



# What's Inside

|                              |    |  |    |
|------------------------------|----|--|----|
| Foreword                     | 1  | 1: Introduction to objects                     | 25 |
| Introduction                 | 5  | The progress of abstraction .....              | 26 |
|                              |    | An object has an interface...                  | 28 |
|                              |    | The hidden implementation .....                | 30 |
|                              |    | Reusing the implementation .....               | 31 |
|                              |    | Inheritance: reusing the interface .....       | 32 |
|                              |    | Overriding base-class functionality .....      | 33 |
|                              |    | Is-a vs. is-like-a relationships... 34         |    |
|                              |    | Interchangeable objects with polymorphism..... | 35 |
|                              |    | Dynamic binding..... 37                        |    |
|                              |    | Abstract base classes and interfaces..... 37   |    |
| Prerequisites .....          | 6  |  |    |
| Learning Java .....          | 6  |  |    |
| Goals .....                  | 7  |  |    |
| Online documentation.....    | 8  |  |    |
| Chapters .....               | 9  |  |    |
| Exercises .....              | 15 |  |    |
| Multimedia CD ROM.....       | 15 |  |    |
| Source code .....            | 16 |  |    |
| Coding standards .....       | 17 |  |    |
| Java versions .....          | 18 |  |    |
| Seminars and mentoring ....  | 19 |  |    |
| Errors .....                 | 19 |  |    |
| Note on the cover design.... | 20 |  |    |
| Acknowledgements .....       | 21 |  |    |

|  |    |
|--|----|
| Object landscapes and lifetimes                          | 38 |
| Collections and iterators                                | 39 |
| The singly-rooted hierarchy                              | 41 |
| Collection libraries and support for easy collection use | 42 |
| The housekeeping dilemma: who should clean up?           | 44 |
| Exception handling: dealing with errors                  | 46 |
| Multithreading   | 47 |
| Persistence  | 48 |
| Java and the Internet                                    | 48 |
| What is the Web?   | 48 |
| Client-side programming                                  | 51 |
| Server-side programming                                  | 57 |
| A separate arena: applications                           | 58 |
| Analysis and Design                                      | 58 |
| Staying on course  | 59 |
| Phase 0: Let's make a plan                               | 59 |
| Phase 1:   |    |
| What are we making?                                      | 60 |
| Phase 2:   |    |
| How will we build it?                                    | 61 |
| Phase 3: Let's build it!                                 | 62 |
| Phase 4: Iteration                                       | 63 |
| Plans pay off  | 64 |
| Java vs. C++?  | 65 |

## 2: Everything is an object 67

|                                     |    |
|-------------------------------------|----|
| You manipulate objects with handles | 68 |
| You must create all the objects     | 69 |
| Where storage lives                 | 69 |
| Special case: primitive types       | 70 |
| Arrays in Java                      | 72 |
| You never need to destroy an object | 73 |
| Scoping                             | 73 |
| Scope of objects                    | 74 |
| Creating new data types: class      | 75 |

|                                      |    |
|--------------------------------------|----|
| Fields and methods                   | 75 |
| Methods, arguments and return values | 77 |
| The argument list                    | 78 |
| Building a Java program              | 79 |
| Name visibility                      | 80 |
| Using other components               | 80 |
| The static keyword                   | 81 |
| Your first Java program              | 83 |
| Comments and embedded documentation  | 86 |
| Comment documentation                | 87 |
| Syntax                               | 88 |
| Embedded HTML                        | 89 |
| @see: referring to other classes     | 89 |
| Class documentation tags             | 90 |
| Variable documentation tags          | 90 |
| Method documentation tags            | 91 |
| Documentation example                | 92 |
| Coding style                         | 93 |
| Summary                              | 93 |
| Exercises                            | 93 |

