

INDEX

Page numbers in italics refer to figures and tables.

Symbols

- + (addition operator), 10
- && (AND operator), 13
- > (arrow symbol), 20, 35
- * (asterisk), 28
- @ (at sign), 25
- \\" (backslash escape sequence), 16
- { } (braces), 16
- : (colon), 29
- + (concatenation operator), 14
- (decrement operator), 12
- / (division operator), 10
- \$ (dollar sign), 15
- \\$ (dollar sign escape sequence), 16
- !! (double-bang or null assertion operator), 18
- ?:(Elvis operator), 17–18
- == (equality operator), 12
- > (greater-than operator), 12
- ++ (increment operator), 12
- != (inequality operator), 12
- < (less-than operator), 12
- = (main assignment operator), 12
- :: (member reference operator), 33
- % (modulo operator), 11, 155
- * (multiplication operator), 10
- ! (NOT operator), 13
- += operator, 53
- = operator, 53
- .. operator, 22
- || (OR operator), 13
- ?· (safe call operator), 17–18
- (subtraction operator), 10

A

- A* search algorithm, xxix, 288, 288–300
 - code for, 292–297
 - display helper functions, 294–295
- g-score, h-score, and f-score, 288
- heuristic functions, 289–291
 - admissible and consistent, 289
 - approaches for generating, 289–290
- result, 298–299
- steps in algorithm, 291–292
- abstract classes, 68, 71–72
 - declaring, 71
 - interfaces vs., 74
- abstraction, heuristic function
 - generation through, 290
- abstract keyword, 71–72
- acceleration coefficients, 348
- access modifiers, 63–64
- ACS algorithm. *See* ant colony system algorithm
- action event listeners, 120–123
- addAll() method, 99, 101, 105, 119
- add() function, 30–34, 53, 55, 80, 98–99, 145, 282
- addition operator (+), 10
- addTask() method, 80
- addToProcessedText() function, 163
- ad hoc selection of h-scores, 289–290
- agent-based algorithms, xxv–xxvi, 345–377. *See also* ant colony system algorithm; particle swarm optimization

alphabet in L-system, 242, 242
amplitude, 189
AnchorPane container, 97
AND operator (`&&`), 13
angular displacement, 190–191, 198
angular velocity, 191, 198
animation
 frame rate, 120
 JavaFX, 115–123
 bouncing ball animation, 118–123
 square animation, 116–117
ant colony system (ACS) algorithm, 356–361, 357
NP-hard problems, 358
pseudocode, 360–361
symbols, 358, 358–359
tour construction, 359–360
traveling salesman problem, 361–376
 updating pheromone
 trails, 360
`appendText()` method, 40
Application class, 92
`applyFunction()` function, 34
apps. *See* computer programs
`area()` method, 72–73
`argmax` function, 358
arguments, 29
 named, 31–32
arithmetic operators, 10–11
`Array` constructor, 49–50
`ArrayDeque` class, 282
`arrayOf()` function, 48, 50–52
arrays, xxiv, 48–52
 `Array` constructor, 49–50
 indexes, 48
 methods, 50, 50–51
 multidimensional, 51–52
 operations, 50
 primitive, 49
arrow symbol (`->`), 20, 35
assignment operators, 12
`aStar()` function, 295–297
asterisk (*), 28
astronomical unit (AU), 211
at sign (@), 25
axiom in L-system, 242, 242
Azul JDK FX, 90
Azul Zulu JDK, 90

B

Babylonian square root algorithm, xxvii, 128–130
 code for, 129–130
 origin of, 128
 result, 130
 steps in, 128
`babylonianSquareRoot()` function, 129
backslash escape sequence (\\"), 16
bar charts, xxvi, 99–102
 code for, 99–101
 result, 101–102, 102
BFS. *See* breadth-first search
`bfsQueue()` function, 286
big O notation, 266–267
binary star system simulation, xxviii, 209–220
 code for, 212–219
 result, 220, 220
 science behind, 210, 210
 strategy for, 211–212
`bisection()` function, 180
bisection method, 178, 178–180
Boolean data type, 7, 8
BorderPane container, 97
bouncing ball animation, xxvii, 118–123, 123
 action event listeners, 120–123
 setting keyframes explicitly, 118–119
`bouncyBall()` method, 122
braces ({ }), 16
breadth-first search (BFS), xxix, 284–287
 code for, 285–286
 FIFO principle, 284–285
 result, 286–287, 287
 steps in algorithm, 285
 time and space complexity, 281
`break` keyword, 23–24
Brown, Robert, 165
Brownian motion, 165
`buildAntTour()` function, 370–371
bytecode, 383
Byte data type, 8

