CONTENTS

PREFACE *xxv*

PART I THE JAVA LANGUAGE 1

CHAPTER 1 Java Programming Fundamentals 3

1.1 Computing Basics 4
The Hardware Components of a Computer 4
Bits, Bytes, and Binary 5
The Operating System 6
1.2 The Program *6*
1.3 Programming Languages *7*
1.4 The Java Language *8*
The Origins of Java 8
Java's Contribution to the Internet 9
Java Applets 10
Security 10
Portability 10
Java's Solution: The Bytecode 10
The Evolution of Java 11
1.5 The Key Attributes of Object-Oriented Programming 12
Encapsulation 13
Polymorphism 13
Inheritance 14
1.6 The Java Development Kit 14
1.7 A First Simple Program 15
Entering the Program 16
Compiling the Program 16
Running the Program 16
The First Sample Program Line by Line 17
1.8 Handling Syntax Errors *19*
1.9 A Second Simple Program *19*
1.10 Another Data Type *21*
1.11 Two Control Statements *24*
The if Statement 24
The for Loop 26
1.12 Create Blocks of Code *28*
1.13 Semicolons and Positioning *29*
1.14 Indentation Practices *30*
1.15 The Java Keywords *32*

1.16 Identifiers in Java *33*
1.17 The Java Class Libraries *34*
Exercises 34
Viva Voce Questions 36
Objective Questions 36

CHAPTER 2 Introducing Data Types and Operators **37**
2.1 Why Data Types Are Important *37*
2.2 Java's Primitive Types *37*
Integers 38
Floating-Point Types 40
Characters 40
The Boolean Type 41
2.3 Literals *44*
Hexadecimal, Octal, and Binary Literals 44
Character Escape Sequences 45
String Literals 45
2.4 A Closer Look at Variables *46*
Initializing a Variable 47
Dynamic Initialization 47
2.5 The Scope and Lifetime of Variables *47*
2.6 Operators *50*
2.7 Arithmetic Operators *51*
Increment and Decrement 51
2.8 Relational and Logical Operators *52*
2.9 Short-Circuit Logical Operators *54*
2.10 The Assignment Operator *56*
2.11 Shorthand Assignments *57*
2.12 Type Conversion in Assignments *57*
2.13 Using a Cast *59*
2.14 Operator Precedence *61*
2.15 Expressions *62*
Type Conversion in Expressions 62
Spacing and Parentheses 64
Exercises 64
Viva Voce Questions 67
Objective Questions 67

CHAPTER 3 Program Control Statements **68**
3.1 Input Characters from the Keyboard *68*
3.2 The if Statement *70*
3.3 Nested **ifs** *71*
3.4 The **if-else-if** Ladder *72*
3.5 The **switch** Statement *73*
3.6 Nested **switch** Statements *77*
3.7 The **for** Loop *80*
3.8 Some Variations on the **for** Loop *81*

Missing Pieces 82
The Infinite Loop 83
Loops with No Body 83
3.9 Declaring Loop Control Variables Inside the **for** Statement *84*
3.10 The Enhanced **for** Loop *85*
3.11 The **while** Loop *85*
3.12 The **do-while** Loop *87*
3.13 Use **break** to Exit a Loop *92*
3.14 Use **break** as a Form of **goto** *94*
3.15 Use **continue** *97*
3.16 Nested Loops *103*
Exercises 104
Viva Voce Questions 106
Objective Questions 106

CHAPTER 4 Introducing Classes, Objects, and Methods **108**
4.1 Class Fundamentals 108
The General Form of a Class 109
Defining a Class 109
4.2 How Objects are Created *112*
4.3 Reference Variables and Assignment *113*
4.4 Methods 114
Adding a Method to the Vehicle Class 114
4.5 Returning from a Method *116*
4.6 Returning a Value *117*
4.7 Using Parameters *119*
Adding a Parameterized Method to Vehicle 121
4.7 Constructors *128*
4.8 Parameterized Constructors *129*
Adding a Constructor to the Vehicle Class 130
4.9 The **new** Operator Revisited *132*
4.10 Garbage Collection and Finalizers *132*
The finalize( ) Method 133
4.11 The **this** Keyword *136*
Exercises 138
Viva Voce Questions 140
Objective Questions 140