## 3: Controlling program flow 95

|                                      |     |
|--------------------------------------|-----|
| Using Java operators                 | 95  |
| Precedence                           | 96  |
| Assignment                           | 96  |
| Mathematical operators               | 100 |
| Auto increment and decrement         | 102 |
| Relational operators                 | 103 |
| Logical operators                    | 105 |
| Bitwise operators                    | 108 |
| Shift operators                      | 109 |
| Ternary if-else operator             | 113 |
| The comma operator                   | 114 |
| String operator +                    | 114 |
| Common pitfalls when using operators | 115 |
| Casting operators                    | 115 |
| Java has no "sizeof"                 | 119 |
| Precedence revisited                 | 119 |

|                           |     |
|---------------------------|-----|
| A compendium of operators | 119 |
| Execution control         | 130 |
| true and false            | 130 |
| if-else                   | 131 |
| Iteration                 | 132 |
| do-while                  | 133 |
| for                       | 133 |
| break and continue        | 135 |
| switch                    | 141 |
| Summary                   | 146 |
| Exercises                 | 146 |

## 4: Initialization and cleanup 147

|  |     |
|--|-----|
| Guaranteed initialization with the constructor | 148 |
| Method overloading                             | 150 |
| Distinguishing overloaded methods              | 152 |
| Overloading with primitives                    | 153 |
| Overloading on return values                   | 157 |
| Default constructors                           | 158 |
| The this keyword                               | 159 |
| Cleanup: finalization and garbage collection   | 162 |
| What is finalize() for?                        | 163 |
| You must perform cleanup                       | 164 |
| Member initialization                          | 168 |
| Specifying initialization                      | 170 |
| Constructor initialization                     | 171 |
| Array initialization                           | 179 |
| Multidimensional arrays                        | 184 |
| Summary  | 186 |
| Exercises                                      | 187 |

## 5: Hiding the implementation 189

|                               |     |
|-------------------------------|-----|
| package: the library unit     | 190 |
| Creating unique package names | 193 |
| A custom tool library         | 196 |

|                                  |     |
|----------------------------------|-----|
| Using imports to change behavior | 199 |
| Package caveat                   | 201 |
| Java access specifiers           | 202 |
| "friendly"                       | 202 |
| public: interface access         | 203 |
| private: you can't touch that!   | 205 |
| protected: "sort of friendly"    | 206 |
| Interface and implementation     | 208 |
| Class access                     | 209 |
| Summary                          | 212 |
| Exercises                        | 214 |

## 6: Reusing classes 217

|                                       |     |
|---------------------------------------|-----|
| Composition syntax                    | 218 |
| Inheritance syntax                    | 221 |
| Initializing the base class           | 224 |
| Combining composition and inheritance | 226 |
| Guaranteeing proper cleanup           | 228 |
| Name hiding                           | 231 |
| Choosing composition vs. inheritance  | 233 |
| protected                             | 234 |
| Incremental development               | 235 |
| Upcasting                             | 236 |
| Why "upcasting"?                      | 237 |
| The final keyword                     | 238 |
| Final data                            | 238 |
| Final methods                         | 243 |
| Final classes                         | 243 |
| Final caution                         | 244 |
| Initialization and class loading      | 245 |
| Initialization with inheritance       | 246 |
| Summary                               | 248 |
| Exercises                             | 248 |

|   |            |
|---|------------|
| <b>7: Polymorphism</b>                                    | <b>251</b> |
| Upcasting .....   | 252        |
| Why upcast?.....  | 253        |
| The twist .....   | 255        |
| Method call binding .....                                 | 255        |
| Producing the right behavior.....                         | 256        |
| Extensibility.....  | 259        |
| Overriding vs. overloading .....                          | 263        |
| Abstract classes and methods .....                        | 264        |
| Interfaces .....  | 268        |
| "Multiple inheritance" in Java.....                       | 272        |
| Extending an interface with inheritance .....             | 274        |
| Grouping constants .....                                  | 275        |
| Initializing fields in interfaces .....                   | 277        |
| Inner classes.....  | 278        |
| Inner classes and upcasting.....                          | 280        |
| Inner classes in methods and scopes .....                 | 282        |
| The link to the outer class .....                         | 288        |
| static inner classes .....                                | 291        |
| Referring to the outer class object .....                 | 293        |
| Inheriting from inner classes.....                        | 294        |
| Can inner classes be overridden? .....                    | 295        |
| Inner class identifiers .....                             | 297        |
| Why inner classes: control frameworks.....                | 298        |
| Constructors and polymorphism .....                       | 306        |
| Order of constructor calls .....                          | 306        |
| Inheritance and <code>finalize()</code> .....             | 308        |
| Behavior of polymorphic methods inside constructors ..... | 312        |
| Designing with inheritance.....                           | 315        |

