

OCA Java SE 7

Programmer I

CERTIFICATION GUIDE

Prepare for the 1Z0-803 exam



Mala Gupta

FOREWORD BY **Jeanne Boyarsky**

 MANNING

*OCA Java SE 7 Programmer I
Certification Guide*

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PREPARE FOR THE 1Z0-803 EXAM

MALA GUPTA



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*To my pillar of strength, my best friend,
and my husband, Dheeraj Prakash*

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foreword

Taking the OCA Java Programmer I exam is a bit like taking a driving test. First you learn the basics, like where the brakes are. Then you start driving, and then you get ready to take the driving test to get your license. The written test includes things everyone should know, things that you'll never use after the road test, and some things that are tricky edge cases. While the programmer exam cares about breaks more than brakes, it certainly likes edge cases!

Consider Mala Gupta your driving instructor to get you ready for the programmer exam. Mala points out what you'll need to know when programming in the real world—on your first job.

And consider this book your driver's manual. It gives you the rules of the road of Java, plus the gotchas that show up on that pesky written test. But don't worry, it is much more fun to read this book than the driver's manual. Just like the driver's manual won't teach you everything about driving, this book won't teach you everything there is to know about Java. If you haven't yet, read an intro to a Java book first. Start with a book like *Head First Java* or *Thinking in Java* and then come back to this book to study for the exam.

As the technical proofreader of this book, I got to see it evolve and get better as Mala worked on it. Through the conversations we had on little things, I learned that Mala knows her stuff and is a great teacher of Java. While I've only technical proofread a handful of books, I've posted reviews of over 150 technical books on Amazon, which makes it easy to spot a book that isn't clear or helpful. I'm happy to say that Mala's explanations are all very clear, and the pointers are great.

I also got to read Mala’s posts in the certification forums at coderanch.com. She’s been sharing updates about the exam as it comes out and posting fairly regularly for over a year. As a senior moderator at coderanch.com, it is great to see an author sharing her wisdom. It’s also nice to see the similarity in writing style between the forum posts and the book. This shows the book is readable and written in an easy-to-understand, casual style.

I particularly liked the diagrams, flow charts, and cartoons in this book. And, of course, the annotated code examples I’ve come to expect from any Manning book. Each chapter ends with sample mock exam questions and there is a full mock exam at the end. This gives you good practice in getting ready for the exam. Wrong answers are well explained so you don’t make the same mistakes over and over.

My favorite part of the book is the “Twist in the Tale” exercises. Mala gives a number of examples of how making a seemingly minor change to the code can have major consequences. These exercises develop your attention to detail so you are more observant for the mock exam questions and the exam itself.

I had already passed the OCA Java Programmer exam with a score of 98% before reading this book. If I hadn’t, the questions would have prepared me for the exam. Studying from this book will give you the skills and confidence you need to become an Oracle Certified Associate Java Programmer. Happy coding and good luck on the exam!

JEANNE BOYARSKY
SENIOR DEVELOPER & MODERATOR
CODERANCH

****preface****

Java programmer certifications are designed to tell would-be employers whether you really know your stuff, and cracking the OCA Java SE 7 Programmer Certification is not an easy task. Thorough preparation is crucial if you want to pass the exam the first time with a score that you can be proud of. You need to know Java inside and out, and you need to understand the certification process so that you’re ready for the challenging questions you’ll face in the exam.

This book is a comprehensive guide to the 1Z0-803 exam. You’ll explore a wide range of important Java topics as you systematically learn how to pass the certification exam. Each chapter starts with a list of the exam objectives covered in that chapter. Throughout the book you’ll find sample questions and exercises designed to reinforce key concepts and prepare you for what you’ll see in the real exam, along with numerous tips, notes, and visual aids.

Unlike many other exam guides, this book provides multiple ways to digest important techniques and concepts, including comic conversations, analogies, pictorial representations, flowcharts, UML diagrams, and, naturally, lots of well-commented code. The book also gives insight into typical exam question mistakes and guides you in avoiding traps and pitfalls. It provides

- 100% coverage of exam topics, all mapped to chapter and section numbers
- Hands-on coding exercises, including particularly challenging ones that throw in a twist

- Instruction on what's happening behind the scenes using the actual code from the Java API source
- Mastery of both the concepts and the exam

This book is written for developers with a working knowledge of Java. My hope is that the book will deepen your knowledge, prepare you well for the exam, and that you will pass it with flying colors!

acknowledgments

First and foremost, I thank Dheeraj Prakash—my pillar of strength, my best friend and my husband. This book wouldn’t exist without his efforts. His constant guidance, encouragement, and love kept me going. He helped me to get started with this book and got me over the goal line.

My sincere gratitude to Marjan Bace, publisher at Manning, for giving me the opportunity to author this book. The Manning team has been wonderful—Scott Meyers ensured that it was worth it for Manning to have a book on this subject. Cynthia Kane, my development editor, played a major role in shaping the organization of individual chapters and the overall book. It has been a real pleasure to work with her. Copyeditors Tara Walsh, Bob Herbstman, and Nancy Wolfe Kotary not only applied their magic to sentence and language constructions but also supplemented their editing with valuable suggestions on technical content.

Technical Editor Brent Watson did a brilliant job of reviewing the complete book contents in a limited time, catching even the smallest errors in the book. Technical Proofreader Jeanne Boyarsky was outstanding and an amazing person to work with. She was very quick at reviewing the book, with an eye for detail. Proofreader Andy Carroll was extremely capable and talented. He reviewed the final manuscript with great precision.

The technical reviewers on this book did an awesome job of reviewing the contents and sharing their valuable feedback and comments: Roel De Nijs, Ivan Todorovic, Michael Piscatello, Javier Valverde, Anayonkar Shivalkar, Kyle Smith, Niklas Rosencrantz, Ashwin Mhatre, Janki Shah, Dmitriy Andrushko, Nitesh Nandwana, and Priyanka Manchanda. I would also like to thank Ozren Harlovic, Review Editor, for managing

the whole review process and meticulously funneling the feedback to make this book better.

Martin Murtonen did an outstanding job of converting the black and white hand-drawn illustrations into glorious images. It was amazing to scrutinize the page proofs. I thank Dennis Dalinnik for adjusting the images in the final page proofs, which was a lot of work. Janet Vail and Mary Piergies were awesome in their expertise at turning all text, code, and images into publishable form. I am also grateful to Candace Gillhoolley and Nermina Miller for their efforts in promoting the book.