CHAPTER 5 More Data Types and Operators **141**
5.1 Arrays *141*
One-Dimensional Arrays 142
5.2 Multidimensional Arrays *147*
Two-Dimensional Arrays 147
Irregular Arrays 148
Arrays of Three or More Dimensions 149
Initializing Multidimensional Arrays 149
5.3 Alternative Array Declaration Syntax *151*
5.4 Assigning Array References *151*

5.5 Using the **length** Member *152*
5.6 The For-Each Style **for** Loop *160*
Iterating Over Multidimensional Arrays 163
*Applying the Enhanced **for** 164*
5.7 Strings *165*
Constructing Strings 165
Operating on Strings 166
Arrays of Strings 167
Strings Are Immutable 168
*Using a String to Control a **switch** Statement 169*
5.8 Using Command-Line Arguments *170*
5.9 The Bitwise Operators *172*
The Bitwise AND, OR, XOR, and NOT Operators 172
The Shift Operators 176
Bitwise Shorthand Assignments 178
5.10 The ? Operator *181*
Exercises 183
Viva Voce Questions 185
Objective Questions 185

CHAPTER 6 A Closer Look at Methods and Classes **187**
6.1 Controlling Access to Class Members *187*
Java's Access Modifiers 188
6.2 Pass Objects to Methods *193*
6.3 How Arguments are Passed *194*
6.4 Returning Objects *196*
6.5 Method Overloading *198*
6.6 Overloading Constructors *203*
6.7 Recursion *208*
6.8 Understanding **static** *212*
Static Variables 212
Static Methods 214
Static Blocks 216
6.9 Introducing Nested and Inner Classes *220*
6.10 Varargs: Variable-Length Arguments *223*
Varargs Basics 223
Overloading Varargs Methods 226
Varargs and Ambiguity 228
Exercises 229
Viva Voce Questions 232
Objective Questions 233

CHAPTER 7 Inheritance **234**
7.1 Inheritance Basics *234*
7.2 Member Access and Inheritance *237*
7.3 Constructors and Inheritance *240*
7.4 Using **super** to Call Superclass Constructors *241*
7.5 Using **super** to Access Superclass Members *245*

7.6 Creating a Multilevel Hierarchy *249*
7.7 When are Constructors Executed? *252*
7.8 Superclass References and Subclass Objects *253*
7.9 Method Overriding *258*
7.10 Overridden Methods Support Polymorphism *260*
7.11 Why Overridden Methods? *262*
Applying Method Overriding to TwoDShape 262
7.12 Using Abstract Classes *266*
7.13 Using **final** *270*
final Prevents Overriding 270
final Prevents Inheritance 271
Using final with Data Members 271
7.14 The **Object** Class *273*
Exercises 273
Viva Voce Questions 275
Objective Questions 275

CHAPTER 8 Interfaces **277**
8.1 Interface Fundamentals *277*
8.2 Creating an Interface *278*
8.3 Implementing an Interface *279*
8.4 Using Interface References *282*
8.5 Implementing Multiple Interfaces *285*
8.6 Constants in Interfaces *292*
8.7 Interfaces Can Be Extended *293*
8.8 Nested Interfaces *294*
8.9 Final Thoughts on Interfaces *296*
Exercises 296
Viva Voce Questions 297
Objective Questions 297

CHAPTER 9 Packages **299**
9.1 Package Fundamentals *299*
Defining a Package 300
Finding Packages and CLASSPATH 300
A Short Package Example 301
9.2 Packages and Member Access 302
A Package Access Example 303
Understanding Protected Members 305
9.3 Importing Packages 307
Importing Java's Standard Packages *308*
9.4 Static Import *311*
Exercises 314
Viva Voce Questions 316
Objective Questions 316

