



Java SE 21 Programming Complete

Student Guide
D1107035GC10

Copyright © 2024, Oracle and/or its affiliates.

Disclaimer

This document contains proprietary information and is protected by copyright and other intellectual property laws. The document may not be modified or altered in any way. Except where your use constitutes "fair use" under copyright law, you may not use, share, download, upload, copy, print, display, perform, reproduce, publish, license, post, transmit, or distribute this document in whole or in part without the express authorization of Oracle.

The information contained in this document is subject to change without notice and is not warranted to be error-free. If you find any errors, please report them to us in writing.

Restricted Rights Notice

If this documentation is delivered to the United States Government or anyone using the documentation on behalf of the United States Government, the following notice is applicable:

U.S. GOVERNMENT END USERS: Oracle programs (including any operating system, integrated software, any programs embedded, installed or activated on delivered hardware, and modifications of such programs) and Oracle computer documentation or other Oracle data delivered to or accessed by U.S. Government end users are "commercial computer software" or "commercial computer software documentation" pursuant to the applicable Federal Acquisition Regulation and agency-specific supplemental regulations. As such, the use, reproduction, duplication, release, display, disclosure, modification, preparation of derivative works, and/or adaptation of i) Oracle programs (including any operating system, integrated software, any programs embedded, installed or activated on delivered hardware, and modifications of such programs), ii) Oracle computer documentation and/or iii) other Oracle data, is subject to the rights and limitations specified in the license contained in the applicable contract. The terms governing the U.S. Government's use of Oracle cloud services are defined by the applicable contract for such services. No other rights are granted to the U.S. Government.

Trademark Notice

Oracle®, Java, MySQL, and NetSuite are registered trademarks of Oracle and/or its affiliates. Other names may be trademarks of their respective owners.

Intel and Intel Inside are trademarks or registered trademarks of Intel Corporation. All SPARC trademarks are used under license and are trademarks or registered trademarks of SPARC International, Inc. AMD, Epyc, and the AMD logo are trademarks or registered trademarks of Advanced Micro Devices. UNIX is a registered trademark of The Open Group.

Third-Party Content, Products, and Services Disclaimer

This documentation may provide access to or information about content, products, and services from third parties. Oracle Corporation and its affiliates are not responsible for and expressly disclaim all warranties of any kind with respect to third-party content, products, and services unless otherwise set forth in an applicable agreement between you and Oracle. Oracle Corporation and its affiliates will not be responsible for any loss, costs, or damages incurred due to your access to or use of third-party content, products, or services, except as set forth in an applicable agreement between you and Oracle.

1006252024

Contents

I Course Introduction

Course Goals 1-2

Audience 1-3

Course Structure 1-4

1 Introduction to Java

Objectives 1-2

What Is Java? 1-3

How Java Works 1-4

Object-Oriented Principles 1-5

Classes and Objects 1-6

Classes 1-7

Objects 1-8

Inheritance 1-9

Java APIs 1-10

Java Keywords, Reserved Words, and Special Identifiers 1-11

Java Naming Conventions 1-12

Java Basic Syntax Rules 1-13

Defining a Java Class 1-14

Accessing Classes Across Packages 1-15

Implementing Encapsulation with Access Modifiers 1-17

Creating a Main Application Class 1-18

Compiling a Java Program 1-19

Executing a Java Program 1-20

Comments and Documentation 1-21

Code Snippets in Javadoc 1-23

External Snippets 1-24

Summary 1-25

Practices for Lesson 1: Overview 1-26

2 Primitive Types, Operators, and Flow Control Statements

Objectives 2-2

Java Primitives 2-3

Declaring and Initializing Primitive Variables 2-4

Primitive Declarations and Initializations: Restrictions 2-5

- Java Operators 2-6
 - Assignment and Arithmetic Operators 2-7
 - Arithmetic Operations and Type Casting 2-8
 - More Mathematical Operations 2-9
 - Binary Number Representation 2-10
 - Bitwise Logical Operators 2-11
 - Equality, Relational, and Conditional Operators 2-12
 - Short-Circuit Evaluation 2-13
 - Flow Control Using if/else Construct 2-14
 - Ternary Operator 2-15
 - Flow Control Using switch Construct 2-16
 - Switch -> No Fall-Through Syntax 2-17
 - Switch Expressions yield a Value 2-18
 - Switch Statements and Expressions Summary 2-19
 - Using JShell (REPL Tool) 2-20
 - JShell Commands 2-21
 - Code Snippets 2-22
 - Summary 2-23
 - Practices for Lesson 2: Overview 2-24