I thank the MEAP readers for buying the book while it was being developed and for their suggestions, corrections, and encouragement: Samuel Prette, David C., Diego Poggioli, Baptize, Jayagopi Jagadeesan, David Vonka, Joel Rainey, Steve Breese, and Jörgen Persson.

I would also like to thank my former colleagues Harry Mantheakis, Paul Rosenthal, and Selvan Rajan, whose names I use in coding examples throughout the book. I have always looked up to them.

I thank my nine-year-old daughter, Shreya, an artist, who often advised me on the images that I created for the book. I'm also grateful to my younger daughter, Pavni, who patiently waited for my attention all these months when my focus was on the book. I thank my family for their unconditional support. The book would have been not been possible without their love and encouragement.

about this book

This book is written for developers with a working knowledge of Java who want to earn the OCA Java SE 7 Programmer certification. It uses powerful tools and features to make reaching your goal of certification a quick, smooth, and enjoyable experience. This section will explain the features used in the book and tell you how to use the book to get the most out of it as you prepare for the certification exam. More information on the exam and on how the book is organized is available in the Introduction.

Start your preparation with the chapter-based exam objective map

I strongly recommend a structured approach to preparing for this exam. To help you with this task, I've developed a chapter-based exam objective map, as shown in figure 1. The full version is in the Introduction (table I.3).

	Exam objectives	Covered in chapter/section	Your readiness score
1	Java basics	Chapters 1 and 3	
1.1	Define the scope of variables	Section 3.1	☆☆☆
1.2	Define the structure of a Java class	Section 1.1	☆☆☆
1.3	Create executable Java applications with a main method	Section 1.2	☆☆☆

Figure 1 The Introduction to this book provides a list of all exam objectives and the corresponding chapter and section numbers where they are covered. See the full table in the Introduction (table I.3).

As you go through your preparation, mark your readiness score for each section. Self-assessment is an important tool that will help you determine when you are ready to take the exam.

The map in the Introduction shows the complete exam objective list mapped to the relevant chapter and section numbers. You can jump to the relevant section number to work on a particular exam topic.

Chapter-based objectives

Each chapter starts with a list of the exam objectives covered in that chapter, as shown in figure 2. This list is followed by a quick comparison of the major concepts and topics covered in the chapter with real-world objects and scenarios.

Exam objectives covered in this chapter	What you need to know
[3.4] Create if and if-else constructs.	<p>How to use if, if-else, if-else-if-else, and nested if constructs.</p> <p>The differences between using these if constructs with and without curly braces {}.</p>

Figure 2 An example of the list of exam objectives and brief explanations at the beginning of each chapter

Section-based objectives

Each main section in a chapter starts by identifying the exam objective(s) that it covers. Each listed exam topic starts with the exam objective and its subobjective number.

In figure 3, the number 4.4 refers to section 4.4 in chapter 4 (the complete list of chapters and sections can be found in the table of contents). The 4.3 preceding the exam objective refers to the objective's numbering in the list of exam objectives on Oracle's website (the complete numbered list of exam objectives is given in table I.3 in the Introduction).

4.4 ArrayList
 [4.3] Declare and use an ArrayList
<p>In this section, I'll cover how to use <code>ArrayList</code>, its commonly used methods, and the advantages it offers over an array.</p>

Figure 3 An example of the beginning of a section, identifying the exam objective that it covers

Exam tips

Each chapter provides multiple *exam tips* to re-emphasize the points that are the most confusing, overlooked, or frequently answered incorrectly by candidates and that therefore require special attention for the exam. Figure 4 shows an example.



EXAM TIP An `ArrayList` preserves the order of insertion of its elements. `Iterator`, `ListIterator`, and the enhanced `for` loop will return the elements in the order in which they were added to the `ArrayList`.

Figure 4 Example of an exam tip; they occur multiple times in a chapter

Notes

All chapters also include multiple notes, which draw your attention to points that should be noted while you're preparing for the exam. Figure 5 shows an example.



NOTE Though the terms *method parameters* and *method arguments* are not the same, you may have noticed that they are used interchangeably by many programmers. *Method parameters* are the variables that appear in the definition of a method. *Method arguments* are the actual values that are passed to a method while executing it. In figure 3.13, variables `phNum` and `msg` are method parameters. If you execute this method as `sendMsg("123456", "Hello")`, then the String values "123456" and "Hello" are method arguments.

Figure 5 Example note

Sidebars

Sidebars contain information that may not be directly relevant to the exam but that is related to it. Figure 6 shows an example.

Static classes and interfaces

Certification aspirants frequently ask questions about static classes and interfaces, so I'll quickly cover these in this section to ward off any confusion related to them. But note that static classes and interfaces are types of nested classes and interfaces that aren't covered by the OCA Java 7 Programmer I exam.

You can't prefix the definition of a top-level class or an interface with the keyword `static`. A top-level class or interface is one that isn't defined within another class or interface. The following code will fail to compile:

```
static class Person {}
```

Figure 6 Example sidebar

Images

I've used a lot of images in the chapters for an immersive learning experience. I believe that a simple image can help you understand a concept quickly, and a little humor can help you to retain information longer.

Simple images are used to draw your attention to a particular line of code (as shown in figure 7).

```

public String replace(char oldChar, char newChar) {
    if (oldChar != newChar) {
        // code to create a new char array and
        // replace the desired char with the new char

        return new String(0, len, buf);
    }
    return this;
}

```

replace creates and returns a new String object. It doesn't modify the existing array value.

Figure 7 An example image that draws your attention to a particular line of code

I've used pictorial representation of data in arrays (figure 8) and other data types to aid visualization and understanding.

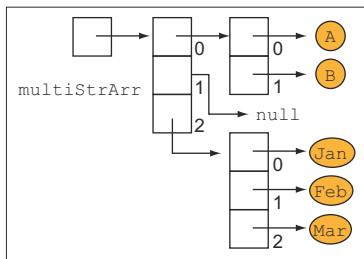


Figure 8 An example pictorial representation of data in an array

To reinforce important points and help you retain them longer, a little humor has been added using comic strips (as in figure 9).