CHAPTER 10 Exception Handling **318**
10.1 The Exception Hierarchy 318

10.2 Exception Handling Fundamentals 319
Using try and catch 319
A Simple Exception Example 320
10.3 The Consequences of an Uncaught Exception *322*
10.4 Exceptions Enable You to Handle Errors Gracefully *323*
10.5 Using Multiple **catch** Clauses *325*
10.6 Catching Subclass Exceptions *326*
10.7 **try** Blocks Can Be Nested *327*
10.8 Throwing an Exception *329*
Rethrowing an Exception 329
10.9 A Closer Look at Throwable *331*
10.10 Using finally *332*
10.11 Using throws *335*
10.12 Java's Built-in Exceptions *336*
10.13 New Exception Features Added by JDK 7 *338*
10.14 Creating Exception Subclasses *339*
Exercises 346
Viva Voce Questions 349
Objective Questions 349

CHAPTER 11 Using I/O **350**

11.1 Java's I/O Is Built on Streams *351*
11.2 Byte Streams and Character Streams *351*
11.3 The Byte Stream Classes *351*
11.4 The Character Stream Classes *352*
11.5 The Predefined Streams *353*
11.6 Using the Byte Streams *353*
Reading Console Input 353
Writing Console Output 355
11.7 Reading and Writing Files Using Byte Streams *356*
Inputting from a File 356
Writing to a File 360
11.8 Automatically Closing a File *362*
11.9 Reading and Writing Binary Data *365*
11.10 Random-Access Files *369*
11.11 Using Java's Character-Based Streams *372*
Console Input Using Character Streams 372
Console Output Using Character Streams 375
11.12 File I/O Using Character Streams *377*
Using a FileWriter 377
Using a FileReader 378
File 379
Obtaining a File's Properties 379
Obtaining a Directory Listing 381
Using FilenameFilter 382
The listFiles( ) Alternative 383
Various File Utility Methods 383

11.13 Using Java's Type Wrappers to Convert Numeric Strings *385*
Exercises 393
Viva Voce Questions 397
Objective Questions 397

CHAPTER 12 Multithreaded Programming 398
12.1 Multithreading Fundamentals *398*
12.2 The **Thread** Class and **Runnable** Interface *399*
12.3 Creating a Thread *400*
Some Simple Improvements 402
12.4 Creating Multiple Threads *407*
12.5 Determining When a Thread Ends *409*
12.6 Thread Priorities *412*
12.7 Synchronization *413*
12.8 Using Synchronized Methods *414*
12.9 The **synchronized** Statement *417*
12.10 Thread Communication Using **notify( )**, **wait( )**, and **notifyAll( )** *419*
An Example That Uses wait( ) and notify( ) 420
12.11 Suspending, Resuming, and Stopping Threads *425*
Exercises 429
Viva Voce Questions 433
Objective Questions 433

CHAPTER 13 Enumerations, Autoboxing, and Annotations 434
13.1 Enumerations 434
Enumeration Fundamentals 435
13.2 Java Enumerations are Class Types 437
13.3 The **values( )** and **valueOf( )** Methods 437
13.4 Constructors, Methods, Instance Variables, and Enumerations 439
Two Important Restrictions 440
13.5 Enumerations Inherit Enum *441*
13.6 Autoboxing *448*
Type Wrappers and Boxing 448
Autoboxing Fundamentals 449
Autoboxing and Methods 450
Autoboxing/Unboxing Occurs in Expressions 452
A Word of Warning 453
13.7 Annotations (Metadata) *454*
Creating and Using an Annotation 454
Built-in Annotations 455
Exercises 457
Viva Voce Questions 459
Objective Questions 460

CHAPTER 14 Generics 461
14.1 Generics Fundamentals *461*
A Simple Generics Example 462
Generics Work Only with Objects 465