|   |     |
|---|-----|
| Pure inheritance .....                            | 316 |
| vs. extension.....                                | 316 |
| Downcasting and run-time type identification..... | 318 |
| Summary .....                                     | 320 |
| Exercises .....                                   | 321 |

|  |            |
|--|------------|
| <b>8: Holding your objects</b>           | <b>323</b> |
| Arrays .....                             | 324        |
| Arrays are first-class objects .....     | 325        |
| Returning an array .....                 | 329        |
| Collections .....                        | 331        |
| Disadvantage: unknown type .....         | 331        |
| Enumerators (iterators) .....            | 337        |
| Types of collections .....               | 341        |
| Vector .....                             | 341        |
| BitSet .....                             | 342        |
| Stack .....                              | 344        |
| Hashtable .....                          | 345        |
| Enumerators revisited .....              | 353        |
| Sorting .....                            | 354        |
| The generic collection library .....     | 360        |
| The new collections .....                | 361        |
| Using Collections .....                  | 366        |
| Using Lists .....                        | 369        |
| Using Sets .....                         | 374        |
| Using Maps .....                         | 376        |
| Choosing an implementation .....         | 379        |
| Unsupported operations .....             | 388        |
| Sorting and searching .....              | 391        |
| Utilities .....                          | 397        |
| Summary .....                            | 400        |
| Exercises .....                          | 401        |
| <b>9: Error handling with exceptions</b> | <b>403</b> |
| Basic exceptions .....                   | 405        |
| Exception arguments .....                | 406        |
| Catching an exception .....              | 406        |
| The try block .....                      | 407        |

|  |            |
|--|------------|
| Exception handlers .....                                 | 407        |
| The exception specification .....                        | 409        |
| Catching any exception .....                             | 410        |
| Rethrowing an exception .....                            | 412        |
| Standard Java exceptions .....                           | 415        |
| The special case of RuntimeException .....               | 416        |
| Creating your own exceptions .....                       | 418        |
| Exception restrictions .....                             | 421        |
| Performing cleanup with finally .....                    | 425        |
| What's finally for? .....                                | 427        |
| Pitfall: the lost exception .....                        | 429        |
| Constructors .....                                       | 431        |
| Exception matching .....                                 | 435        |
| Exception guidelines .....                               | 436        |
| Summary .....  | 437        |
| Exercises .....  | 437        |
| <b>10: The Java IO system</b>                            | <b>439</b> |
| Input and output .....                                   | 440        |
| Types of InputStream .....                               | 440        |
| Types of OutputStream .....                              | 442        |
| Adding attributes and useful interfaces .....            | 444        |
| Reading from an InputStream with FilterInputStream ..... | 445        |
| Writing to an OutputStream with FilterOutputStream ..... | 446        |
| Off by itself:   |            |
| RandomAccessFile .....                                   | 448        |
| The File class .....                                     | 449        |
| A directory lister .....                                 | 449        |
| Checking for and creating directories .....              | 454        |
| Typical uses of IO streams .....                         | 456        |
| Input streams .....                                      | 460        |
| Output streams .....                                     | 462        |
| Shorthand for file manipulation .....                    | 463        |
| Reading from standard input .....                        | 465        |
| Piped streams .....                                      | 466        |
| <b>StreamTokenizer</b> .....                             | <b>467</b> |
| StringTokenizer .....                                    | 470        |
| Java 1.1 IO streams .....                                | 473        |
| Sources and sinks of data .....                          | 474        |
| Modifying stream behavior .....                          | 474        |
| Unchanged Classes .....                                  | 476        |
| An example .....   | 476        |
| Redirecting standard IO .....                            | 480        |
| Compression .....  | 482        |
| Simple compression with GZIP .....                       | 483        |
| Multi-file storage with Zip .....                        | 484        |
| The Java archive (jar) utility .....                     | 487        |
| Object serialization .....                               | 489        |
| Finding the class .....                                  | 493        |
| Controlling serialization .....                          | 495        |
| Using persistence .....                                  | 504        |
| Summary .....  | 512        |
| Exercises .....  | 513        |