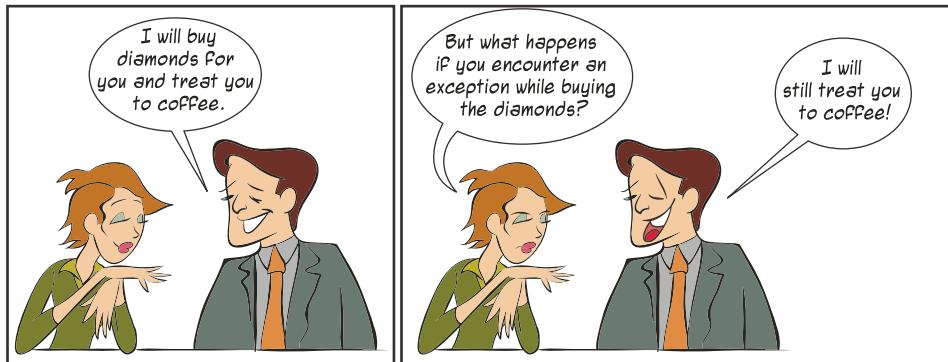


Figure 9 An example of a little humor to help you remember that the finally block always executes

I've also used images to group and represent information for quick reference. Figure 10 shows an example of the protected members that can be accessed by derived

or unrelated classes in the same or separate packages. I strongly recommend that you try to create a few of your own figures like these.

	Same package	Separate package
Derived classes	✓	✓
Unrelated classes	✓	✓

Figure 10 An example of grouping and representing information for quick reference

An image can also add more meaning to a sequence of steps also explained in the text. For example, figure 11 seems to bring the Java compiler to life by allowing it to talk with you and convey what it does when it gets to compile a class that doesn't define a constructor. Again, try a few of your own! It'll be fun!

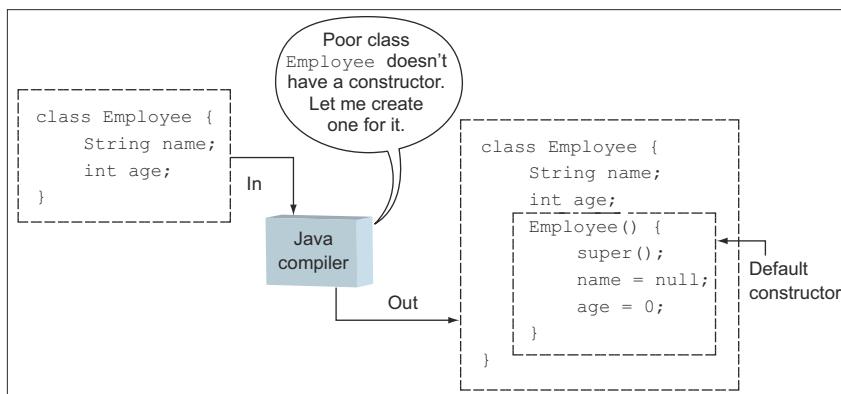


Figure 11 An example pictorial representation of steps executed by the Java compiler when it compiles a class without a constructor

The exam requires that you know multiple methods from classes such as `String`, `StringBuilder`, `ArrayList`, and others. The number of these methods can be overwhelming, but grouping these methods according to their functionality can make this task a lot more manageable. Figure 12 shows an example of an image that groups methods of the `String` class according to their functionality.

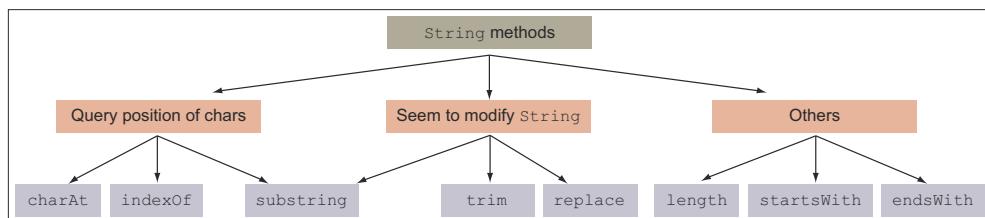


Figure 12 An example image used to group methods of the `String` class according to their functionality.

Expressions that involve multiple operands can be hard to comprehend. Figure 13 is an example of an image that can save you from the mayhem of unary increment and decrement operators used in prefix and postfix notation.

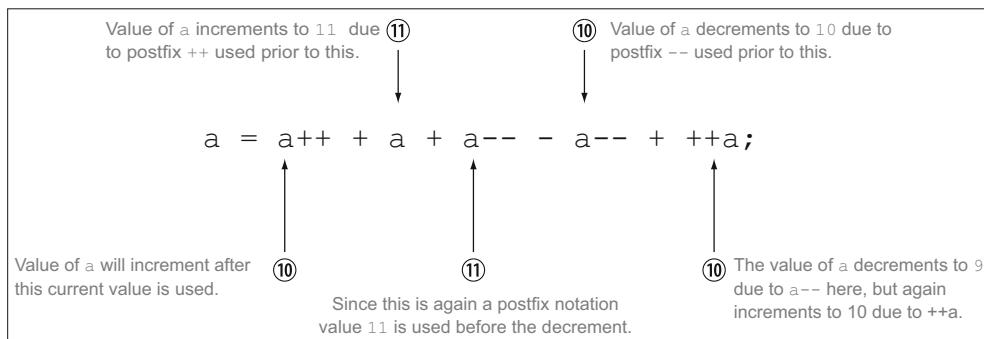


Figure 13 Example of values taken by the operands during execution of an expression

Code snippets that define multiple points and that may result in the nonlinear execution of code can be very difficult to comprehend. These may include selection statements, loops, or exception-handling code. Figure 14 is an example of an image that clearly outlines the lines of code that will execute.