Generic Types Differ Based on Their Type Arguments 465
A Generic Class with Two Type Parameters 466
The General Form of a Generic Class 467
14.2 Bounded Types *468*
14.3 Using Wildcard Arguments *471*
14.4 Bounded Wildcards *474*
14.5 Generic Methods *477*
14.6 Generic Constructors *479*
14.7 Generic Class Hierarchies *479*
14.8 Generic Interfaces *483*
14.9 Raw Types and Legacy Code *490*
14.10 Type Inference with the Diamond Operator *492*
14.11 Erasure *494*
14.12 Ambiguity Errors *494*
14.13 Some Generic Restrictions *495*
Type Parameters Cannot Be Instantiated 495
Restrictions on Static Members 495
Generic Array Restrictions 496
Generic Exception Restriction 497
Exercises 497
Objective Questions 500
Viva Voce Questions 501

CHAPTER 15 Applets and the Remaining Java Keywords **502**
15.1 Applet Basics *502*
15.2 A Complete Applet Skeleton *505*
15.3 Applet Initialization and Termination *506*
15.4 A Key Aspect of an Applet's Architecture *507*
15.5 Requesting Repainting *507*
15.6 Using the Status Window *512*
15.7 Passing Parameters to Applets *513*
15.8 The Remaining Java Keywords *515*
The volatile Modifier 515
The transient Modifier 515
instanceof 515
strictfp 516
assert 516
Native Methods 517
Exercises 518
Viva Voce Questions 519
Objective Questions 520

CHAPTER 16 Introduction to Object-Oriented Design **521**
16.1 Elegant Software and Why It Matters *521*
Properties of Elegant Software 523
16.2 Elegant Methods 524
Naming Conventions 524
Method Cohesion 525

Well-formed Objects 527
Internal Documentation 528
External Documentation 529
16.3 Elegant Classes 531
Class Cohesion and the Expert Pattern 531
Avoiding Duplication 533
Complete Interface 534
Design with Change in Mind 535
Demeter's Law 537
16.4 Inheritance Versus Delegation *539*
UML Class Diagrams 539
Code Reuse Perspective 541
The Is-a Relationship 541
Similar Behavior 543
Polymorphism 546
Costs of Inheritance 546
16.5 Design Patterns *549*
Adapter Pattern 549
Observer Pattern 552
Exercises 557
Viva Voce Questions 560
Objective Questions 561

PART II INTRODUCING GUI PROGRAMMING WITH SWING 563

CHAPTER 17 Swing Fundamentals 565
17.1 The Origins and Design Philosophy of Swing *565*
17.2 Components and Containers *567*
Components 568
Containers 568
The Top-Level Container Panes 568
17.3 Layout Managers *569*
17.4 A First Simple Swing Program *570*
The First Swing Example Line by Line 571
17.5 Event Handling *575*
Events 575
Event Sources 575
Event Listeners 576
Event Classes and Listener Interfaces 576
Adapter Classes 576
17.6 Using a Push Button *578*
17.7 Introducing **JTextField** *586*
17.8 Use Anonymous Inner Classes to Handle Events *597*
Exercises 598
Viva Voce Questions 599
Objective Questions 600

CHAPTER 18 Exploring Swing Controls 601
18.1 **JLabel** and ImageIcon *602*

18.2 The Swing Buttons *604*
Handling Action Events 605
Handling Item Events 605
JButton 606
JToggleButton 608
Check Boxes 610
Radio Buttons 612
JTextField 615
JScrollPane 624
JList 630
JComboBox 633
18.3 Trees *637*
JTable 640
18.4 A Brief Word about Models *643*
Exercises 643
Viva Voce Questions 645
Objective Questions 646

CHAPTER 19 Working with Menus **647**
19.1 Menu Basics *647*
19.2 An Overview of **JMenuBar**, **JMenu**, and **JMenuItem** *648*
JmenuBar 648
JMenu 649
JMenuItem 650
19.3 Create a Main Menu *651*
19.4 Add Mnemonics and Accelerators to Menu Items *655*
19.5 Add Images and Tooltips to Menu Items *657*
19.6 Use **JRadioButtonMenuItem** and **JCheckBoxMenuItem** *664*
Exercises 666
Viva Voce Questions 667
Objective Questions 668