|  |            |
|--|------------|
| <b>11: Run-time type identification</b>      | <b>515</b> |
| The need for RTTI .....                      | 516        |
| The Class object .....                       | 518        |
| Checking before a cast .....                 | 521        |
| RTTI syntax .....                            | 528        |
| Reflection: run-time class information ..... | 531        |
| A class method extractor .....               | 532        |
| Summary .....                                | 537        |
| Exercises .....                              | 538        |
| <b>12: Passing and returning objects</b>     | <b>541</b> |
| Passing handles around .....                 | 542        |
| Aliasing .....                               | 543        |
| Making local copies .....                    | 545        |
| Pass by value .....                          | 546        |
| Cloning objects .....                        | 546        |
| Adding cloneability to a class .....         | 548        |

|   |     |
|---|-----|
| Successful cloning.....   | 550 |
| The effect of <code>Object.clone()</code> ....                        | 552 |
| Cloning a composed object.....  | 555 |
| A deep copy with <code>Vector</code> .....                            | 557 |
| Deep copy via serialization .....                                     | 559 |
| Adding cloneability<br>further down a hierarchy .....                 | 561 |
| Why this strange design?.....   | 562 |
| Controlling cloneability.....   | 563 |
| The copy-constructor .....  | 568 |
| Read-only classes .....   | 572 |
| Creating read-only classes .....                                      | 574 |
| The drawback<br>to immutability .....                                 | 575 |
| Immutable <code>String</code> s .....                                 | 577 |
| The <code>String</code> and<br><code>StringBuffer</code> classes..... | 581 |
| Strings are special .....   | 584 |
| Summary .....   | 584 |
| Exercises .....   | 586 |

## 13: Creating windows and applets 587

|  |     |
|--|-----|
| Why use the AWT? .....                       | 589 |
| The basic applet .....                       | 590 |
| Testing applets.....                         | 593 |
| A more graphical example .....               | 594 |
| Demonstrating<br>the framework methods ..... | 595 |
| Making a button.....                         | 596 |
| Capturing an event .....                     | 596 |
| Text fields.....                             | 600 |
| Text areas.....                              | 601 |
| Labels .....                                 | 602 |
| Check boxes .....                            | 604 |
| Radio buttons .....                          | 606 |
| Drop-down lists .....                        | 607 |
| List boxes .....                             | 609 |
| <code>handleEvent()</code> .....             | 610 |
| Controlling layout .....                     | 613 |
| <code>FlowLayout</code> .....                | 613 |
| <code>BorderLayout</code> .....              | 614 |
| <code>GridLayout</code> .....                | 615 |
| <code>CardLayout</code> .....                | 616 |

|  |     |
|--|-----|
| <b>GridBagLayout</b> .....                               | 618 |
| <b>Alternatives to action</b> .....                      | 619 |
| <b>Applet restrictions</b> .....                         | 625 |
| Applet advantages .....                                  | 626 |
| <b>Windowed applications</b> .....                       | 627 |
| Menus .....  | 627 |
| Dialog boxes .....                                       | 631 |
| <b>The new AWT</b> .....                                 | 638 |
| The new event model.....                                 | 639 |
| Event and listener types.....                            | 641 |
| Making windows and applets<br>with the Java 1.1 AWT..... | 646 |
| Revisiting the<br>earlier examples.....                  | 650 |
| Binding events dynamically ...                           | 670 |
| Separating business logic<br>from UI logic .....         | 672 |
| Recommended<br>coding approaches .....                   | 675 |
| <b>Java 1.1 UI APIs</b> .....                            | 692 |
| Desktop colors .....                                     | 692 |
| Printing .....   | 693 |
| The clipboard.....                                       | 701 |