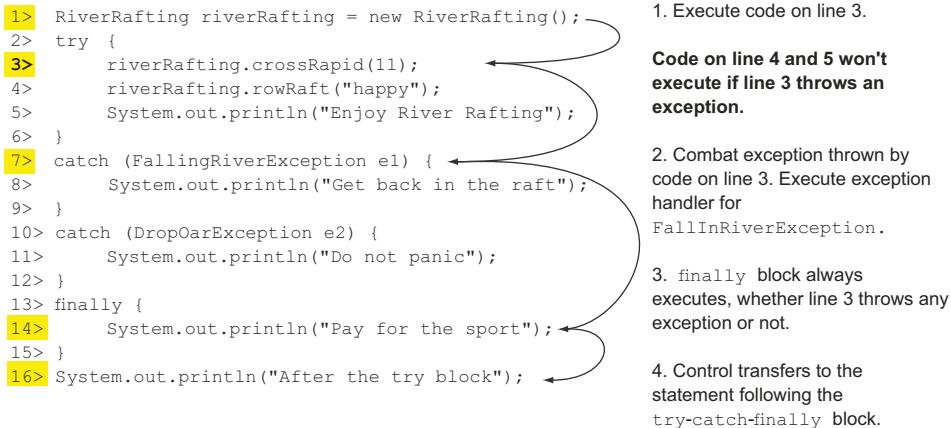


Figure 14 An example of flow of control in a code snippet that may define multiple points of nonlinear execution of code

Twist in the Tale exercises

Each chapter includes a few Twist in the Tale exercises. For these exercises, I've tried to use modified code from the examples already covered in a chapter, and the "Twist in the Tale" title refers to modified or tweaked code. These exercises highlight how

even small code modifications can change the behavior of your code. They should encourage you to carefully examine all of the code in the exam.

My main reason for including these exercises is that on the real exam, you may get to answer more than one question that seems to define exactly the same question and answer options. But upon closer inspection, you'll realize that these questions differ slightly, and that these differences change the behavior of the code and the correct answer option.

The answers to all of the Twist in the Tale exercises are given in the appendix.

Code Indentation

Some of the examples in this book show incorrect indentation of code. This has been done on purpose because on the real exam you can't expect to see perfectly indented code. You should be able to comprehend incorrectly indented code to answer an exam question correctly.

Review notes

When you're ready to take your exam, don't forget to reread the review notes a day before or on the morning of the exam. These notes contain important points from each chapter as a quick refresher.

Exam questions

Each chapter concludes with a set of 10 to 11 exam questions. These follow the same pattern as the real exam questions. Attempt these exam questions after completing a chapter.

Answers to exam questions

The answers to all exam questions provide detailed explanations, including why options are correct or incorrect. Mark your incorrect answers and identify the sections that you need to reread. If possible, draw a few diagrams—you'll be amazed at how much they can help you retain the concepts. Give it a try—it'll be fun!

Author Online

The purchase of *OCA Java SE 7 Programmer I Certification Guide* includes free access to a private forum run by Manning Publications where you can make comments about the book, ask technical questions, and receive help from the author and other users. You can access and subscribe to the forum at www.manning.com/OCAJavaSE7ProgrammerICertification-Guide. This page provides information on how to get on the forum once you're registered, what kind of help is available, and the rules of conduct in the forum.

Manning's commitment to our readers is to provide a venue where a meaningful dialogue among individual readers and between readers and the author can take place. It's not a commitment to any specific amount of participation on the part of the authors, whose contribution to the book's forum remains voluntary (and unpaid). We suggest you try asking the author some challenging questions, lest her interest stray!

The Author Online forum and the archives of previous discussions will be accessible from the publisher's website as long as the book is in print.

about the author

Mala Gupta has a Master's degree in Computer Applications (MCA). She is an Oracle Certified Associate-Java SE 7 Programmer, Java Sun Certified Web Component Developer (SCWCD), and Sun Certified Java 2 Programmer (SCJP).

She has more than 12 years of experience in software design and development and training. Her work experience is in Java technologies, primarily as an analyst, programmer, and mentor.

Mala has worked with international training and software services organizations in Europe and development centers in India on various Java-based portals and web applications. She has experience in mentoring and ramping up teams' technical and process skills.

She is the founder and lead mentor of a portal (<http://ejavaguru.com>) that has offered an online Java course in Java Programmer certification since 2006.

about the cover illustration

The figure on the cover of the *OCA Java SE 7 Programmer I Certification Guide* is captioned a “Morlach.” This illustration is taken from a recent reprint of Balthasar Hacquet’s *Images and Descriptions of Southwestern and Eastern Wenda, Illyrians, and Slavs* published by the Ethnographic Museum in Split, Croatia, in 2008. Hacquet (1739–1815) was an Austrian physician and scientist who spent many years studying the botany, geology, and ethnography of many parts of the Austrian Empire, as well as the Veneto, the Julian Alps, and the western Balkans, inhabited in the past by peoples of many different tribes and nationalities. Hand-drawn illustrations accompany the many scientific papers and books that Hacquet published.

Morlachs were a rural population that lived in the Dinaric Alps in the western Balkans hundreds of years ago. Many of them were shepherds who migrated in search of better pastures for their flocks, alternating between the mountains in the summer and the seashore in the winter. They were also called “Vlachs” in Serbian and Croatian. The rich diversity of the drawings in Hacquet’s publications speaks vividly of the uniqueness and individuality of Alpine and Balkan regions just 200 years ago. This was a time when the dress codes of two villages separated by a few miles identified people uniquely as belonging to one or the other, and when members of an ethnic tribe, social class, or trade could be easily distinguished by what they were wearing.

Dress codes have changed since then and the diversity by region, so rich at the time, has faded away. It is now often hard to tell the inhabitant of one continent from another and the residents of the picturesque towns and villages in the Balkans are not readily distinguishable from people who live in other parts of the world.

We at Manning celebrate the inventiveness, the initiative, and the fun of the computer business with book covers based on costumes from two centuries ago brought back to life by illustrations such as this one.

Introduction

This introduction covers

- Introduction to the Oracle Certified Associate (OCA) Java SE 7 Programmer certification (exam number 1Z0-803)
- Importance of OCA Java SE 7 Programmer certification
- Comparison of the OCA Java SE 7 Programmer I exam with OCA Java SE 5/6 exam
- Comparison of the OCA Java SE 7 Programmer I exam (1Z0-803) with OCP Java SE 7 Programmer II exam (1Z0-804)
- Detailed exam objectives, mapped to book chapters
- Readiness checklist to determine your readiness level for writing the exam
- FAQ on exam preparation and on taking the exam
- Introduction to the testing engine used for the exam

This book is intended specifically for individuals who wish to earn the Oracle Certified Associate (OCA) Java SE 7 Programmer certification (exam number 1Z0-803). It assumes that you are familiar with Java and have some experience working with it.