CHAPTER 20 Dialogs **669**
20.1 JOptionPane *670*
20.2 showMessageDialog( ) *671*
20.3 showConfirmDialog( ) *675*
20.4 showInputDialog( ) *679*
20.5 showOptionDialog( ) *683*
20.6 JDialog *688*
20.7 Create a Modeless Dialog *692*
20.8 Select Files with JFileChooser *693*
Exercises 703
Objective Questions 705
Viva Voce Questions 705

CHAPTER 21 Threading, Applet, and Painting **706**
21.1 Multithreading in Swing *706*
21.2 Use **Timer** *712*

21.3 Create Swing Applets *717*
A Simple Swing Applet 718
21.4 Painting *725*
Painting Fundamentals 725
The Graphics Context 725
Compute the Paintable Area 726
Request Painting 727
A Paint Example 727
Exercises 731
Viva Voce Questions 733
Objective Questions 733

PART III EXPLORING THE JAVA API LIBRARY 735

CHAPTER 22 String Handling **737**
22.1 String Fundamentals *737*
22.2 The String Constructors *738*
22.3 Three String-Related Language Features *740*
String Literals 740
String Concatenation 740
String Concatenation with Other Data Types 741
Overriding toString( ) 742
22.4 The **length()** Method *746*
22.5 Obtaining the Characters within a String *747*
charAt( ) 747
getChars( ) 747
toCharArray( ) 748
22.6 String Comparison *749*
equals( ) and equalsIgnoreCase( ) 749
equals( ) Versus == 750
regionMatches( ) 751
startsWith( ) and endsWith( ) 751
compareTo( ) and compareToIgnoreCase( ) 752
22.7 Using **indexOf( )** and **lastIndexOf( )** *754*
22.8 Obtaining a Modified String *755*
substring( ) 755
replace( ) 757
trim( ) 758
22.9 Changing the Case of Characters Within a String *759*
StringBuffer and StringBuilder 761
Exercises 761
Viva Voce Questions 763
Objective Questions 764

CHAPTER 23 Exploring java.lang **765**
23.1 Primitive Type Wrappers *766*
Number 766
Double and Float 766
Byte, Short, Integer, and Long 768

Character 770
Boolean 773
Autoboxing and the Type Wrappers 773
23.2 The Math class *774*
23.3 The **Process** Class *777*
23.4 The **ProcessBuilder** Class *777*
23.5 The **Runtime** Class *779*
23.6 The **System** Class *781*
Using currentTimeMillis( ) to Time Program Execution 781
Using arraycopy( ) 783
Obtaining Property Values 783
Redirecting Standard I/O Streams 784
23.7 The **Object** Class *785*
23.8 The **Class** Class *786*
23.9 The **Enum** Class *788*
23.10 Thread-Related Classes and the **Runnable** Interface *788*
23.11 Other Classes *788*
23.12 The **java.lang** Interfaces *789*
The Comparable Interface 789
The Appendable Interface 791
The Iterable Interface 791
The Readable Interface 792
The CharSequence Interface 792
The AutoCloseable Interface 793
Exercises 793
Viva Voce Questions 795
Objective Questions 795

CHAPTER 24 Exploring java.util **796**
24.1 The **Locale** Class *797*
24.2 Working with Date and Time *800*
Date 801
Calendar and GregorianCalendar 801
24.3 Formatting Output with Formatter 806
The Formatter Constructors 806
Formatting Basics 808
Formatting Strings and Characters 809
Formatting Numbers 809
Formatting Date and Time 810
The %n and %% Specifiers 811
Specifying a Minimum Field Width 811
Specifying Precision 813
Using the Format Flags 813
Justifying Output 814
The Uppercase Option 816
Using an Argument Index 816
Formatting for a Different Locale 817

Closing a Formatter 818
24.4 Formatting and the printf( ) Method *821*
24.5 The **Scanner** Class *822*
The Scanner Constructors 822
Scanning Basics 823
Some Scanner Examples 824
Some Other Scanner Features 828
24.6 The **Random** Class *829*
24.7 Use **Observable** And **Observer** *831*
24.8 The **Timer** and **TimerTask** Classes *834*
24.9 Miscellaneous Utility Classes and Interfaces *836*
Exercises 837
Viva Voce Questions 839
Objective Questions 839