3 Text, Date, Time, and Numeric Objects

- Objectives 3-2
- String Initialization 3-3
- String Operations 3-4
- String Indexing 3-5
- Mutable Text Objects 3-6
- Text Blocks 3-7
- Spaces, Lines, and Quotes 3-9
- Wrapper Classes for Primitives 3-10
- Representing Numbers Using BigDecimal Class 3-11
- Method Chaining 3-12
- Local Date and Time API 3-13
- More Local Date and Time Operations 3-14
- Instant, Durations, and Periods 3-16
- Zoned Date and Time 3-18
- Representing Languages and Countries 3-19
- Formatting and Parsing Numeric Values 3-21
- Formatting and Parsing Date and Time Values 3-23
- Localizable Resources 3-26
- Formatting Message Patterns 3-27
- Formatting and Localization: Summary 3-29

Summary 3-31
Practices for Lesson 3: Overview 3-32

4 Classes and Objects

Objectives 4-2
UML: Introduction 4-3
Modeling Classes 4-4
Modeling Interactions and Activities 4-6
Designing Classes 4-7
Creating Objects 4-8
Defining Instance Variables 4-9
Defining Instance Methods 4-10
Object Creation and Access: Example 4-11
Local Variables and Recursive Object Reference 4-12
Local Variable Type Inference 4-14
Defining Constants 4-16
Static Context 4-17
Accessing Static Context 4-18
Combining Static and Final 4-19
Other Static Context Use Cases 4-20
IntelliJ IDE: Introduction 4-21
Summary 4-22
Practices for Lesson 4: Overview 4-23

5 Improved Class Design

Objectives 5-2
Overload Methods 5-3
Variable Number of Arguments 5-4
Defining Constructors 5-5
Reusing Constructors 5-6
Access Modifiers: Summary 5-7
Defining Encapsulation 5-8
Defining Immutability 5-9
Constants and Immutability 5-10
Enumerations 5-11
Complex Enumerations 5-13
Java Memory Allocation 5-14
Parameter Passing 5-15
Java Memory Cleanup 5-16
Summary 5-17
Practices for Lesson 5: Overview 5-18

6 Implement Inheritance and Use Records

- Objectives 6-2
- Extending Classes 6-3
- Object Class 6-4
- Reusing Parent Class Code Through Inheritance 6-5
- Instantiating Classes and Accessing Objects 6-6
- Rules of Reference Type Casting 6-7
- Verifying Object Type Before Casting the Reference 6-8
- Pattern Matching for instanceof 6-9
- Reference Code Within the Current or Parent Object 6-10
- Defining Subclass Constructors 6-11
- Class and Object Initialization: Summary 6-12
- Overriding Methods and Using Polymorphism 6-13
- Reusing Parent Class Logic in Overwritten Method 6-15
- Defining Abstract Classes and Methods 6-16
- Defining Final Classes and Methods 6-17
- Sealed Classes and Interfaces 6-18
- Overriding Object Class Operations: toString 6-20
- Overriding Object Class Operations: equals 6-21
- Override Object Class Operations: hashCode 6-22
- Comparing String Objects 6-23
- Java Records 6-24
- Custom Record Constructors 6-25
- Record Patterns 6-26
- Pattern Matching for switch 6-27
- Factory Methods 6-28
- Summary 6-29
- Practices for Lesson 6: Overview 6-30

7 Interfaces and Generics

- Objectives 7-2
- Java Interfaces 7-3
- Multiple Inheritance Problem 7-5
- Implement Interfaces 7-6
- Default, Private, and Static Methods in Interfaces 7-7
- Interface Hierarchy 7-8
- Default Methods Inheritance 7-9
- Interface Is a Type 7-10
- Functional Interfaces 7-11
- Generics 7-12
- Use Generics 7-13

Examples of Java Interfaces: `java.lang.Comparable` 7-15
Examples of Java Interfaces: `java.util.Comparator` 7-16
Examples of Java Interfaces: `java.lang.Cloneable` 7-17
Composition Pattern 7-18
Summary 7-19
Practices for Lesson 7: Overview 7-20

8 Arrays and Loops

Objectives 8-2
Arrays 8-3
Combined Declaration, Creation, and Initialization of Arrays 8-4
Multidimensional Arrays 8-5
Copying Array Content 8-6
Arrays Class 8-7
Loops 8-8
Processing Arrays by Using Loops 8-9
Complex for Loops 8-10
Embedded Loops 8-11
Break and Continue 8-12
Summary 8-13
Practices for Lesson 8: Overview 8-14

9 Collections

Objectives 9-2
Introduction to Java Collection API 9-3
Java Collection API Interfaces 9-4
Java Collection API Implementation Classes 9-5
Java Collection API Interfaces and Implementation Classes 9-6
Create List Object 9-7
Manage List Contents 9-8
Create Set Object 9-9
Manage Set Contents 9-11
Create Deque Object 9-12
Manage Deque Contents 9-13
Create HashMap Object 9-15
Manage HashMap Contents 9-16
Iterate Through Collections 9-17
Sequenced Collections 9-18
Other Collection Behaviors 9-20
Use `java.util.Collections` Class 9-21
Access Collections Concurrently 9-22