## Visual programming and Beans .....

|  |     |
|--|-----|
| What is a Bean?.....   | 705 |
| Extracting <code>BeanInfo</code> with<br>the <code>Introspector</code> ..... | 708 |
| A more sophisticated Bean.....   | 714 |
| Packaging a Bean.....  | 718 |
| More complex Bean support ...  | 719 |
| More to Beans.....   | 720 |
| <b>Introduction to Swing</b> .....   | 721 |
| Benefits of Swing .....  | 722 |
| Easy conversion.....   | 722 |
| A display framework.....   | 724 |
| Tool tips .....  | 725 |
| Borders .....  | 725 |
| Buttons.....   | 726 |
| Button groups .....  | 728 |
| Icons .....  | 730 |
| Menus .....  | 732 |
| Popup menus.....   | 737 |
| List boxes and combo boxes .....   | 738 |

|                                |     |
|--------------------------------|-----|
| Sliders and progress bars..... | 739 |
| Trees .....                    | 740 |
| Tables.....                    | 743 |
| Tabbed Panes.....              | 745 |
| The Swing message box .....    | 747 |
| More to Swing .....            | 747 |
| <b>Summary</b> .....           | 748 |
| <b>Exercises</b> .....         | 749 |

## 14: Multiple threads 751

|   |     |
|---|-----|
| <b>Responsive<br/>user interfaces</b> .....       | 752 |
| Inheriting from <code>Thread</code> .....         | 755 |
| Threading for a<br>responsive interface.....      | 757 |
| Combining the thread<br>with the main class ..... | 761 |
| Making many threads.....                          | 764 |
| Daemon threads.....                               | 767 |
| <b>Sharing<br/>limited resources</b> .....        | 769 |
| Improperly accessing<br>resources .....           | 770 |
| How Java shares resources....                     | 775 |
| Java Beans revisited .....                        | 780 |
| <b>Blocking</b> .....                             | 785 |
| Becoming blocked.....                             | 786 |
| Deadlock .....                                    | 797 |
| <b>Priorities</b> .....                           | 801 |
| Thread groups.....                                | 806 |
| <b>Runnable</b> revisited .....                   | 814 |
| Too many threads.....                             | 817 |
| <b>Summary</b> .....                              | 820 |
| <b>Exercises</b> .....                            | 822 |

## 15: Network programming 825

|  |     |
|--|-----|
| <b>Identifying a machine</b> .....               | 826 |
| Servers and clients.....                         | 828 |
| Port: a unique place<br>within the machine ..... | 829 |
| <b>Sockets</b> .....                             | 830 |
| A simple server and client.....                  | 831 |
| <b>Serving multiple clients</b> ....             | 837 |

|  |     |
|--|-----|
| <b>Datagrams</b> .....                             | 842 |
| <b>A Web application</b> .....                     | 850 |
| The server application .....                       | 851 |
| The <code>NameSender</code> applet .....           | 857 |
| Problems with<br>this approach .....               | 863 |
| <b>Connecting Java to CGI</b> .....                | 864 |
| Encoding data for CGI .....                        | 865 |
| The applet .....                                   | 867 |
| The CGI program in C++ .....                       | 872 |
| What about POST? .....                             | 882 |
| <b>Connecting to<br/>databases with JDBC</b> ..... | 887 |
| Getting the example to work..                      | 890 |
| A GUI version of<br>the lookup program .....       | 894 |
| Why the JDBC API<br>seems so complex .....         | 897 |
| <b>Remote methods</b> .....                        | 897 |
| Remote interfaces .....                            | 898 |
| Implementing the<br>remote interface .....         | 899 |
| Creating stubs and skeletons ..                    | 902 |
| Using the remote object.....                       | 903 |
| Alternatives to RMI .....                          | 904 |
| Summary .....                                      | 905 |
| Exercises .....                                    | 905 |

