

# CONTENTS IN DETAIL

<b>ACKNOWLEDGMENTS</b>	<b>xix</b>
<b>INTRODUCTION</b>	<b>xxi</b>
The Power of Coding . . . . .	xxii
Why Kotlin? . . . . .	xxii
Who Is This Book For? . . . . .	xxiii
What's in This Book? . . . . .	xxiv
The Projects . . . . .	xxvi
Getting Started . . . . .	xxx
Resources . . . . .	xxx
 <b>PART I: PROGRAMMING FUNDAMENTALS</b> <b>1</b>	
<b>1</b>	
<b>KOTLIN BASICS</b>	<b>3</b>
Using Comments . . . . .	4
Variables . . . . .	5
Constants . . . . .	6
Common Data Types . . . . .	7
Operators . . . . .	10
Arithmetic . . . . .	10
Assignment . . . . .	12
Unary . . . . .	12
Relational . . . . .	12
Logical . . . . .	13
Working with Strings . . . . .	14
Concatenation . . . . .	14
String Templates . . . . .	15
Escape Sequences . . . . .	16
Null and Nullable Types . . . . .	17
Flow Control . . . . .	18
Conditional Statements . . . . .	18
Loops . . . . .	22
Functions . . . . .	27
Built-in Mathematical Functions . . . . .	28
Custom Functions . . . . .	29
Scope Functions . . . . .	34
Lambda Expressions . . . . .	35
Basic Input and Output . . . . .	37
Console-Based Input and Output . . . . .	37
Simple File Operations . . . . .	39
<b>Project 1: Build a Console-Based Calculator</b> . . . . .	<b>40</b>
The Code . . . . .	41
The Result . . . . .	44

Summary .....	45
Resource .....	45

## **2**

### **ARRAYS, COLLECTIONS, AND CLASSES**

**47**

Arrays .....	48
Primitive Arrays. ....	49
The Array Constructor .....	49
Array Operations .....	50
Multidimensional Arrays .....	51
Collections .....	52
Lists .....	52
Sets .....	54
Maps. ....	56
An Introduction to Classes .....	57
Constructors .....	58
The init Block .....	61
Methods .....	62
Encapsulation .....	63
The this Keyword .....	64
Inheritance and Polymorphism .....	65
Common Classes and Custom Types .....	67
Data Classes .....	68
Pairs and Triples .....	70
Abstract Classes .....	71
Interfaces .....	72
Enum Classes .....	74
Copying Objects .....	75
Shallow Copy .....	75
Deep Copy .....	76
<b>Project 2: Build a Versatile Task Manager</b> .....	<b>78</b>
The Code .....	78
The Result .....	84
Summary .....	85
Resource .....	86

## **3**

### **VISUALIZING WITH JAVAFX**

**87**

Data Visualization Tools for Kotlin .....	88
An Overview of JavaFX .....	89
Key Functionalities .....	89
Setup .....	90
<b>Project 3: Build “Hello, World!” in JavaFX</b> .....	<b>90</b>
The Code .....	92
The Result .....	95
The JavaFX Object Hierarchy .....	96
The Stage .....	96
Scenes .....	96
Layout Containers .....	97
Child Nodes .....	98

Creating JavaFX Charts . . . . .	98
<b>Project 4: Visualize Data as a Bar Chart . . . . .</b>	<b>99</b>
The Code . . . . .	99
The Result . . . . .	101
<b>Project 5: Create a Multiseries Line Chart . . . . .</b>	<b>102</b>
The Code . . . . .	103
The Result . . . . .	105
Drawing with the Canvas . . . . .	107
A Simple Shape . . . . .	107
Common Graphics Context Methods . . . . .	109
<b>Project 6: Draw a Spiral Seashell . . . . .</b>	<b>110</b>
The Strategy . . . . .	110
The Code . . . . .	111
The Result . . . . .	115
Animation in JavaFX . . . . .	115
<b>Project 7: Animate a Square . . . . .</b>	<b>116</b>
The Code . . . . .	116
The Result . . . . .	117
<b>Project 8: Animate a Bouncing Ball . . . . .</b>	<b>118</b>
Setting Keyframes Explicitly . . . . .	118
Using an Action Event Listener . . . . .	120
Summary . . . . .	124
Resources . . . . .	124

