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TENTH EDITION

Paul Deitel • Harvey Deitel

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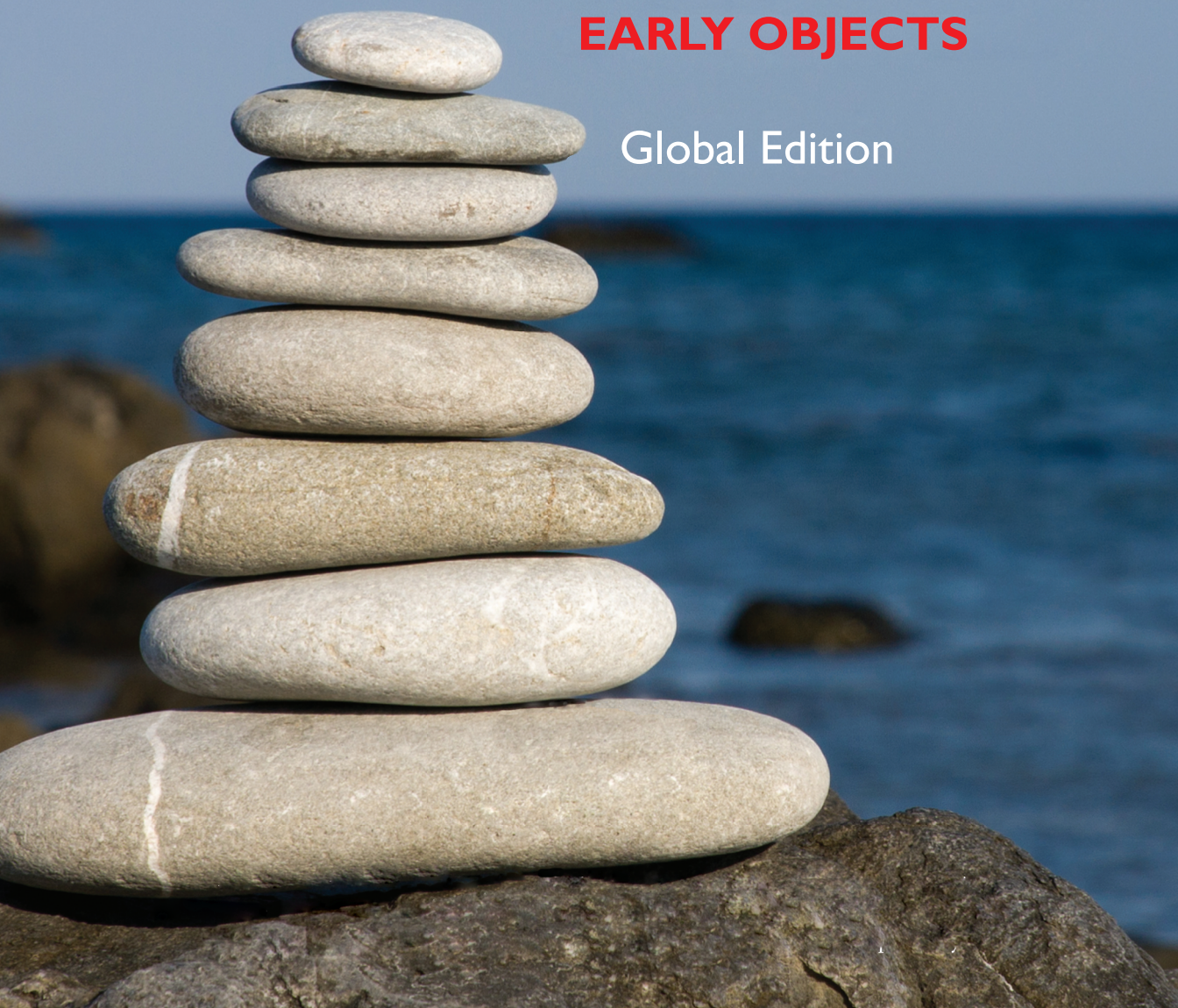

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Global Edition

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Authorized adaptation from the United States edition, entitled Java How to Program, Early Objects, 10th edition, ISBN 978-0-13-380780-6, by Paul Deitel and Harvey Deitel, published by Pearson Education © 2015.

ISBN 10: 1-292-01819-4

ISBN 13: 978-1-292-01819-5

British Library Cataloguing-in-Publication Data
A catalogue record for this book is available from the British Library

10 9 8 7 6 5 4 3 2 1

Typeset in 10.5 AGaramond-Regular by GEX Publishing Services.

Printed and bound by Courier Kendallville in the United States of America.

To Brian Goetz,
Oracle's Java Language Architect and
Specification Lead for Java SE 8's Project Lambda:

Your mentorship helped us make a better book.
Thank you for insisting that we get it right.