## 16: Design patterns 907

|   |     |
|---|-----|
| <b>The pattern concept</b> .....            | 908 |
| The singleton.....                          | 909 |
| Classifying patterns.....                   | 911 |
| <b>The observer pattern</b> .....           | 911 |
| Simulating the<br>trash recycler .....      | 915 |
| Improving the design.....                   | 919 |
| “Make more objects” .....                   | 919 |
| A pattern for<br>prototyping creation ..... | 922 |
| <b>Abstracting usage</b> .....              | 932 |
| <b>Multiple dispatching</b> .....           | 936 |
| Implementing the<br>double dispatch .....   | 937 |
| <b>The “visitor” pattern</b> .....          | 944 |

|                               |     |
|-------------------------------|-----|
| RTTI considered harmful?..... | 952 |
| Summary .....                 | 955 |
| Exercises .....               | 956 |

|                                    |            |
|------------------------------------|------------|
| <b>17: Projects</b>                | <b>957</b> |
| Text processing.....               | 957        |
| Extracting code listings.....      | 958        |
| Checking capitalization style..... | 974        |
| A method lookup tool .....         | 983        |
| Complexity theory .....            | 988        |
| Summary .....                      | 995        |
| Exercises .....                    | 996        |

|                               |            |
|-------------------------------|------------|
| <b>A: Using non-Java code</b> | <b>997</b> |
|-------------------------------|------------|

|                                      |      |
|--------------------------------------|------|
| The Java Native Interface .....      | 998  |
| Calling a native method.....         | 999  |
| Accessing JNI functions:             |      |
| The <b>JNIEnv</b> argument .....     | 1002 |
| Passing and using Java objects ..... | 1003 |
| JNI and Java exceptions .....        | 1006 |
| JNI and threading.....               | 1007 |
| Using a pre-existing code base ..... | 1007 |
| The Microsoft way .....              | 1007 |
| J/Direct .....                       | 1008 |
| The <b>@dll.import</b> directive.... | 1009 |
| The com.ms.win32 package .....       | 1011 |
| Marshaling .....                     | 1012 |
| Writing callback functions....       | 1013 |
| Other J/Direct features .....        | 1015 |
| Raw Native Interface (RNI) .....     | 1015 |
| RNI Summary .....                    | 1017 |
| Java/COM integration ....            | 1017 |
| COM Fundamentals.....                | 1019 |
| MS Java/COM Integration....          | 1022 |
| Developing COM servers in Java ..... | 1023 |

|   |      |
|---|------|
| Developing COM clients in Java .....          | 1025 |
| ActiveX/Beans integration ...                 | 1027 |
| A note about native methods and applets ..... | 1027 |
| CORBA .....                                   | 1028 |
| CORBA Fundamentals.....                       | 1028 |
| An example.....                               | 1030 |
| Java Applets and CORBA .....                  | 1035 |
| CORBA vs. RMI .....                           | 1036 |
| Summary .....                                 | 1036 |

|                                  |             |
|----------------------------------|-------------|
| <b>B: Comparing C++ and Java</b> | <b>1039</b> |
|----------------------------------|-------------|

|                                       |             |
|---------------------------------------|-------------|
| <b>C: Java programming guidelines</b> | <b>1051</b> |
|---------------------------------------|-------------|

|                       |             |
|-----------------------|-------------|
| <b>D: Performance</b> | <b>1057</b> |
|-----------------------|-------------|

|   |      |
|---|------|
| Basic approach .....                      | 1057 |
| Locating the bottleneck... 1058           |      |
| 1. Install your own instrumentation ..... | 1058 |
| 2. JDK profiling [2].....                 | 1059 |
| 3. Special tools .....                    | 1059 |
| Tips for measuring performance .....      | 1059 |
| Speedup techniques .....                  | 1060 |
| Generic approaches .....                  | 1060 |
| Language dependent approaches .....       | 1060 |
| Specific situations .....                 | 1061 |
| References .....                          | 1064 |
| Performance tools.....                    | 1064 |
| Web sites .....                           | 1064 |
| Articles .....                            | 1064 |
| Java specific books.....                  | 1065 |
| General books .....                       | 1065 |

|  |             |
|--|-------------|
| <b>E: A bit about garbage collection</b> | <b>1067</b> |
|--|-------------|

|                               |             |
|-------------------------------|-------------|
| <b>F: Recommended reading</b> | <b>1073</b> |
| <b>Index</b>                  | <b>1075</b> |