	435