JAVA - ADVANCED OBJECT ORIENTED PROGRAMMING

- CLASSES - OBJECTS
- INHERITANCE
- ASSOCIATION
- POLYMORPHISM
- DATA STRUCTURES
- GENERICS
- INTERFACES
- AUTOMATED TESTING
- DESIGN PATTERNS
- OOP BEST PRACTICES

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DR. KEVIN ROARK | 2026 EDITION

Book Overview

J*ava Object-Oriented Programming* is a comprehensive, student-friendly textbook designed for learners ready to advance beyond basic programming into object-oriented design. Whether you're pursuing a degree in Computer Science, preparing for a career in software development, or simply eager to deepen your programming skills, this book provides a clear and engaging path to mastering Java and core OOP principles.

Organized into focused, progressive modules, the textbook blends theory with hands-on application. Students explore Java fundamentals through the lens of object-oriented concepts, including classes, objects, inheritance, polymorphism, composition, interfaces, exception handling, and design patterns. Every topic is reinforced with real-world examples, guided demos, lab assignments, and video-style walkthroughs that make abstract ideas tangible. Each chapter is designed to build both technical skills and a deeper understanding of software architecture, fostering computational thinking and professional-level problem-solving.

With a strong emphasis on clean coding practices, maintainable design, and the practical application of OOP principles, *Java Object-Oriented Programming* prepares students for both academic success and future roles in the software industry. The content is accessible and adaptable, making it ideal for classroom instruction, hybrid learning, or self-paced study.

This digital textbook is enhanced by a library of video tutorials that guide learners step by step through Java syntax, object design, and project implementation. These visual aids clarify complex concepts, demonstrate coding best practices, and build confidence through guided examples.

Throughout the course, students engage in meaningful projects that range from building class hierarchies and interactive applications to designing modular, scalable systems. Assignments are intentionally tied to practical themes, ensuring that learners not only understand Java syntax but also how to use it to create real-world solutions. These experiences reinforce key concepts while cultivating a professional approach to problem-solving, preparing students to write code that is robust, reusable, and ready for production environments.

Key Features of Object-Oriented Programming with Java

Beginner-Friendly, Easy-to-Read Format. This textbook is thoughtfully written, clear, and purposeful, making it ideal for students who have introductory programming experience. The book breaks down complex topics into simple, manageable sections to help you learn with confidence.

Includes Over 50 Video Walkthroughs. Each major topic is paired with engaging video demonstrations that guide students through coding examples, syntax explanations, and best practices. This approach helps turn abstract ideas into a clear, tangible understanding.

Flexible Delivery Options. Designed to support multiple teaching formats:

- Self-paced learning
- Instructor-facilitated courses
- Face-to-face classroom instruction
- Synchronous or asynchronous online delivery

Hands-On Labs and Creative Projects. Each module features themed lab assignments designed to reinforce concepts through engaging practice and creativity. This approach helps students connect with what they've learned in a meaningful and personal way.

Designed specifically for college students and adult learners. The book is thoughtfully organized to align with college-level learning outcomes. It's an excellent choice for academic programs and workforce training, providing support and relevance at every step.

Available online and as an iOS app. Students can easily access the textbook on any device, via the web or the iOS/Android app. The platform remembers where they paused and visually shows their progress through each module, making learning more seamless and encouraging.

Who This Book Is For

- **Students who have completed an introductory programming course** – This book is designed for learners who already have a foundation in basic programming concepts and are ready to take the next step into object-oriented design and development with Java. It builds on that prior experience, guiding students from fundamental OOP principles to advanced applications through a blend of theory and hands-on practice..
- **Career Switchers and Industry Trainees -** Ideal for workforce training programs or individuals transitioning into tech, the book offers clear explanations, hands-on practice, and real-world context.
- **High School Dual Credit and College-Level Courses -** Designed to meet the needs of dual-credit programs and introductory college courses, supporting both academic rigor and student accessibility.