Prevent Collections Corruption 9-23
Legacy Collection Classes 9-25
Summary 9-26
Practices for Lesson 9: Overview 9-27

10 Nested Classes and Lambda Expressions

Objectives 10-2
Types of Nested Classes 10-3
Static Nested Classes 10-6
Member Inner Classes 10-7
Local Inner Classes 10-9
Anonymous Inner Classes 10-10
Anonymous Inner Classes and Functional Interfaces 10-12
Understand Lambda Expressions 10-13
Define Lambda Expression Parameters and Body 10-14
Use Method References 10-15
Default and Static Methods in Functional Interfaces 10-16
Use Default and Static Methods of the Comparator Interface 10-17
Use Default and Static Methods of the Predicate Interface 10-18
Summary 10-19
Practices for Lesson 10: Overview 10-20

11 Java Streams API

Objectives 11-2
Characteristics of Streams 11-3
Create Streams Using Stream API 11-4
Stream Pipeline Processing Operations 11-5
Using Functional Interfaces 11-6
Primitive Variants of Functional Interfaces 11-7
Bi-argument Variants of Functional Interfaces 11-9
Perform Actions with Stream Pipeline Elements 11-10
Perform Filtering of Stream Pipeline Elements 11-11
Perform Mapping of Stream Pipeline Elements 11-12
Join Streams Using flatMap Operation 11-13
Other Intermediate Stream Operations 11-14
Short-Circuit Terminal Operations 11-15
Process Stream Using count, min, max, sum, average Operations 11-16
Aggregate Stream Data using reduce Operation 11-17
General Logic of the collect Operation 11-19
Using Basic Collectors 11-20
Perform a Conversion of a Collector Result 11-21

- Perform Grouping or Partitioning of the Stream Content 11-22
- Mapping and Filtering with Respect to Groups or Partitions 11-23
- Parallel Stream Processing 11-25
- Parallel Stream Processing Guidelines 11-26
- Restrictions on Parallel Stream Processing 11-27
- Spliterator 11-28
- Spliterator Characteristics 11-29
- Summary 11-30
- Practices for Lesson 11: Overview 11-31

12 Exception Handling, Logging, and Debugging

- Objectives 12-2
- Using Java Logging API 12-3
- Logging Method Categories 12-4
- Guarded Logging 12-5
- Log Writing Handling 12-6
- Logging Configuration 12-7
- Describe Java Exceptions 12-8
- Create Custom Exceptions 12-9
- Throwing Exceptions 12-10
- Catching Exceptions 12-11
- Exceptions and the Execution Flow 12-12
- Helpful NullPointerExceptions 12-13
- Example Throwing an Unchecked Exception 12-14
- Example Throwing a Checked Exception 12-15
- Handling Exceptions 12-16
- Resource Auto-Closure 12-17
- Suppressed Exceptions 12-18
- Handle Exception Cause 12-19
- Java Debugger 12-20
- Debugger Actions 12-21
- Manipulate Program Data in Debug Mode 12-22
- Validate Program Logic Using Assertions 12-23
- Normal Program Flow with No Exceptions 12-24
- Program Flow Producing a Runtime Exception 12-26
- Program Flow Catching Specific Checked Exception 12-28
- Program Flow Catching Any Exceptions 12-30
- Summary 12-32
- Practices for Lesson 12: Overview 12-33

13 Java IO API

Objectives	13-2
Java Input-Output Principals	13-3
Java Input-Output API	13-4
Reading and Writing Binary Data	13-5
Basic Binary Data Reading and Writing	13-6
Reading and Writing Character Data	13-7
Basic Character Data Reading and Writing	13-8
Connecting Streams	13-9
Standard Input and Output	13-10
Using Console	13-11
Understand Serialization	13-13
Serializable Object Graph	13-14
Object Serialization	13-15
Serialization of Sensitive Information	13-16
Customize Serialization Process	13-17
Serialization and Versioning	13-18
Working with Filesystems	13-19
Constructing Filesystem Paths	13-20
Navigating the Filesystem	13-21
Analyze Path Properties	13-22
Set Path Properties	13-23
Create Paths	13-24
Create Temporary Files and Folders	13-25
Copy and Move Paths	13-26
Delete Paths	13-27
Handle Zip Archives	13-28
Represent Zip Archive as a FileSystem	13-29
Access HTTP Resources	13-31
Summary	13-32
Practices for Lesson 13: Overview	13-33