C

- calcRMS1d() function, 169–170
- calculateEarthMetrics() function, 138–139
- calculateEdges() function, 366–367
- calculatePheromone0() function, 365, 367–368
- calculator, console-based, xxvi, 40–44
 - code for, 41–44
 - result, 44
- camelCase, 5
- cannonball flight prediction, xxvii, 175–182, 176
 - bisection method, 178, 178–180
 - code for, 179
 - numerical method, 178
 - result, 181, 181
 - strategy for, 178–179
 - trajectories, 181, 182
- canvas in JavaFX, 107–115
 - drawing simple shapes, 107–108, 108
 - graphics context, 107
 - common methods, 109, 109–110
 - spiral seashell drawing, 110–117
- Char data type, 7, 8
- charts, 98–105
 - bar charts, 99–102
 - multiseries line charts, 102–105
 - steps for creating, 99
- child classes, 65–67
- child nodes, 97–98
- ciphertext, 154
- circumference of Earth, calculating, xxvii, 136, 136–139
- classes, xxiv, 57
 - common, 67–75
 - abstract, 68, 71–72
 - data, 68, 68–69
 - enum, 68, 74–75
 - interface, 68, 72–73
 - pair, 68, 70–71
 - triple, 68, 70
 - constructors, 58–61
 - primary, 58–59
 - secondary, 59–61
- declaring, 57–58
- encapsulation, 63–64
- inheritance, 65–67
- init block, 61–62
- instances and instantiation, 57–58
- methods, 62
- naming, 7
- polymorphism, 65–67
- subclasses, 57
- this keyword, 64–65
- ::class.java construct, 94
- class keyword, 57
- clear() method, 54
- coding, xxii
 - benefits of learning, xxii
 - code examples on GitHub, xxx
 - key terms, xxx
 - workflow, 383–384
- coffee cooling physics, xxviii, 200–209
 - code for, 202–209
 - calculating temperature changes, 206–207
 - plotting temperature profiles, 207–209, 208
 - effect of mixing liquids, 201
 - Newton’s law of cooling, 200
 - strategy for, 201–202, 202
- collections, xxiv, 52–57
 - lists, 52–54
 - mutable, 53–54
 - read-only, 52–53
 - maps, 56
 - sets, 54–55
- colon (:), 29
- comments, 4–5
 - documentation, 4–5
 - multiline, 4–5
 - single-line, 4
 - syntax, 4–5
- compilers, 383
- computer programs (software; apps), 382
- creation workflow, 383–384
- concatenation, 14–15
 - method chaining, 15
 - operator (+), 14–15
 - techniques for, 15–16

conditional statements, 18–21
 if statements, 19–20
 when statements, 20–21
console-based calculator, xxvi, 40–44
 code for, 41–44
 result, 44
constants, 6–7, 7
const keyword, 6–7
constructors, 49–50, 58–61
 primary, 58–59
 secondary, 59–61
contains() function, 55
containsKey() function, 56
continue keyword, 23
copying objects, 75–78
 deep copy, 76–78
 shallow copy, 75–76
copy() method, 68, 75–78
 deep copy, 77–78
 shallow copy, 75–76
cos() function, 112–113
createCoolingChart() function, 207
createRWChart1() and createRWChart2()
 functions, 170, 172
crossover, 311, 314–315
 real-coded genes, 314–315
 single-point crossover, 314, 314
crossover() function, 319, 321,
 329, 336