If you are completely new to Java or to object-oriented languages, I suggest that you start your journey with an entry-level book and then come back to this one.

1***Disclaimer***

The information in this chapter is sourced from Oracle.com, public websites, and user forums. Input has been taken from real people who have earned Java certification, including the author. All efforts have been made to maintain the accuracy of the content, but the details of the exam—including the exam objectives, pricing, exam pass score, total number of questions, maximum exam duration, and others—are subject to change per Oracle's policies. The author and publisher of the book shall not be held responsible for any loss or damage accrued due to any information contained in this book or due to any direct or indirect use of this information.

2***Introduction to OCA Java SE 7 Programmer certification***

The Oracle Certified Associate (OCA) Java SE 7 Programmer I exam (1Z0-803) covers the fundamentals of Java SE 7 programming, such as the importance of object-oriented programming, its implementation in code, and using flow control, arrays, and other constructs.

This exam is the first of the two steps in earning the title of Oracle Certified Professional (OCP) Java SE 7 Programmer. It certifies that an individual possesses a strong foundation in the Java programming language. Table 1 lists the details of this exam.

Table 1 Details for OCA Java SE 7 Programmer I exam (1Z0-803)

Exam number	1Z0-803
Java version	Based on Java version 7
Number of questions	90
Passing score	77%
Time duration	140 minutes
Pricing	US\$300
Type of questions	Multiple-choice questions

2.1***The importance of OCA Java SE 7 Programmer certification***

The OCA Java SE 7 Programmer I exam (1Z0-803) is an entry-level exam in your Java certification roadmap, as shown in figure 1. This exam is a prerequisite for the OCP Java SE 7 Programmer II exam (1Z0-804), which is itself a prerequisite for most of the other Oracle certifications in Java. The dashed lines and arrows in figure 1 depict the prerequisites for a certification.

As shown in figure 1, the Java certification tracks are offered under the categories Associate, Professional, Expert, and Master.

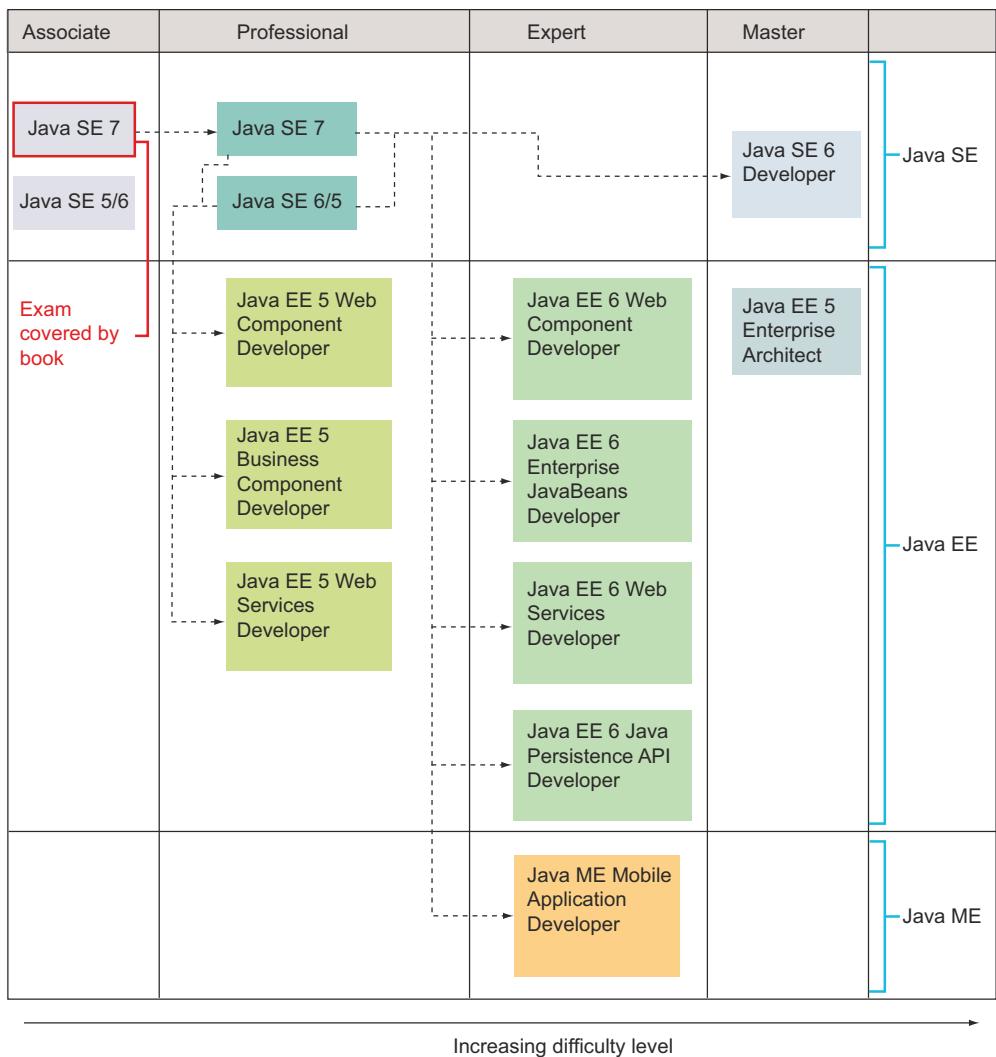


Figure 1 OCA Java SE 7 Programmer certification is the entry-level certification in the Java certification roadmap. It's a prerequisite for the OCP Java SE 7 Programmer II exam (1Z0-804), which is a prerequisite for most of the other certifications in Java.

2.2 Comparing OCA Java exam versions

This section will clear up any confusion surrounding the different versions of the OCA Java exam. As of now, Oracle offers two versions of the OCA certification in Java:

- OCA Java SE 7 Programmer I (exam number: 1Z0-803)
- OCA Java SE 5/SE 6 (exam number: 1Z0-850)

These two exam versions are quite different as far target audience, total number of questions, passing score, and exam duration are concerned, as listed in table 2.