Course/Textbook Overview

Module 1: Introduction to Programming in Java

This module is designed to lay the groundwork for your journey into Java programming. Whether you're new to Java programming or looking to solidify your understanding of Java fundamentals, this module will provide you with the essential knowledge and skills to write basic Java programs.

Throughout this module, you'll explore the core programming concepts using Java as the learning vehicle. You'll set up your development environment, write and run your first Java programs, and delve into the fundamental building blocks of the language, such as variables, data types, operators, control flow statements, and methods. By the end of this module, you'll be equipped with a solid foundation to tackle more advanced topics in subsequent modules.

By the end of this module, you will be able to:

- Define the programming purpose and describe the key features and benefits of the Java programming language.
- Install the Java Development Kit (JDK) and configure an Integrated Development Environment (IDE) for Java programming.
- Explain the structure of a basic Java program, including the role of classes, the main method, and keywords like public, static, and void.
- Write and execute a simple Java program using both the command line and an IDE.
- Declare and initialize variables using Java’s primitive data types and proper naming conventions, including the use of constants with the final keyword.
- Perform calculations and create expressions using arithmetic, assignment, relational, and logical operators.
- Create formatted console output with System.out.printf() and read user input with the Scanner class.
- Implement control flow structures, including if statements, switch statements, and loops (for, while, and do-while).
- Differentiate between implicit and explicit type casting and apply data type conversions in programs.
- Write clear, maintainable, and readable code by using comments effectively and adhering to coding best practices.

Module 2: Introduction to Object-Oriented Programming

Object-oriented programming (OOP) is one of the most critical programming paradigms in software development. It allows developers to model real-world entities as objects, making programs more modular, reusable, and maintainable. In this module, we will explore the key principles of OOP and how they are applied in Java. You will learn to define and use classes and objects, implement encapsulation, and understand concepts such as inheritance and polymorphism, as well as critical concepts like abstraction.

By mastering the fundamentals of OOP, you will be equipped to write more efficient, flexible, and maintainable Java programs. This module will also cover essential topics like exception handling, static members, testing and debugging, and best practices for writing well-documented code using JavaDoc.

By the end of this module, you will be able to:

- Explain the four key principles of Object-Oriented Programming (encapsulation, inheritance, polymorphism, and abstraction) and describe their benefits for modularity, reusability, and maintainability.
- Define Java classes, create objects, and use constructors to initialize them.
- Apply access modifiers (public, private, protected) to control visibility and access to class members.
- Use the this keyword in object-oriented contexts to reference the current instance of a class.
- Utilize standard methods from the Object class, such as toString(), equals(), and hashCode().
- Implement encapsulation by using getters and setters to manage private data and ensure data integrity through validation.
- Differentiate between instance and static members, and use the static keyword to define class-wide variables and methods.
- Handle exceptions effectively using try-catch blocks, the finally block, and Java's exception hierarchy.
- Use debugging tools to identify and resolve errors, including setting breakpoints, stepping through code, and inspecting variables in an IDE.
- Write JavaDoc comments to document classes, methods, and fields, and generate professional HTML documentation.

Module 3: Aggregation and Composition

This module will explore the essential concepts of aggregation and composition in object-oriented programming. Understanding these relationships enables us to create more complex and structured applications by defining how classes collaborate. Building on fundamental concepts, we will learn to model associations in which objects interact or depend on one another, and how these relationships influence program structure and behavior.

This module provides a comprehensive overview of how class relationships and dependencies are vital in object-oriented programming, moving us toward building robust, modular applications.

By the end of this module, you will be able to:

- Differentiate between association, aggregation, and composition relationships in object-oriented programming.
- Implement aggregation and composition in Java to create classes with layered, complex structures.
- Use Java I/O streams to read from and write to files.
- Test and debug applications with aggregated and composed classes to ensure reliability in complex object interactions..