D

data classes, 68, 68–69
data structures
 arrays, 48–52
 Array constructor, 49–50
 methods, 50, 50–51
 multidimensional, 51–52
 primitive, 49
 classes, 57–75
 constructors, 58–61
 encapsulation, 63–64
 inheritance, 65–67
 init block, 61–62
 methods, 62
 polymorphism, 65–67
 this keyword, 64–65
collections, 52–57
 lists, 52–54
maps, 56
sets, 54–55
console-based task manager, 78–85
copying objects, 75–78
 deep copy, 76–78
 shallow copy, 75–76
data types, 7–10
 casting (conversion), 9–10
 common, 8
 inferring, 8–9
 suffixes, 9
data visualization. *See* visualization
debugging, 383–384
deconstruction, 69
decrement operator (–), 12
decrypt() function, 163
decryptIndexBlock() function, 163
deepCopyPerson() function, 77
deleteTask() method, 83
depth-first search (DFS), xxix, 280–284
depth in L-system, 242, 242
 code for, 281–282
 LIFO principle, 281
 result, 282–284, 283
 steps in algorithm, 280–281
 time and space complexity, 285
describe() method, 72
determinants in encryption, 155
deterministic systems, 164
dfsStack() function, 282
displayGraph() function, 294
displayInfo() method, 65
displayList() function, 294
displayProduct() function, 161
displayShortestPath() function,
 294–295
division operator (/), 10
documentation comments, 4–5
dollar sign (\$), 15
dollar sign escape sequence (\\$), 16
domain-specific knowledge, 289
Dorigo, Marco, 356
dot notation, 10
double-bang operator (!!), 18
Double data type, 7, 8
do...while loops, 27
downTo keyword, 23
drawCircle() method, 112–114

drawFibonacciSpiral() function,
 145–146
drawFountain() function, 188
draw() function, 247–248
 drawing
 Fibonacci spiral, 141–142, 142,
 145–147
JavaFX
 canvas, 107–115
 graphics context, 107, 109,
 109–110
 simple shapes, 107–108
 spiral seashell, 110–115
drawMSet() function, 256, 259
drawMultiTurnSpiral() method,
 112–113
drawNozzles() function, 188
drawRectangle() method, 108
drawSquares() function, 231–232
drawStars() function, 217–218
drawTree() function, 240–241
drawTriangle() function, 237

E

Earth’s circumference, xxvii, 136,
 136–139
 code for, 138–139
 Eratosthenes’s calculation,
 136–138
 exterior angle theorem, 137
 result, 139
Eggholder function, 308, 309, 332–336,
 339–340, 340, 350–351,
 355, 355–356

Einstein, Albert, 165
 elitism, 315
else clause, 19–20
 Elvis operator (`?:`), 17–18
 encapsulation, 63–64
 access modifiers, 63–64
encrypt() function, 163
encryptIndexBlock() function, 163
 encryption, 154
 Hill cipher, xxvii, 154–164
 enums, 68, 74–75
 equality operator (`==`), 12
equals() method, 68
 Eratosthenes, 133, 136–138

escape sequences, 16
 Euclid’s formula
 code for, 130–131
 creating Pythagorean triples with,
 xxvii, 130–132
 primitive triples, 131
 result, 132
 steps in, 130
 Euler-Cromer numerical method,
 191–192
 evolving gibberish into Shakespeare,
 xxix, 316–323
 code for, 316
 driver function, 318–320
 global declarations, 316–317
 initializing population
 and fitness evaluation,
 317–318
 operator functions, 320–321
 result, 321–322
 strategy for, 316
 executable files, 383
exitProcess() function, 42
 expressions, 9

F

Fibonacci (Leonardo of Pisa), 139–140
 Fibonacci sequence, xxvii, 139–148
 code for, 143–147
 drawing the spiral, 145–147
 generating the sequence, 145
 printing the sequence, 147
 setting up, 143–145
 Fibonacci spiral, 141–142, 142
 golden ratio, 141, 141
 rabbit analogy, 140, 140
 result, 147–148
 steps in sequence, 140
 Fibonacci spiral, 141–142, 142
FibonacciSpiral application class,
 143–144
File class, 39–40
fill0val() method, 114
fillText() function, 114
 fitness, 310
 initializing evaluation of, 317–318,
 326–327, 335–336
Float data type, 7–8, 8