Table 2 Comparing exams: OCA Java SE 7 Programmer I and OCA Java SE 5/6

	OCA Java SE 7 Programmer I (1Z0-803)	OCA Java SE 5/SE 6 (1Z0-850)
Target audience	Java programmers	Java programmers and IT managers
Java version	Based on Java version 7	Based on Java version 5/6
Total number of questions	90	51
Exam duration	140 minutes	115 minutes
Passing score	77%	68%
Pricing	US\$300	US\$300

Figure 2 shows a detailed comparison of the exam objectives of OCA Java SE 5/6 (1Z0-850) and OCA Java SE 7 Programmer I (1Z0-803). It shows objectives that are exclusive to each of these exam versions and those that are common to both. The first column shows the objectives that are included only in OCA Java SE 5/6 (1Z0-850), the middle column shows common exam objectives, and the right column shows exam objectives covered only in OCA Java SE 7 Programmer I (1Z0-803).

2.3 Comparing the OCA Java SE 7 Programmer I (1Z0-803) and OCP Java SE 7 Programmer II (1Z0-804) exams

The confusion between these two exams is due to the similarity in their names, but these are two separate exams. Starting with Java 7, Oracle has raised the bar to earn the title of Oracle Certified Professional Java SE 7 Programmer, which now requires successfully completing the following two exams:

- OCA Java SE 7 Programmer I (exam number: 1Z0-803)
- OCP Java SE 7 Programmer II (exam number: 1Z0-804)

The OCP Java SE 7 Programmer certification is designed for individuals who possess advanced skills in the Java programming language. This certification covers comparatively advanced Java features, such as threads, concurrency, Java file I/O, inner classes, localization, and others.

2.4 Complete exam objectives, mapped to book chapters, and readiness checklist

Table 3 includes a complete list of exam objectives for the OCA Java SE 7 Programmer I exam, which was taken from Oracle's website. All the objectives are mapped to the book's chapters and the section numbers that cover them. You can also check your readiness to take the exam by selecting the appropriate stars. Here's the legend:

- ★ Basic knowledge
- ★★ Intermediate (you can use it in code)
- ★★★ Advanced (you can answer all questions about it)

OCA Java SE 5/6 1Z0-850	Common objectives	OCA Java SE 7 Programmer I 1Z0-803
Algorithm design and implementation <ul style="list-style-type: none"> • Algorithm • Pseudocode 	Java basics <ul style="list-style-type: none"> • Variable scope • Structure of Java class • import and package statements • main method 	OCA Java SE 7 Programmer I 1Z0-803
Working with Java data types <ul style="list-style-type: none"> • Enums 	Primitives, object references <ul style="list-style-type: none"> • Read/write to object fields • Call methods on objects • Strings 	StringBuilder
Java development fundamentals <ul style="list-style-type: none"> • Use of javac command • Use of java command • Purpose and type of classes in packages <ul style="list-style-type: none"> java.awt javax.swing java.io java.net java.util 	Operators and decision constructs <ul style="list-style-type: none"> • Java operators • if and if-else constructs • switch statement 	Parentheses to override operator precedence <ul style="list-style-type: none"> • Test equality between String and other objects using == and equals()
Java platforms and integration technologies <ul style="list-style-type: none"> • Compare and contrast J2SE, J2ME, J2EE • RMI • JDBC, SQL, RDMS • JNDI, messaging, and JMS 	Creating and using arrays <ul style="list-style-type: none"> • One-dimensional arrays • Multidimensional arrays 	ArrayList
Client technologies <ul style="list-style-type: none"> • HTML, JavaScript • J2ME MIDlets • Applets • Swing 	Loop constructs <ul style="list-style-type: none"> • for and enhanced for loops • while and do-while loops • break and continue statements 	
Server technologies <ul style="list-style-type: none"> • EJB, servlets, JSP, JMS, SMTP, JAX-RPC, WebServices, JavaMail • Servlet and JSP for HTML • EJB session, entity, and message-driven beans • Web tier, business tier, EIS tier 	Methods and encapsulation <ul style="list-style-type: none"> • Create methods with arguments and return types • Apply access modifiers • Effect on object references and primitives when they are passed to methods 	Apply static keyword to methods and fields <ul style="list-style-type: none"> • Overloaded constructors and methods • Default and user-defined constructors
OOP concepts <ul style="list-style-type: none"> • UML diagrams • Association • Composition • Association navigation 	Inheritance <ul style="list-style-type: none"> • Implement inheritance • Polymorphism • Differentiate between type of a reference variable and object • Use abstract classes and interfaces 	Determine when casting is necessary <ul style="list-style-type: none"> • Use super and this to access objects and constructors
		Handling exceptions <ul style="list-style-type: none"> • Exceptions and errors • try-catch blocks • Use of exceptions • Methods that throw exceptions • Common exception classes and categories

Figure 2 Comparing objectives of exams OCA Java SE 5/6 and OCA Java SE 7 Programmer I

Table 3 Exam objectives and subobjectives mapped to chapter and section numbers, with readiness score

	Exam objectives	Covered in chapter/section	Your readiness score
1	Java basics	Chapters 1 and 3	
1.1	Define the scope of variables	Section 3.1	☆☆☆
1.2	Define the structure of a Java class	Section 1.1	☆☆☆
1.3	Create executable Java applications with a main method	Section 1.2	☆☆☆
1.4	Import other Java packages to make them accessible in your code	Section 1.3	☆☆☆
2	Working with Java data types	Chapters 2, 3, and 4	
2.1	Declare and initialize variables	Sections 2.1 and 2.3	☆☆☆
2.2	Differentiate between object reference variables and primitive variables	Sections 2.1 and 2.3	☆☆☆
2.3	Read or write to object fields	Section 3.6	☆☆☆
2.4	Explain an object's life cycle	Section 3.2	☆☆☆
2.5	Call methods on objects	Section 3.6	☆☆☆
2.6	Manipulate data using the String-Builder class and its methods	Section 4.2	☆☆☆
2.7	Create and manipulate strings	Section 4.1	☆☆☆
3	Using operators and decision constructs	Chapters 2, 4, and 5	
3.1	Use Java operators	Section 2.4	☆☆☆
3.2	Use parentheses to override operator precedence	Section 2.4	☆☆☆
3.3	Test equality between strings and other objects using == and equals()	Section 4.1	☆☆☆
3.4	Create if and if-else constructs	Section 5.1	☆☆☆
3.5	Use a switch statement	Section 5.2	☆☆☆
4	Creating and using arrays	Chapter 4	
4.1	Declare, instantiate, initialize, and use a one-dimensional array	Section 4.3	☆☆☆
4.2	Declare, instantiate, initialize, and use a multidimensional array	Section 4.3	☆☆☆
4.3	Declare and use an ArrayList	Section 4.4	☆☆☆