CHAPTER 25 Using the Data Structures in the Collections Framework 840
25.1 An Overview of Data Structures *840*
Stacks and Queues 841
Linked Lists 841
Trees 842
Hash Tables 843
Choosing a Data Structure 843
25.2 Collections Overview *844*
25.3 The Collection Interfaces *845*
The Collection Interface 846
The List Interface 847
The Set Interface 848
The SortedSet Interface 848
The NavigableSet Interface 848
The Queue Interface 851
The Deque Interface 851
25.4 The Collection Classes *853*
The ArrayList Class 854
The LinkedList Class 857
The HashSet Class 860
The TreeSet Class 862
The LinkedHashSet Class 863
The ArrayDeque Class 865
The PriorityQueue Class 866
25.5 Accessing a Collection via an Iterator *867*
Using an Iterator 868
The For-Each Alternative to Iterators 871
25.6 Working with Maps *871*
The Map Interfaces 871
The Map Classes 875
25.7 Comparators *880*
25.8 The Collection Algorithms *882*
25.9 The **Arrays** Class *885*

25.10 The Legacy Classes and Interfaces *886*
The Enumeration Interface *886*
Vector *886*
Stack *886*
Dictionary *886*
Hashtable *886*
Properties *887*
Exercises *887*
Viva Voce Questions *889*
Objective Questions *889*

CHAPTER 26 Networking with java.net **890**
26.1 Networking Fundamentals *890*
26.2 The Networking Classes and Interfaces *891*
26.3 The **InetAddress** Class *892*
26.4 The **Socket** Class *894*
26.5 The **URL** Class *898*
26.6 The **URLConnection** Class *899*
26.7 The **HttpURLConnection** Class *903*
26.8 Datagrams *906*
DatagramSocket *906*
DatagramPacket *906*
A Datagram Example *907*
Exercises *910*
Objective Questions *911*
Viva Voce Questions *911*

CHAPTER 27 The Concurrency Utilities **912**
27.1 The Concurrent API Packages *913*
java.util.concurrent *913*
java.util.concurrent.atomic *914*
java.util.concurrent.locks *914*
27.2 Using Synchronization Objects *914*
Semaphore *914*
CountDownLatch *917*
CyclicBarrier *919*
Exchanger *922*
Phaser *924*
27.3 Using an Executor *931*
A Simple Executor Example *931*
27.4 Using **Callable** and **Future** *933*
27.5 The **TimeUnit** Enumeration *936*
27.6 The Concurrent Collections *937*
27.7 Locks *937*
27.8 Atomic Operations *941*
27.9 Parallel Programming Via the Fork/Join Framework *941*
27.10 The Main Fork/Join Classes *942*
ForkJoinTask<V> *942*

RecursiveAction *943*
RecursiveTask<V> *943*
ForkJoinPool *943*
27.11 The Divide-and-Conquer Strategy 944
A Simple First Fork/Join Example *945*
Understanding the Impact of the Level of Parallelism *947*
An Example That Uses RecursiveTask<V> *950*
Executing a Task Asynchronously *952*
27.12 The Concurrency Utilities Versus Java's Traditional Approach 952
Exercises *953*
Viva Voce Questions *955*
Objective Questions *955*

APPENDIX A Using Java's Documentation Comments **956**
A.1 The **javadoc** Tags *956*
A.2 The General Form of a Documentation Comment *960*
A.3 What **javadoc** Outputs *960*
A.4 An Example That Uses Documentation Comments *960*

APPENDIX B An Introduction to Regular Expressions **962**
B.1 The **Pattern** Class *962*
B.2 The **Matcher** Class *962*
B.3 Regular Expression Syntax Basics *963*
B.4 Demonstrating Pattern Matching *964*
B.5 Using the Wildcard Character and Quantifiers *966*
B.6 Working with Classes of Characters *967*
B.7 Using **replaceAll( )** *968*
B.8 The **String** Class Connection *968*
B.9 Things to Explore *968*

APPENDIX C Answers to Selected Exercises **969**

Index **1018**