14 Java Concurrency and Multithreading

Objectives	14-2
Java Concurrency Concepts	14-3
Implement Threads	14-4
Thread Life Cycle	14-5
Interrupt Thread	14-6
Block Thread	14-7
Make Thread Wait Until Notified	14-8
Common Thread Properties	14-10

- Create Executor Service Objects 14-11
- Manage Executor Service Life Cycle 14-14
- Implementing Executor Service Tasks 14-16
- Locking Problems 14-18
- Writing Thread-Safe Code 14-19
- Ensure Consistent Access to Shared Data 14-21
- Nonblocking Atomic Actions 14-22
- Ensure Exclusive Object Access Using Intrinsic Locks 14-23
- Intrinsic Lock Automation 14-24
- Nonblocking Concurrency Automation 14-25
- Alternative Locking Mechanisms 14-26
- CPU Versus IO Bound Concurrent Tasks 14-27
- Virtual Threads API 14-28
- Virtual Thread Operations 14-29
- Summary 14-30
- Practices for Lesson 14: Overview 14-31

15 Modules and Deployment

- Objectives 15-2
- Compile, Package, and Execute Nonmodular Java Applications 15-3
- Nonmodular Java Characteristics 15-4
- What Is a Module? 15-5
- Java Modules 15-7
- Java Module Categories 15-8
- Define Module Dependencies 15-9
- Export Module Content 15-10
- Module Example 15-11
- Open Module Content 15-12
- Open an Entire Module 15-13
- Produce and Consume Services 15-14
- Services Example 15-15
- Multi-Release Module Archives 15-16
- Compile and Package a Module 15-17
- Execute a Modularized Application 15-18
- Migrating Legacy Java Applications Using Automatic module 15-19
- Create Custom Runtime Image 15-20
- Execute Runtime Image 15-22
- Optimize a Custom Runtime Image 15-23
- Check Dependencies 15-24
- Summary 15-25
- Practices for Lesson 15: Overview 15-26

A Annotations

- Objectives A-2
- Annotations: Introduction A-3
- Design Annotations A-4
- Apply Annotations A-5
- Dynamically Discover Annotations A-6
- Document the Use of Annotations A-7
- Annotations that Validate Design A-8
- Deprecated Annotation A-9
- Suppress Compiler Warnings A-10
- Varargs and Heap Pollution A-11
- Summary A-12

B Java Database Connectivity

- Objectives B-2
- Java Database Connectivity (JDBC) B-3
- JDBC API Structure B-4
- Manage Database Connections B-5
- Create and Execute Basic SQL Statements B-6
- Create and Execute Prepared SQL Statements B-7
- Create and Execute Callable SQL Statements B-8
- Process Query Results B-9
- Control Transactions B-11
- Discover Metadata B-12
- Customize ResultSet B-13
- Set Up ResultSet Type B-14
- Set Up ResultSet Concurrency and Holdability B-16
- Summary B-17

C Java Security

- Objectives C-2
- Security as Nonfunctional Requirement C-3
- Security Threats C-4
- Denial of Service (DoS) Attack C-5
- Define Security Policies C-6
- Changes in the Security API C-8
- Secure File System and I/O Operations C-9
- Best Practices for Protecting Your Code C-10
- Erroneous Value Guards C-11
- Protect Sensitive Data (Part 1) C-12
- Protect Sensitive Data (Part 2) C-13

- Prevent SQL Injections C-14
- Prevent JavaScript Injections C-15
- Prevent XML Injections C-16
- Discover and Document Security Issues C-17
- Summary C-18

D Advanced Generics

- Objectives D-2
- Compiler Erases Information About Generics D-3
- Generic and Raw Type Compatibility D-4
- Generics and Type Hierarchy D-5
- Wildcard Generics D-6
- Upper Bound Wildcard D-7
- Lower Bound Wildcard D-8
- Collections and Generics Best Practices D-9
- Summary D-10

E Java Applications on Oracle Cloud

- Objectives E-2
- Cloud Application Requirements E-3
- Cloud Application Runtime Infrastructure E-4
- Cloud Java Application Servers E-5
- Package and Deploy Cloud Application E-6
- Optimise deployment with GraalVM E-7
- HTTP Protocol Basics E-9
- REST Service Conventions and Resources E-11
- Configure and Launch REST Service Application Using Helidon SE E-12
- Summary E-13

F Miscellaneous Java Topics

- Objectives F-2
- Builder Design Pattern F-3
- Singleton Design Pattern F-4
- Java Regular Expression API F-5
- Regular Expressions: Character Classes F-6
- Regular Expressions: Quantifiers F-7
- Regular Expressions: Boundaries F-8
- File IO Watch Service F-9
- Summary F-11