Table 3 Exam objectives and subobjectives mapped to chapter and section numbers, with readiness score (continued)

	Exam objectives	Covered in chapter/section	Your readiness score
5	Using loop constructs	Chapter 5	
5.1	Create and use while loops	Section 5.5	☆☆☆
5.2	Create and use for loops, including the enhanced for loop	Sections 5.3 and 5.4	☆☆☆
5.3	Create and use do-while loops	Section 5.5	☆☆☆
5.4	Compare loop constructs	Section 5.6	☆☆☆
5.5	Use break and continue	Section 5.7	☆☆☆
6	Working with methods and encapsulation	Chapters 1 and 3	
6.1	Create methods with arguments and return values	Section 3.3	☆☆☆
6.2	Apply the static keyword to methods and fields	Section 1.5	☆☆☆
6.3	Create an overloaded method	Section 3.4	☆☆☆
6.4	Differentiate between default and user-defined constructors	Section 3.5	☆☆☆
6.5	Create and overload constructors	Section 3.5	☆☆☆
6.6	Apply access modifiers	Section 1.4	☆☆☆
6.7	Apply encapsulation principles to a class	Section 3.7	☆☆☆
6.8	Determine the effect upon object references and primitive values when they are passed into methods that change the values	Section 3.8	☆☆☆
7	Working with inheritance	Chapters 1 and 6	
7.1	Implement inheritance	Section 6.1	☆☆☆
7.2	Develop code that demonstrates the use of polymorphism	Section 6.6	☆☆☆
7.3	Differentiate between the type of a reference and the type of an object	Section 6.3	☆☆☆
7.4	Determine when casting is necessary	Section 6.4	☆☆☆
7.5	Use super and this to access objects and constructors	Section 6.5	☆☆☆
7.6	Use abstract classes and interfaces	Sections 1.5, 6.2, and 6.6	☆☆☆

Table 3 Exam objectives and subobjectives mapped to chapter and section numbers, with readiness score (continued)

	Exam objectives	Covered in chapter/section	Your readiness score
8	Handling exceptions	Chapter 7	
8.1	Differentiate among checked exceptions, <code>RuntimeExceptions</code> , and <code>Errors</code>	Section 7.3	☆☆☆
8.2	Create a <code>try-catch</code> block and determine how exceptions alter normal program flow	Section 7.2	☆☆☆
8.3	Describe what exceptions are used for in Java	Section 7.1	☆☆☆
8.4	Invoke a method that throws an exception	Section 7.2	☆☆☆
8.5	Recognize common exception classes and categories	Section 7.4	☆☆☆

When you are ready to take the exam, you should ideally be able to select three stars for each item in the table. But let's define a better way to evaluate your exam readiness. Once you have marked all the stars in the previous chart, calculate your total points using the following values:

- ☆ 1 point
- ☆☆ 2 points
- ☆☆☆ 4 points

As the maximum number of points is 172 (43 objectives × 4), a score in the range of 150–172 is considered a good score.

You can download a PDF version of the form from the book's web page at <http://manning.com/gupta/> if you wish to mark yourself more than once.

3

FAQs

You might be anxious when you start your exam preparation or even think about getting certified. This section can help calm your nerves by answering frequently asked questions on exam preparation and on writing the exam.

3.1

FAQs on exam preparation

This sections answers frequently asked questions on how to prepare for the exam, including the best approach, study material, preparation duration, how to test self-readiness, and more.

WILL THE EXAM DETAILS EVER CHANGE FOR THE OCA JAVA SE 7 PROGRAMMER I EXAM?

Oracle can change the exam details for a certification even after the certification is made live. The changes can be to the exam objectives, pricing, exam duration, exam questions, and other parts. In the past, Oracle has made similar changes to certification

exams. Such changes may not be major, but it is always advisable to check Oracle's website for the latest exam information when you start your exam preparation.

WHAT IS THE BEST WAY TO PREPARE FOR THIS EXAM?

At the time of writing this book, there weren't many resources available to prepare for this exam. Apart from this book, Oracle offers an online course on this exam.

Generally, candidates use a combination of resources, such as books, online study materials, articles on the exam, free and paid mock exams, and training to prepare for the exam. Different combinations work best for different people, and there is no one perfect formula to prepare. Depending on whether training or self-study works best for you, you can select the method that is most appropriate for you. Combine it with a lot of code practice and mock exams.

HOW DO I KNOW WHEN I AM READY FOR THE EXAM?

You can be sure about your exam readiness by *consistently* getting a good score in the mock exams. Generally, a score of 80% and above in approximately seven mock exams (the more the better) attempted consecutively will assure you of a similar score in the real exam. You can also test your exam readiness using table 3. This table contains exam objectives and subobjectives with multiple stars representing different levels of expertise.

HOW MANY MOCK TESTS SHOULD I ATTEMPT BEFORE THE REAL EXAM?

Ideally, you should attempt at least 10 mock exams before you attempt the real exam. The more the better!

I HAVE TWO YEARS' EXPERIENCE WORKING WITH JAVA. DO I STILL NEED TO PREPARE FOR THIS CERTIFICATION?

It is important to understand that there is a difference between the practical knowledge of having worked with Java and the knowledge required to pass this certification exam. The authors of the Java certification exams employ multiple tricks to test your knowledge. Hence, you need a structured preparation and approach to succeed in the certification exam.

WHAT IS THE IDEAL TIME REQUIRED TO PREPARE FOR THE EXAM?

The preparation time frame mainly depends on your experience with Java and the amount of time that you can spend to prepare yourself. On average, you will require approximately 150 hours of study over two or three months to prepare for this exam. Again, the number of study hours required depends on individual learning curves and backgrounds.

It's important to be consistent with your exam preparation. You cannot study for a month and then restart after, say, a gap of a month or more.