- flow control, 18–27
 conditional statements, 18–21
 if statements, 19–20
 when statements, 20–21
 loops, 22
 break keyword, 23–24
 continue keyword, 23
 for loops, 22–23
 named for loops, 24–26
 nested for loops, 24–26
 while loops, 26–27
- FlowPane container, 97
- for loops, 22–26
 break keyword, 23–24
 continue keyword, 23
 named, 24–26
 nested, 24–26
 step value, 22
- fractals, 225–263. *See also* L-system;
 Mandelbrot set
 concept of, 226
 fractal dimension, 227
 fractal trees, xxviii, 239–242
 code for, 240–241, 241
 strategy for, 239, 239–240
“Hello, World!” project,
 229–234
recursive functions, 227–229, 228
- Sierpiński triangles, 226, 226–227,
 227, 234–239
- frame rate, 120
- free diffusion, 165
- frequency, 189
- function overloading, 29, 32–33
- functions, 27–34
 custom, 29–34
 arguments, 29
 conditional expression
 syntax, 33
 declaring, 29
 named arguments, 31–32
 overloading, 29, 32–33
 parameters, 29
 providing default parameter
 values, 31
 referencing functions without
 calling, 33–34
- return type, 29
- signatures, 29
- single-expression functions,
 30–31
- higher-order, 35
- importing, 28
- invoking, 10
- mathematical, 28–29
- methods vs., 10
- naming, 7
- scope, 34–35
- G**
- generateFibonacciNumbers()
 function, 145
- generate() function, 246–247
- generatePythagoreanTriple() function,
 131–132
- genetic algorithms, xxv, 305–343.
 See also genetic operators;
 nature-inspired
 algorithms
chromosomes, 310
evolving gibberish into
 Shakespeare, 316–323
- fitness, 310
- key components of, 310–311
- knapsack problem, 323–332
- multivariate function optimization,
 332–341
- stopping condition for, 341–342
- genetic operators, 310, 311–315
 crossover, 311, 314–315
 elitism, 315
 mutation, 310–311, 315
 selection, 311–314
- getAngleAndVel() function, 186–187
- getArithmeticOperation() function, 43
- getConvergence() function, 256–258
- getData() function, 101
- getFactorial() function, 228,
 228–229
- getFitness() function, 317–318, 321,
 327, 334, 336, 353
- getGraphicsContext2D() method, 108
- getHScore() function, 291, 297
- getIndexBlock() function, 163

- `getMaleData()` and `getFemaleData()` functions, 104
- `get()` method, 14, 56
- `getText()` function, 159, 161
- `getTrajectories()` function, 186–188
- GitHub, xxx
- global minima and optima, 308, 308
- `globalPheromoneUpdate()` function, 372
- golden ratio, 141, 141
- graphical user interfaces (GUIs), 37
- greater-than operator (`>`), 12
- `greet()` function, 31
- `GridPane` container, 97
- H**
- `hashCode()` method, 68
- hash codes, 68
- `hasNextLine()` method, 39
- `haversineDistance()` function, 152–153
- haversine formula, 148–153
- heap sort
- compared to other sorting algorithms, 268
 - features of, 267
- “Hello, world!” projects
- creating, 385–387, 386, 387, 388
 - fractals, xxviii, 229–234
 - code for, 231–234, 232
 - strategy for, 230, 230–231
 - JavaFX, xxvi, 90–95
 - code for, 91, 92, 92–94
 - result, 93, 95
- Heron of Alexandria, 128
- heuristic search, 288–300, 309
- higher-order functions, 35
- Hill, Lester S., 154
- Hill cipher, xxvii, 154–164
- code for, 157–163
 - helper functions, 159–163
 - variables and data structures, 157–158
 - decryption steps, 157
 - encryption steps, 156–157
 - multiplying two matrices, 160–161
 - result, 163–164
 - terminology, 155–156
- hyperspaces, 309
- I**
- identity matrices, 155
- IDEs (integrated development environments), 4, 382–383
- `if...else` structure, 19–20
- `if` statements, 19–20
- `import` keyword, 28
- increment operator (`++`), 12
- indexed characters, 14
- inequality operator (`!=`), 12
- inheritance, 65–67
- `init` block, 61–62
- `initializeAnts()` function, 369
- `initializePheromone()` function, 365, 368
- `initialPositions()` function, 215–216
- `initPopulation()` function, 317–318, 321, 326, 330, 338
- `initSwarm()` function, 351–352, 354
- input and output, 37–40
- console based, 37–38
 - file operations, 39
- insertion sort, xxviii, 268–270
- code for, 269–270
 - compared to other sorting algorithms, 267
 - features of, 267
 - result, 270
 - steps in algorithm, 268–269
- `insertionSort()` function, 269–270
- `intArrayOf()` function, 52
- Int data type, 7–8, 8
- integrated development environments (IDEs), 4, 382–383
- IntelliJ IDEA, 4, 90–91
- creating new projects, 385–387, 386, 387, 388
 - downloading and installing, 384
- interfaces, 68, 72–73
- abstract classes vs., 74
 - defining, 73
- intermediate code, 382
- internal access modifier, 64
- `intersect()` function, 55
- `introduce()` method, 63
- inverse matrices, 155