Module 4: Java Data Structures

In this module, students will explore fundamental data structures in Java, beginning with arrays and ArrayLists and progressing to more complex structures such as HashMaps and generic types. Understanding data structures is essential for writing efficient, organized, and reusable code, as they enable programmers to manage and manipulate data effectively.

We’ll introduce arrays, covering how they’re declared, initialized, and used, along with some common operations. From there, we'll move to the more flexible ArrayList class and discuss its advantages over traditional arrays. Following this, students will learn about HashMap for managing key-value pairs and discover the power of generics for creating flexible, type-safe code.

Additionally, this module covers techniques for iterating over arrays and collections, sorting and searching, and handling common exceptions that can arise when working with data structures. You will also learn testing and debugging practices specific to data structures to ensure robust and reliable code..

By the end of this module, you will be able to:

- Declare, initialize, and manipulate one-dimensional and multidimensional arrays, performing common operations such as traversal and modification.
- Use the ArrayList class to store and manage data dynamically, leveraging its advantages over arrays and applying commonly used methods like add(), remove(), and size().
- Work with HashMaps to store, retrieve, and manipulate data using key-value pairs, and understand their practical use cases.
- Understand the concept of generics in Java, their syntax, and how they enhance type safety when working with collections.
- Iterate over arrays and collections using traditional loops, enhanced for-loops, and the Iterator interface for efficient data traversal.
- Apply sorting techniques, including Arrays.sort() and Collections.sort(), and implement searching methods, such as linear and binary search, on arrays and lists.
- Identify and handle common exceptions that arise when working with arrays and collections, using defensive programming practices to ensure program stability.
- Write test cases to validate the behavior of arrays and collections, debug common issues, and use assertions to ensure the integrity of data structures.

Module 5: Inheritance

Inheritance is a cornerstone of object-oriented programming, allowing developers to create a class hierarchy that models real-world relationships. In this module, you will explore how inheritance enables code reuse by extending existing classes to create new subclasses. Understanding inheritance allows you to build more robust and organized applications with clear class relationships and shared functionality.

Through this module, you will develop a solid understanding of inheritance and apply it to design and organize Java applications effectively. Each topic combines theoretical concepts with practical examples to reinforce Java's inheritance principles.

By the end of this module, you will be able to:

- Explain the concept of inheritance, its benefits for code reuse and organization, and how it allows the creation of a hierarchy of related types.
- Implement inheritance in Java using the extends keyword to define superclasses and subclasses and understand their relationship.
- Use the super keyword to access superclass constructors and methods, ensuring clean and organized subclass implementations.
- Override methods in subclasses to provide specific implementations, applying the @Override annotation to ensure correctness and leveraging polymorphism effectively.
- Understand exception handling in the context of inheritance, including the rules for overridden methods that throw exceptions and the use of custom exceptions.
- Write unit tests to validate behavior in superclasses and subclasses, ensuring correct implementation of inheritance features.
- Debug inheritance-related issues by identifying and resolving common problems with method overriding, constructor calls, and polymorphic behavior.

Module 6: Polymorphism

Polymorphism is one of the core principles of Object-Oriented Programming (OOP). It allows objects to take on many forms, enabling flexibility and adaptability in code design. With polymorphism, you can write more modular, maintainable, and scalable programs. This module delves into polymorphism, explaining how it works in Java and why it is crucial for effective object-oriented programming.

In this module, you will learn how polymorphism enables objects to behave differently depending on their runtime context. Using techniques such as method overriding, dynamic method dispatch, and abstract classes, you will understand how Java achieves polymorphic behavior and simplifies software development. We will also explore how polymorphism interacts with other concepts, such as type casting and exception handling.