## PART II: APPLICATIONS IN MATH AND SCIENCE

**125**

<b>4</b>	
<b>SOLVING MATHEMATICAL PROBLEMS WITH CODE</b>	<b>127</b>
<b>Project 9: Find the Square Root with the Babylonian Algorithm . . . . .</b>	<b>128</b>
The Code . . . . .	129
The Result . . . . .	130
<b>Project 10: Create Pythagorean Triples with Euclid's Formula . . . . .</b>	<b>130</b>
The Code . . . . .	131
The Result . . . . .	132
<b>Project 11: Identify Prime Numbers with the Sieve of Eratosthenes . . . . .</b>	<b>133</b>
The Strategy . . . . .	133
The Code . . . . .	134
The Result . . . . .	135
<b>Project 12: Calculate Earth's Circumference the Ancient Way . . . . .</b>	<b>136</b>
The Code . . . . .	138
The Result . . . . .	139
<b>Project 13: Code the Fibonacci Sequence . . . . .</b>	<b>139</b>
The Golden Ratio . . . . .	141
The Fibonacci Spiral . . . . .	141
The Code . . . . .	143
The Result . . . . .	147
<b>Project 14: Find the Shortest Distance Between Two Locations on Earth . . . . .</b>	<b>148</b>
The Code . . . . .	150
The Result . . . . .	153

<b>Project 15: Do Encryption with the Hill Cipher . . . . .</b>	<b>154</b>
How It Works . . . . .	154
The Code . . . . .	157
The Result . . . . .	163
<b>Project 16: Simulate a One-Dimensional Random Walk . . . . .</b>	<b>164</b>
A One-Dimensional Model . . . . .	165
The Code . . . . .	166
The Result . . . . .	170
Summary . . . . .	173
Resources . . . . .	174

## 5

### MODELING AND SIMULATION

<b>Project 17: Predict the Flight of a Cannonball. . . . .</b>	<b>175</b>
The Strategy . . . . .	178
The Code . . . . .	179
The Result . . . . .	181
<b>Project 18: Design a Fountain with Water Jets . . . . .</b>	<b>182</b>
The Strategy . . . . .	184
The Code . . . . .	184
The Result . . . . .	188
<b>Project 19: Track a Pendulum's Motion and Phase . . . . .</b>	<b>189</b>
The Motion of a Simple Pendulum . . . . .	190
The Strategy . . . . .	191
The Code . . . . .	192
The Result . . . . .	197
<b>Project 20: The Physics of Coffee Cooling. . . . .</b>	<b>200</b>
Newton's Law of Cooling . . . . .	200
The Effect of Mixing Liquids . . . . .	201
The Strategy . . . . .	201
The Code . . . . .	202
<b>Project 21: Simulate a Binary Star System . . . . .</b>	<b>209</b>
The Science of Binary Star Systems . . . . .	210
The Strategy . . . . .	211
The Code . . . . .	212
The Result . . . . .	220
Summary . . . . .	221
Resources . . . . .	221

## PART III: RECURSION, SORTING, AND SEARCHING

**223**

## 6

### RECURSIVE FUNCTIONS AND FRACTALS

**225**

The Concept of Fractals . . . . .	226
Recursive Functions . . . . .	227

<b>Project 22: The “Hello, World!” of Fractals.....</b>	<b>229</b>
The Strategy.....	230
The Code.....	231
<b>Project 23: Draw the Sierpiński Triangle.....</b>	<b>234</b>
The Strategy.....	235
The Code.....	236
<b>Project 24: Create a Fractal Tree .....</b>	<b>239</b>
The Strategy.....	239
The Code.....	240
The L-System and Turtle Graphics.....	241
Formalizing the L-System .....	242
Drawing L-System Patterns with Turtle Graphics.....	243
<b>Project 25: Design an L-System Simulator .....</b>	<b>245</b>
The Code.....	245
The Result.....	251
The Mighty Mandelbrot Set.....	252
<b>Project 26: Code and Visualize the Mandelbrot Set .....</b>	<b>254</b>
The Code.....	255
The Result.....	259
Summary .....	262
Resources .....	262