J

Java, xxii
Java Archive (JAR) files, 384
Java Development Kit (JDK), 89, 383
 downloading and setting up, 385
JavaFX, 88, 89–123. *See also* charts
 animation, 115–123
 bouncing ball animation,
 118–123
 square animation, 116–117
 creating projects in, 91
 drawing with the canvas, 107–115
 “Hello, world!” project, 90–95
 key functionalities of, 89–90
 object hierarchy, 96–98
 child nodes, 98
 layout containers, 97–98
 Scene objects, 96–97
 Stage object, 96
 overview, 89–95
 setting up, 90
Java Runtime Environment (JRE), 383
Java Virtual Machine (JVM), xxii, 383
JDK. *See* Java Development Kit
JetBrains, xxii
Jetpack Compose, 88
`joinToString()` method, 54
JRE (Java Runtime Environment), 383
JVM (Java Virtual Machine), xxii, 383

K

KeyFrame objects, 118–119, 122
keywords, 5
knapsack problem, xxix, 323–332
 code for, 324–330
 driver function, 327–328
 global parameters, 324–326
 initializing population and
 fitness evaluation,
 326–327
 operator functions, 328–329
 problem definition, 324–326
 result, 330–332
 strategy for, 323–324

Kotlin

 advantages of, xxiii
 app creation workflow, 383–384

basic skills, xxiv, 3–45
 comments, 4–5
 flow control, 18–27
 functions, 27–34
 input and output, 37–40
 lambda expressions, 35–36
 null and nullable types, 17–18
 operators, 10–14
 scope functions, 34–35
 strings, 14–16
 variables, 5–10
code examples on GitHub, xxx
creating new projects, 385–387,
 386, 387, 388
Java and, xxii–xxiii
origin of, xxii

L

lambda expressions (lambdas),
 35–36
 parameters, 36
layout containers, 96–98
 Group container, 97
 HBox container, 98
 Pane container, 97
 VBox container, 98
Leonardo of Pisa (Fibonacci),
 139–140
less-than operator (<), 12
Lets-Plot, 88
Liber Abaci (Fibonacci), 140
Liberica Full JDK, 90
libraries, 382
Lindenmayer, Aristid, 241
`listOf()` function, 52–53
lists, 40, 52–54
 mutable, 53–54
 read-only, 52–53
`listTasks()` method, 81–82
local minima and optima, 308,
 308–309, 309
logical operators, 13, 13–14
Long data type, 8, 8
loops, 22–27
 `do...while` loops, 27
 `for` loops, 22–26
 `break` keyword, 23–24
 `continue` keyword, 23

- named, 24–26
 - nested, 24–26
 - `while` loops, 26–27
 - L-system, 241–245
 - components of, 242, 242
 - drawing patterns with Turtle Graphics, 243–245, 244
 - notations and procedures, 243, 243
 - `LSystemApp` class, 249–251
 - L-system simulator, xxviii, 245–252
 - code for, 245–251
 - global declarations, 245
 - problem definition, 246
 - fractal examples, 251, 252
 - result, 251, 251, 252
- M**
- machine code, 382
 - main assignment operator (`=`), 12
 - Mandelbrot, Benoit, 226
 - Mandelbrot set, 252–254
 - bulbs, 260, 260
 - cardioid, 260, 260
 - complex plane, 254
 - elephant valley, 260, 260–261, 261
 - orbits, 253, 253–254, 254
 - other fractals vs., 252
 - quadratic and recursive functions, 252–253
 - seahorse valley, 260, 260–261, 261
 - Mandelbrot set project, xxviii, 254–262
 - code for, 255–259
 - checking for convergence, 257–258
 - combining code segments, 258–259
 - finding and drawing members, 256–257, 257
 - global variables, 255–256
 - result, 259–261, 260, 261
 - `map()` method, 77–78
 - `mapOf()` function, 56
 - maps, 56
 - `markTaskAsDone()` method, 82–83
 - mathematical problems, xxv, 127–174
 - Babylonian square root algorithm, 128–130
 - Earth’s circumference, 136–139
 - Euclid’s formula and Pythagorean triples, 130–132
 - Fibonacci sequence, 139–148
 - Hill cipher, 154–164
 - one-dimensional random walk simulation, 164–173
 - shortest distance between two locations, 148–153
 - sieve of Eratosthenes and prime numbers, 133–136
 - mathematical spaces, 164
 - matrices in encryption, 155
 - multiplying two, 160–161
 - member reference operator (`::`), 33
 - merge sort, xxviii–xxix, 270–274, 271
 - code for, 271–273
 - compared to other sorting algorithms, 268
 - features of, 267
 - result, 273–274
 - `mergeSort()` function, 271–273
 - methods, 62
 - array operation, 50, 50–51
 - class, 62
 - common, for type casting, 9
 - functions vs., 10
 - invoking, 10
 - object-oriented programming, 38
 - Metrica* (Heron), 128
 - modeling and simulation, xxv, 175–222
 - binary star system simulation, 209–220
 - cannonball flight prediction, 175–182
 - coffee cooling physics, 200–209
 - pendulum motion and phase tracking, 189–199
 - water jet fountain design, 182–189
 - modular multiplicative inverse (MMI), 155
 - modules, 64
 - modulo operator (`%`), 11, 155
 - modulus, 155
 - multidimensional arrays, 51–52
 - multiline comments, 4–5
 - multiplication operator (`*`), 10
 - `multiply()` function, 33–34
 - `multiplyMatricesMod29()` function, 160