Paul and Harvey Deitel

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Contents

Chapters 26–34 and Appendices F–N are PDF documents posted online at the book's Companion Website (located at `www.pearsonglobaleditions.com/deitel`). See the inside front cover for information on accessing the Companion Website.

Online Chapters and Appendices

Chapters 26–34 and Appendices F–N are PDF documents posted online at the book's Companion Website (located at `www.pearsonglobaleditions.com/deitel`). See the inside front cover for information on accessing the Companion Website.

Foreword

I've been enamored with Java even prior to its 1.0 release in 1995, and have subsequently been a Java developer, author, speaker, teacher and Oracle Java Technology Ambassador. In this journey, it has been my privilege to call Paul Deitel a colleague, and to often leverage and recommend his *Java How To Program* book. In its many editions, this book has proven to be a great text for college and professional courses that I and others have developed to teach the Java programming language.

One of the qualities that makes this book a great resource is its thorough and insightful coverage of Java concepts, including those introduced recently in Java SE 8. Another useful quality is its treatment of concepts and practices essential to effective software development.

As a long-time fan of this book, I'd like to point out some of the features of this tenth edition about which I'm most excited:

- An ambitious new chapter on Java lambda expressions and streams. This chapter starts out with a primer on functional programming, introducing Java lambda expressions and how to use streams to perform functional programming tasks on collections.
- Although concurrency has been addressed since the first edition of the book, it is increasingly important because of multi-core architectures. There are timing examples—using the new Date/Time API classes introduced in Java SE 8—in the concurrency chapter that show the performance improvements with multi-core over single-core.
- JavaFX is Java's GUI/graphics/multimedia technology moving forward, so it is nice to see a three-chapter treatment of JavaFX in the Deitel live-code pedagogic style. One of these chapters is in the printed book and the other two are online.

Please join me in congratulating Paul and Harvey Deitel on their latest edition of a wonderful resource for computer science students and software developers alike!

James L. Weaver
Java Technology Ambassador
Oracle Corporation

Preface

"The chief merit of language is clearness…"
—Galen

Welcome to the Java programming language and *Java How to Program, Tenth Edition*! This book presents leading-edge computing technologies for students, instructors and software developers. It's appropriate for introductory academic and professional course sequences based on the curriculum recommendations of the ACM and the IEEE, and for AP Computer Science exam preparation. Please read this Preface carefully, we've mentioned important details about the book.

We focus on software engineering best practices. At the heart of the book is the Deitel signature "live-code approach"—rather than using code snippets, we present concepts in the context of complete working programs that run on recent versions of Windows®, OS X® and Linux®. Each complete code example is accompanied by live sample executions.

Keeping in Touch with the Authors

As you read the book, if you have questions, send an e-mail to us at

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Source Code and VideoNotes

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```

Modular Organization[1]

Java How to Program, 10/e, is appropriate for programming courses at various levels, most notably CS 1 and CS 2 courses and introductory course sequences in related disciplines. The book's modular organization helps instructors plan their syllabi:

Introduction

- Chapter 1, Introduction to Computers, the Internet and Java
- Chapter 2, Introduction to Java Applications; Input/Output and Operators
- Chapter 3, Introduction to Classes, Objects, Methods and Strings

Additional Programming Fundamentals

- Chapter 4, Control Statements: Part 1; Assignment, ++ and -- Operators
- Chapter 5, Control Statements: Part 2; Logical Operators
- Chapter 6, Methods: A Deeper Look
- Chapter 7, Arrays and ArrayLists
- Chapter 14, Strings, Characters and Regular Expressions
- Chapter 15, Files, Streams and Object Serialization

Object-Oriented Programming and Object-Oriented Design

- Chapter 8, Classes and Objects: A Deeper Look
- Chapter 9, Object-Oriented Programming: Inheritance
- Chapter 10, Object-Oriented Programming: Polymorphism and Interfaces
- Chapter 11, Exception Handling: A Deeper Look
- (**Online**) Chapter 33, ATM Case Study, Part 1: Object-Oriented Design with the UML
- (**Online**) Chapter 34, ATM Case Study Part 2: Implementing an Object-Oriented Design

Swing Graphical User Interfaces and Java 2D Graphics

- Chapter 12, GUI Components: Part 1
- Chapter 13, Graphics and Java 2D
- Chapter 22, GUI Components: Part 2

Data Structures, Collections, Lambdas and Streams

- Chapter 16, Generic Collections
- Chapter 17, Java SE 8 Lambdas and Streams
- Chapter 18, Recursion
- Chapter 19, Searching, Sorting and Big O
- Chapter 20, Generic Classes and Methods
- Chapter 21, Custom Generic Data Structures