By the end of this module, you will be able to:

- Define polymorphism and explain how it enables a single interface to represent multiple types, using real-world analogies to contextualize its role in programming.
- Distinguish between compile-time polymorphism (method overloading) and run-time polymorphism (method overriding), and identify when to use each approach for practical design.
- Demonstrate dynamic method dispatch in Java, explaining how the JVM determines the appropriate method to call based on the actual type of the object at runtime.
- Utilize abstract classes and methods to design flexible and extensible programs by defining shared behaviors and structures for related objects.
- Implement polymorphic behavior by using a superclass reference to hold subclass objects, promoting code generalization and flexibility.
- Perform type casting and type checking, using upcasting and downcasting effectively while leveraging the instanceof operator to ensure safe runtime type conversions.
- Handle exceptions in polymorphic systems, aligning overridden methods with appropriate exception types and applying covariant return types and narrowing exception scopes.
- Test polymorphic systems thoroughly, ensuring that subclass-specific methods function correctly when accessed through superclass references, and use mock objects to validate dynamic behavior.

Module 7: Interfaces and Design Patterns

Interfaces are a cornerstone of Object-Oriented Programming (OOP), providing a way to define contracts that classes must adhere to. In Java, interfaces are powerful tools for achieving abstraction, enforcing design consistency, and enabling flexible, scalable systems. They allow you to define method signatures and constants without dictating how those methods are implemented, making them essential for designing robust and maintainable codebases.

In this module, you will explore the many facets of interfaces, from their basic syntax to their role in advanced programming paradigms like functional programming and design patterns. You will also learn about new features introduced in Java 8 and beyond, such as default and static methods, which have transformed how interfaces are used.

A Java interface is a collection of abstract methods that enables abstraction and multiple inheritance. A class can implement an interface using the 'implements' keyword. When a class implements an interface, it must provide concrete implementations for all the methods defined in that interface. Interfaces define contracts or blueprints for classes, promoting loose coupling and flexibility in the code.

In essence, a Java interface serves as a contract, specifying the rules that a class must follow. It enforces specific behaviors within a class, much like a contract outlines the services a company commits to deliver.

By the end of these sections, you will be able to:

- Define interfaces in Java, including their syntax, abstract methods, and constants.
- Implement interfaces using the implements keyword and apply advanced concepts such as multiple interface implementation and interface inheritance.
- Differentiate between interfaces and abstract classes, and decide when to use each based on design requirements.
- Utilize default and static methods introduced in Java 8 to extend interface functionality and streamline code design.
- Analyze the role of interfaces in popular design patterns, including Composite, Strategy, Chain of Responsibility, and Comparable.
- Explore functional programming concepts by using the @FunctionalInterface annotation and applying lambda expressions with functional interfaces.
- Simplify code and improve readability by introducing lambda expressions.
- Handle exceptions in interface methods by declaring and managing exceptions in implementing classes.
- Write unit tests for interface implementations and leverage interfaces within testing frameworks, using dependency injection to enable flexible testing.

Module 8: Design Patterns and Best Practices

As you near the conclusion of your journey into Java programming, this module shifts focus to the design patterns and best practices that elevate your code from functional to elegant, scalable, and maintainable. Understanding and applying these concepts is critical for designing robust software systems and working effectively as part of a development team.

In this module, you will explore the foundational design patterns that have shaped modern software engineering, delve into OOP principles and best practices, and learn how to integrate these patterns into your Java applications. You'll also discover advanced techniques for testing and debugging that ensure your code is reliable, maintainable, and ready for real-world development challenges.

By the end of this module, you will be able to:

- Define design patterns and explain their significance in addressing common software design challenges.
- Classify design patterns into the three main categories: Creational, Structural, and Behavioral, and describe their unique purposes.
- Apply object-oriented programming principles, such as the SOLID principles, to create maintainable and scalable code.
- Demonstrate coding best practices, including composition over inheritance, the DRY (Don't Repeat Yourself) principle, the KISS (Keep It Simple, Stupid) principle, and refactoring techniques to avoid code smells.
- Implement popular design patterns in Java, including Singleton, State, Observer, Adapter, Template, and Prototype, with hands-on examples.
- Analyze real-world scenarios to identify where and how design patterns can be effectively applied.
- Identify common pitfalls in the use of design patterns and apply best practices to avoid them.