multiseries line charts, xxvi, 102–105
code for, 103–105
result, 105
multivariate function optimization
with genetic algorithm, xxix,
332–341
code for, 333–338
result, 338–341
strategy for, 333
with particle swarm, xxix,
350–356
code for, 350–354
result, 354–356
`mutableListOf()` function, 53–54
mutable lists, 53–54
`mutableMapOf()` function, 56
`mutableSetOf()` function, 54
mutation, 310–311, 315, 315
`mutation()` function, 321, 329, 336–337

N

named for loops, 24–26
namespace pollution, 28
nature-inspired algorithms (NIAs),
306–310. *See also* genetic
algorithms
 decision variables, 306–307
 global minima and optima, 308, 308
 hyperspaces, 309
 local minima and optima, 308,
 308–309, 309
 objective functions, 306–308, 307
 optimization problems, 306–310
 well-behaved functions, 308
 when to use, 310
nested for loops, 24–26
newline escape sequence (`\n`), 16, 40
`newtonCooling()` function, 205–207
Newton’s law of cooling, 200
NOT operator (!), 13
NP-hard problems, 358
null, 17–18
nullable types, 17–18
null assertion operator (!!), 18
null pointer exceptions, 17
numerical method for predicting
 trajectory of
 projectiles, 178

O

objective functions, 306–308, 307
object-oriented programming, 38
objects, 38, 49
one-dimensional random walk
 simulation, xxvii, 164–173
code for, 166–170
one-dimensional model, 165,
165–166
random walks, 164
result, 170–173, 171, 172
RMS distance, 166, 168–173, 172
OpenFX project, 89
open keyword, 66
operating systems (OSs), 382
operators, 10–14
 arithmetic, 10–11
 assignment, 12
 logical, 13–14, 13
 relational, 12–13
 unary, 12
Oracle, 89
OR operator (||), 13
OSs (operating systems), 382
out-of-place sorting, 267
`override` keyword, 67

P

packages, naming, 7
pair classes, 68, 70–71
parameters, 29, 31
parent classes, 65–67
particle swarm optimization (PSO),
346–349
 acceleration coefficients, 348
 implementing for function
 minimization, 348–349
 initializing particle position and
 velocity, 346
 multivariate function optimization,
 350–356
 pseudocode, 349
 updating particle position, 346, 348
 updating particle velocity,
 346–348, 347
 velocity explosion, 348
`partition()` function, 275–277