1. The online chapters will be available on the book's Companion Website for Autumn 2014 classes.

Concurrency; Networking

- Chapter 23, Concurrency
- (**Online**) Chapter 28, Networking

JavaFX Graphical User Interfaces, Graphics and Multimedia

- Chapter 25, JavaFX GUI: Part 1
- (**Online**) Chapter 26, JavaFX GUI: Part 2
- (**Online**) Chapter 27, JavaFX Graphics and Multimedia

Database-Driven Desktop and Web Development

- Chapter 24, Accessing Databases with JDBC
- (**Online**) Chapter 29, Java Persistence API (JPA)
- (**Online**) Chapter 30, JavaServer™ Faces Web Apps: Part 1
- (**Online**) Chapter 31, JavaServer™ Faces Web Apps: Part 2
- (**Online**) Chapter 32, REST-Based Web Services

New and Updated Features

Here are the updates we've made for *Java How to Program, 10/e*:

Java Standard Edition: Java SE 7 and the New Java SE 8

- ***Easy to use with Java SE 7 or Java SE 8.*** To meet the needs of our audiences, we designed the book for college and professional courses based on Java SE 7, Java SE 8 or a mixture of both. The Java SE 8 features are covered in optional, easy-to-include-or-omit sections. The new Java SE 8 capabilities can dramatically improve the programming process. Figure 1 lists some new Java SE 8 features that we cover.

Java SE 8 features
Lambda expressions
Type-inference improvements
`@FunctionalInterface` annotation
Parallel array sorting
Bulk data operations for Java Collections—`filter`, `map` and `reduce`
Library enhancements to support lambdas (e.g., `java.util.stream`, `java.util.function`)
Date & Time API (`java.time`)
Java concurrency API improvements
`static` and `default` methods in interfaces
Functional interfaces—interfaces that define only one `abstract` method and can include `static` and `default` methods
JavaFX enhancements

Fig. 1 | Some new Java SE 8 features.

- *Java SE 8 lambdas, streams, and interfaces with* **`default`** *and* **`static`** *methods.* The most significant new features in JavaSE 8 are lambdas and complementary technologies, which we cover in detail in the optional Chapter 17 and optional sections marked "Java SE 8" in later chapters. In Chapter 17, you'll see that functional programming with lambdas and streams can help you write programs faster, more concisely, more simply, with fewer bugs and that are easier to parallelize (to get performance improvements on multi-core systems) than programs written with previous techniques. You'll see that functional programming complements object-oriented programming. After you read Chapter 17, you'll be able to cleverly reimplement many of the Java SE 7 examples throughout the book (Fig. 2).

Pre-Java-SE-8 topics	Corresponding Java SE 8 discussions and examples
Chapter 7, Arrays and ArrayLists	Sections 17.3–17.4 introduce basic lambda and streams capabilities that process one-dimensional arrays.
Chapter 10, Object-Oriented Programming: Polymorphism and Interfaces	Section 10.10 introduces the new Java SE 8 interface features (`default` methods, `static` methods and the concept of functional interfaces) that support functional programming with lambdas and streams.
Chapters 12 and 22, GUI Components: Part 1 and 2, respectively	Section 17.9 shows how to use a lambda to implement a Swing event-listener functional interface.
Chapter 14, Strings, Characters and Regular Expressions	Section 17.5 shows how to use lambdas and streams to process collections of `String` objects.
Chapter 15, Files, Streams and Object Serialization	Section 17.7 shows how to use lambdas and streams to process lines of text from a file.
Chapter 23, Concurrency	Shows that functional programs are easier to parallelize so that they can take advantage of multi-core architectures to enhance performance. Demonstrates parallel stream processing. Shows that `Arrays` method `parallelSort` improves performance on multi-core architectures when sorting large arrays.
Chapter 25, JavaFX GUI: Part 1	Section 25.5.5 shows how to use a lambda to implement a JavaFX event-listener functional interface.

Fig. 2 | Java SE 8 lambdas and streams discussions and examples.

- *Java SE 7's* **`try`***-with-resources statement and the* **`AutoClosable`** *Interface.* `AutoClosable` objects reduce the likelihood of resource leaks when you use them with the `try`-with-resources statement, which automatically closes the `AutoClosable` objects. In this edition, we use `try`-with-resources and `AutoClosable` objects as appropriate starting in Chapter 15, Files, Streams and Object Serialization.
- *Java security.* We audited our book against the CERT Oracle Secure Coding Standard for Java as appropriate for an introductory textbook.

```
http://bit.ly/CERTOracleSecureJava
```

See the Secure Java Programming section of this Preface for more information about CERT.