## 7

### SORTING AND SEARCHING

**265**

Sorting Algorithms .....	266
<b>Project 27: Space-Efficient Sorting with Insertion Sort.....</b>	<b>268</b>
The Code.....	269
The Result.....	270
<b>Project 28: Faster Sorting with Merge Sort.....</b>	<b>270</b>
The Code.....	271
The Result.....	273
<b>Project 29: High-Efficiency Sorting with Quick Sort.....</b>	<b>274</b>
The Code.....	275
The Result.....	277
Search Algorithms .....	278
What Is a Graph?.....	278
How to Search a Graph.....	279
<b>Project 30: Stack-Based Searching with Depth-First Search.....</b>	<b>280</b>
The Code.....	281
The Result.....	282
<b>Project 31: Queue-Based Searching with Breadth-First Search .....</b>	<b>284</b>
The Code.....	285
The Result.....	286
<b>Project 32: Heuristic Searching with A*</b> .....	<b>288</b>
The Heuristic Function .....	289
The Algorithm.....	291
The Code.....	292
The Result.....	298
Summary .....	300
Resources .....	301

## PART IV: OPTIMIZATION WITH NATURE-INSPIRED ALGORITHMS 303

<b>8</b>		
<b>THE GENETIC ALGORITHM</b>		<b>305</b>
Nature-Inspired Algorithms . . . . .	306	
The Optimization Problem . . . . .	306	
When to Use NIAs . . . . .	310	
An Overview of the Genetic Algorithm . . . . .	310	
Genetic Operators . . . . .	311	
Selection . . . . .	312	
Crossover . . . . .	314	
Mutation . . . . .	315	
Elitism . . . . .	315	
<b>Project 33: Evolve Gibberish into Shakespeare.</b> . . . . .	<b>316</b>	
The Strategy . . . . .	316	
The Code . . . . .	316	
The Result . . . . .	321	
<b>Project 34: Solve the Knapsack Problem</b> . . . . .	<b>323</b>	
The Strategy . . . . .	323	
The Code . . . . .	324	
The Result . . . . .	330	
<b>Project 35: Optimize a Multivariate Function with the Genetic Algorithm</b> . . . . .	<b>332</b>	
The Strategy . . . . .	333	
The Code . . . . .	333	
The Result . . . . .	338	
Stopping Condition for Genetic Algorithms . . . . .	341	
Summary . . . . .	343	
Resources . . . . .	343	
<b>9</b>		
<b>AGENT-BASED ALGORITHMS</b>		<b>345</b>
An Overview of Particle Swarm Optimization . . . . .	346	
Implementing PSO for Function Minimization . . . . .	348	
<b>Project 36: Optimize a Multivariate Function with a Particle Swarm</b> . . . . .	<b>350</b>	
The Code . . . . .	350	
The Result . . . . .	354	
Ant Colony Optimization . . . . .	356	
The ACS Algorithm . . . . .	358	
Symbols and Their Meanings . . . . .	358	
The Steps of ACS . . . . .	359	
<b>Project 37: Solve the Traveling Salesman Problem with an Ant Colony System.</b> . . . . .	<b>361</b>	
The Code . . . . .	361	
The Result . . . . .	373	
Summary . . . . .	376	
Resources . . . . .	376	

<b>AFTERWORD</b>	<b>379</b>
<b>APPENDIX</b>	<b>381</b>
Key Definitions . . . . .	381
Workflow for Creating an App . . . . .	383
Setting Up Shop . . . . .	384
Step 1: Download and Install IntelliJ IDEA . . . . .	384
Step 2: Download and Set Up the JDK . . . . .	385
Step 3: Create a New Project . . . . .	385
<b>INDEX</b>	<b>389</b>