pattern databases, heuristic function generation through, 290
 pendulum motion and phase tracking, xxviii, 189–199
 angular displacement, 190–191, 198
 angular velocity, 191, 198
 code for, 192–197
 Euler-Cromer numerical method, 191–192
 result, 197–199, 198, 199
 simple harmonic motion, 189–190
 simple pendulum, 190, 190–191
 strategy for, 191–192
 performCalculation() function, 43
 perimeter() method, 73
 period, 189
 periodic motion, 189
 plaintext, 154
 play() method, 119, 122
 Plotly, 88
 plus() method, 14
 polymorphism, 65–67
 pow() function, 28
 primary constructors, 58–59
 prime numbers, 133
 identifying with sieve of Eratosthenes, xxvii, 133–136
 code for, 134–135
 result, 135–136
 steps in algorithm, 133
 strategy for, 133–134
 primitive arrays, 49
 printBestOverallFitnessAndTour()
 function, 373
 printFibonacciSequenceAndRatios()
 function, 147
 print() function, 42
 printLatLong() function, 151–152
 println() function, 35, 42, 69, 114
 printMessage() function, 34
 printOptions() function, 79
 printParams() method, 112–114
 printPrimes() function, 135
 printProcessedText() function,
 163–164
 printTimeAndTemp() function, 205
 private access modifier, 63
 processInterimResults() function, 365,
 372–373
 programming languages, 382
 projectile() function, 180
 projectiles, 176
 cannonball flight prediction, 175–182
 water jet fountain design, 182–189
 properties, 38
 protected access modifier, 64
 PSO. *See* particle swarm optimization
 public access modifier, 63
 put() method, 56
 Pythagoras, 130
 Pythagorean triples, 130
 creating with Euclid's formula,
 xxvii, 130–132
 code for, 130–131
 primitive triples, 131
 Pythagorean theorem, 130, 131
 result, 132
 steps in formula, 130

Q

quadratic equations, 177
 queue-based searching, 284–287
 quick sort, xxix, 274–278
 alternative techniques to avoid time complexity, 275
 code for, 275–277
 compared to other sorting algorithms, 268
 features of, 267
 result, 277, 277
 steps in algorithm, 274
 quickSort() function, 275–277

R

rabbit analogy by Fibonacci, 140, 140
 randomization, 309
 RandomWalk1D application class, 168
 randomWalk1d() function, 168–169
 random walks, 164
 one-dimensional random walk simulation, 164–173
 code for, 166–170
 one-dimensional model, 165, 165–166

- random walks (*continued*)
 - one-dimensional random walk
 - simulation (*continued*)
 - result, 170–173, 171, 172
 - RMS distance, 166, 168–173, 172
 - rank-based selection, 314
 - `readCities()` function, 366
 - `readDoubleInput()` function, 42
 - `readIndex()` function, 79, 82–83
 - `readLines()` method, 40
 - `readIn()` function, 37, 44
 - read-only lists, 52–53
 - recursive functions, xxv, 227–229, 228.
 - See also* fractals
 - relational operators, 12–13
 - relaxation heuristics, 289–290
 - `removeAll()` method, 53–54
 - `removeAt()` method, 53
 - `remove()` function, 55, 56
 - root-mean-square (RMS) distance, 165, 168–173
 - roulette wheel selection, 312, 312–313, 313
 - `roundToInt()` method, 325
 - rules in L-system, 242, 242
 - `runACS()` function, 365, 368–369
 - `runGA()` function, 318–319, 321, 327–328, 338
 - `runPSO()` function, 352–354
 - `runValidation()` function, 159–160

S

 - safe call operator (?.), 17–18
 - `sayHello()` method, 62
 - Scanner class, 39–40
 - Scene objects, 96–97
 - scope functions, 34–35
 - secondary constructors, 59–61
 - `selectElites()` function, 319–321
 - selection, 311
 - rank-based, 314
 - roulette wheel, 312, 312–313, 313
 - tournament, 312, 312
 - `selectNodeToVisit()` function, 370–372
 - `setOf()` function, 54
 - sets, 54–55
 - ShapeOfWater application class, 185–186

SHM (simple harmonic motion), 189

Short data type, 8

shortest distance between two locations, finding, xxvii, 148–153

code for, 150–153

great circle concept, 148–149, 149

haversine formula, 148–153

latitude and longitude, 149

result, 153

`showChoices()` function, 42

`show()` method, 94, 99, 101, 105, 108, 122

Sierpiński triangles, xxviii, 226, 226–227, 227, 234–239

code for, 236–238, 238

L-system, 251, 252

strategy for, 235, 235

sieve of Eratosthenes, identifying prime numbers with, xxvii, 133–136

code for, 134–135

result, 135–136

steps in algorithm, 133

strategy for, 133–134

`sieveOfEratosthenes()` function, 134–135

simple harmonic motion (SHM), 189

`simplePendulumWithDrag()` function, 194–196

`SimulateBinarySystem` application class, 212–216

simulation. *See* modeling and simulation

`sin()` function, 112–113

single-line comments, 4

single-point crossover, 314, 314

`singleXYChart()` function, 196–197

software. *See* computer programs

solar year (yr), 211

sorting and searching, xxv, 265–301

 - importance of, 265–266
 - search algorithms, 278–280
 - A* search algorithm, 288–300
 - breadth-first search, 284–287
 - depth-first search, 280–284
 - graphs, 278–279, 279
 - searching graphs, 279–280
 - sorting algorithms, 266–268
 - heap sort, 267, 268
 - insertion sort, 267, 267, 268–270