- ***Java NIO API.*** We updated the file-processing examples in Chapter 15 to use features from the Java NIO (new IO) API.
- ***Java Documentation.*** Throughout the book, we provide links to Java documentation where you can learn more about various topics that we present. For Java SE 7 documentation, the links begin with

```
http://docs.oracle.com/javase/7/
```

and for Java SE 8 documentation, the links begin with

```
http://download.java.net/jdk8/
```

These links could change when Oracle releases Java SE 8—*possibly* to links beginning with

```
http://docs.oracle.com/javase/8/
```

For any links that change after publication, we'll post updates at

```
http://www.pearsonglobaleditions.com/deitel
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Swing and JavaFX GUI, Graphics and Multimedia

- ***Swing GUI and Java 2D graphics.*** Java's Swing GUI is discussed in the optional GUI and graphics sections in Chapters 3–10 and in Chapters 12 and 22. Swing is now in maintenance mode—Oracle has stopped development and will provide only bug fixes going forward, however it will remain part of Java and is still widely used. Chapter 13 discusses Java 2D graphics.
- ***JavaFX GUI, graphics and multimedia.*** Java's GUI, graphics and multimedia API going forward is JavaFX. In Chapter 25, we use JavaFX 2.2 (released in 2012) with Java SE 7. Our online Chapters 26 and 27—located on the book's companion website (see the inside front cover of this book)—present additional JavaFX GUI features and introduce JavaFX graphics and multimedia in the context of Java FX 8 and Java SE 8. In Chapters 25–27 we use Scene Builder—a drag-and-drop tool for creating JavaFX GUIs quickly and conveniently. It's a standalone tool that you can use separately or with any of the Java IDEs.
- ***Scalable GUI and graphics presentation.*** Instructors teaching introductory courses have a broad choice of the amount of GUI, graphics and multimedia to cover—from none at all, to optional introductory sections in the early chapters, to a deep treatment of Swing GUI and Java 2D graphics in Chapters 12, 13 and 22, and a deep treatment of JavaFX GUI, graphics and multimedia in Chapter 25 and online Chapters 26–27.

Concurrency

- ***Concurrency for optimal multi-core performance.*** In this edition, we were privileged to have as a reviewer Brian Goetz, co-author of *Java Concurrency in Practice* (Addison-Wesley). We updated Chapter 23, with Java SE 8 technology and idiom. We added a `parallelSort` vs. `sort` example that uses the Java SE 8 Date/Time API to time each operation and demonstrate `parallelSort`'s better performance on a multi-core system. We include a Java SE 8 parallel vs. sequential stream processing example, again using the Date/Time API to show performance improvements. Fi-

nally, we added a Java SE 8 `CompletableFuture` example that demonstrates sequential and parallel execution of long-running calculations.

- ***`SwingWorker` class.*** We use class `SwingWorker` to create multithreaded user interfaces. In online Chapter 26, we show how JavaFX handles concurrency.
- ***Concurrency is challenging.*** Programming concurrent applications is difficult and error-prone. There's a great variety of concurrency features. We point out the ones that most people should use and mention those that should be left to the experts.

Getting Monetary Amounts Right

- ***Monetary amounts.*** In the early chapters, for convenience, we use type `double` to represent monetary amounts. Due to the potential for incorrect monetary calculations with type `double`, class `BigDecimal` (which is a bit more complex) should be used to represent monetary amounts. We demonstrate `BigDecimal` in Chapters 8 and 25.

Object Technology

- ***Object-oriented programming and design.*** We use an *early objects* approach, introducing the basic concepts and terminology of object technology in Chapter 1. Students develop their first customized classes and objects in Chapter 3. Presenting objects and classes early gets students "thinking about objects" immediately and mastering these concepts more thoroughly. [For courses that require a late-objects approach, consider *Java How to Program, 10/e, Late Objects Version*.]
- ***Early objects real-world case studies.*** The early classes and objects presentation features `Account`, `Student`, `AutoPolicy`, `Time`, `Employee`, `GradeBook` and `Card` shuffling-and-dealing case studies, gradually introducing deeper OO concepts.
- ***Inheritance, Interfaces, Polymorphism and Composition.*** We use a series of real-world case studies to illustrate each of these OO concepts and explain situations in which each is preferred in building industrial-strength applications.
- ***Exception handling.*** We integrate basic exception handling early in the book then present a deeper treatment in Chapter 11. Exception handling is important for building "mission-critical" and "business-critical" applications. Programmers need to be concerned with, "What happens when the component I call on to do a job experiences difficulty? How will that component signal that it had a problem?" To use a Java component, you need to know not only how that component behaves when "things go well," but also what exceptions that component "throws" when "things go poorly."
- ***Class `Arrays` and `ArrayList`.*** Chapter 7 covers class `Arrays`—which contains methods for performing common array manipulations—and class `ArrayList`—which implements a dynamically resizable array-like data structure. This follows our philosophy of getting lots of practice using existing classes while learning how to define your own classes. The chapter's rich selection of exercises includes a substantial project on building your own computer through the technique of software simulation. Chapter 21 includes a follow-on project on building your own compiler that can compile high-level language programs into machine language code that will execute on your computer simulator.