merge sort, 267, 268, 270–274
quick sort, 267, 268, 274–278
space complexity, 267
stability, 267
 time complexity, 266
spiral seashell drawing, xxvi, 110–115
 code for, 111–114
 result, 115, 115
 strategy for, 110, 110–111
`sqrt()` function, 28–29
square animation, xxvi, 116–117
 code for, 116–117
 result, 117
square roots, finding with Babylonian
 algorithm, xxvii, 128–130
 code for, 129–130
 origin of algorithm, 128
 result, 130
 stable solution, 191
 steps in algorithm, 128
stack-based searching, 280–284
StackPane container, 97
stack space, 229
Stage object, 96
standard libraries, 382
`start()` method, 100–101, 108,
 112, 120–121
stochasticity, 164, 310
String data type, 7, 8
strings, 14–16
 concatenation, 14–15
 escape sequences, 16
 indexed characters, 14
 string templates, 15–16
string templates, 15–16
 complex expressions, 16
 syntax, 15
`strokeLine()` function, 241
`strokeOval()` method, 114
`strokePolygon()` function, 231, 237
`strokeRect()` method, 108
`subtract()` function, 55
subtraction operator (-), 10
Sun Microsystems, 89

T

\t (tab escape sequence), 16
tail call optimization (TCO), 229
tail recursion, 229
task manager, console-based, xxvi,
 78–85
code for, 78–84
 adding tasks, 80
 deleting tasks, 83
 exiting program, 84
 listing tasks, 81
 marking tasks as done, 81–83
 result, 84–85
TCO (tail call optimization), 229
`tempAfterMixing()` function,
 205–207
text editors, 382
thermal mass, 201
this keyword, 64–65
Timeline class, 118–119, 122
`toMutableList()` function, 78
`toRadians()` function, 112–113
`toString()` method, 59, 68
tournament selection, 312, 312
TranslateTransition class, 117
traveling salesman problem, xxix,
 361–376
code for, 361
 `buildAntTour()` function,
 370–371
 `calculateEdges()` function,
 366–367
 `calculatePheromone()`
 function, 367–368
global declarations, 362–364
`globalPheromoneUpdate()`
 function, 372
`initializeAnts()` function, 369
`initializePheromone()`
 function, 368
`main()` block, 364–366
problem definition,
 362–364, 363
`readCities()` function, 366
`runACS()` function, 368–369
`selectNodeToVisit()` function,
 371–372
 result, 373–376, 375
triple classes, 68, 70
truth tables, 13, 13
try...catch blocks, 38, 40

Turtle class, 248–249
Turtle Graphics, 243–245, 244

U

unary operators, 12
`union()` function, 55
`updateAndDrawTrails()` function, 219
`updateInfo()` method, 65
`updateStarPositions()` function, 217

V

`val` keyword, 5
variables, 5–10. *See also* data types
 constants, 6–7
 declaring, 5–6
 initializing, 5–6
 mutable, 5
 naming, 5, 7
 read-only, 5
 syntax, 5
`var` keyword, 5–6
vectors
 in encryption, 155
 forces with magnitude and
 direction, 210
velocity explosion, 348
visualization, xxiv, 87–124
 animation, 115–123
 bouncing ball animation,
 xxvii, 118–123
 square animation, xxvi,
 116–117
charts, 98–105
 bar charts, xxvi, 99–102

multiseries line charts, xxvi,
 102–105
drawing with the canvas, xxvi,
 107–115
“Hello, world!” project, xxvi,
 90–95
object hierarchy, 96–98
overview, 89–95
tools for, 88

W

Waclaw Sierpiński, 226
water jet fountain design, xxviii,
 182–189
code for, 184
 `getAngleAndVel()` function,
 186–187
 `getTrajectories()` function,
 187–188
 `ShapeOfWater` application class,
 185–186
displacement equations, 177
nozzles, 183, 183
parameters, 183
result, 188, 188–189
strategy for, 184
well-behaved functions, 308
when expression, 80
when statements, 20–21
while loops, 26–27, 38, 80

Y

Yale University Library, 128
yr (solar year), 211