DOES THIS EXAM INCLUDE ANY UNSCORED QUESTIONS?

A few of the questions that you write in any Oracle exam may be marked unscored. Oracle's policy states that while writing an exam, you won't be informed whether a question will be scored. You may be surprised to learn that as many as 10 questions out of the 90 questions in the OCA Java SE 7 Programmer I exam may be unscored. Even if you answer a few questions incorrectly, you stand a chance of scoring 100%.

Oracle regularly updates its question bank for all its certification exams. These unscored questions may be used for research and to evaluate new questions that can be added to an exam.

CAN I START MY EXAM PREPARATION WITH THE MOCK EXAMS?

If you are quite comfortable with the Java language features, then yes, you can start your exam preparation with the mock exams. This will also help you to understand the types of questions to expect in the real certification exam. But if you have little or no experience working with Java, or if you are not quite comfortable with the language features of Java, I don't advise you to start with the mock exams. The exam authors often use a lot of tricks to evaluate a candidate in the real certification exam. Starting your exam preparation with mock exams will only leave you confused about the Java concepts.

SHOULD I REALLY BOTHER GETTING CERTIFIED?

Yes, you should, for the simple reason that employers bother about the certification of employees. Organizations prefer a certified Java developer over a noncertified Java developer with similar IT skills and experience. The certification can also get you a higher paycheck than uncertified peers with comparable skills.

3.2**FAQs on taking the exam**

This section contains a list of frequently asked questions related to the exam registration, exam coupon, do's and don'ts while taking the exam, and exam retakes.

WHERE AND HOW DO I WRITE THIS EXAM?

You can write this exam at an Oracle Testing Center or Pearson VUE Authorized Testing Center. To sit for the exam, you must register for the exam and purchase an exam voucher. The following options are available:

- Register for the exam and pay Pearson VUE directly.
- Purchase an exam voucher from Oracle and register at Pearson VUE to take the exam.
- Register at an Oracle Testing Center.

Look for the nearest testing centers in your area, register yourself, and schedule an exam date and time. Most of the popular computer training institutes also have a testing center on their premises. You can locate a Pearson VUE testing site at www.pearsonvue.com/oracle/, which contains detailed information on locating testing centers and scheduling or rescheduling an exam. At the time of registration, you'll need to provide the following details along with your name, address, and contact numbers:

- Exam title and number (OCA Java SE 7 Programmer I, 1Z0-803)
- Any discount code that should be applied during registration
- Oracle Testing ID/Candidate ID, if you have written any other Oracle/Sun certification exam
- Your OPN Company ID (if your employer is in the Oracle Partner Network, you can find out the company ID and use any available discounts on the exam fee)

HOW LONG IS THE EXAM COUPON VALID FOR?

Each exam coupon is printed with an expiry date. Beware of any discounted coupons that come with an assurance that they can be used past the expiration date.

CAN I REFER TO NOTES OR BOOKS WHILE WRITING THIS EXAM?

You can't refer to any books or notes while writing this exam. You are not allowed to carry any blank paper for rough work or even your mobile phone inside the testing cubicle.

WHAT IS THE PURPOSE OF MARKING A QUESTION WHILE WRITING THE EXAM?

By marking a question, you can manage your time efficiently. Don't spend a lot of time on a single question. You can mark a difficult question to defer answering it while writing your exam. The exam gives you an option to review answers to the marked questions at the end of the exam. Also, navigating from one question to another using the Back and Next buttons is usually time consuming. If you are unsure of an answer, mark it and review it at the end.

CAN I WRITE DOWN THE EXAM QUESTIONS AND BRING THEM BACK WITH ME?

No. The exam centers no longer provide sheets of paper for the rough work that you may need to do while taking the exam. The testing center will provide you with either erasable or nonerasable boards. If you're provided with a nonerasable board, you may request another one if you need it.

Oracle is quite particular about certification candidates distributing or circulating the memorized questions in any form. If Oracle finds out that this is happening, it may cancel a candidate's certificate, bar that candidate forever from writing any Oracle certification, inform the employer, or take legal action.

WHAT HAPPENS IF I COMPLETE THE EXAM BEFORE OR AFTER THE TOTAL TIME?

If you complete the exam before the total exam time has elapsed, revise your answers and click the Submit or Finish button. The screen will display your score within 10 seconds of clicking the Submit button!

If you have not clicked the Submit button and you use up all the exam time, the exam engine will no longer allow you to modify any of the exam answers and will present the screen with the Submit button.

WILL I RECEIVE MY SCORE IMMEDIATELY AFTER THE EXAM?

Yes, you will. When you click the Submit button, the screen will show your total score. It will also show what you scored on each objective. The testing center will also give you hard copies of your certification score. The certificate itself will arrive via post within six to eight weeks.

WHAT HAPPENS IF I FAIL? CAN I RETAKE THE EXAM?

It's not the end of the world. Don't worry if you fail. You can retake the exam after 14 days (and the world will not know it's a retake).

However, you cannot retake a passed exam to improve your score. Also, you cannot retake a beta exam.

4 The testing engine used in the exam

The user interface of the testing engine used for the certification exam is quite simple. (You could even call it primitive, compared to today's web, desktop, and smartphone applications.)

Before you can start the exam, you will be required to accept the terms and conditions of the Oracle Certification Candidate Agreement. Your computer screen will display all these conditions and give you an option to accept the conditions. You can proceed with writing the exam only if you accept these conditions.

Here are the features of the testing engine used by Oracle:

- *Engine UI is divided into three sections*—The UI of the testing engine is divided into the following three segments:
 - *Static upper section*—Displays question number, time remaining, and a checkbox to mark a question for review.
 - *Scollable middle section*—Displays the question text and the answer options.
 - *Static bottom section*—Displays buttons to display the previous question, display the next question, end the exam, and review marked questions.
- *Each question is displayed on a separate screen*—The exam engine displays one question on the screen at a time. It does not display multiple questions on a single screen, like a scrollable web page. All effort is made to display the complete question and answer options without scrolling, or with little scrolling.
- *Code Exhibit button*—Many questions include code. Such questions, together with their answers, may require significant scrolling to be viewed. As this can be quite inconvenient, such questions include a Code Exhibit button that displays the code in a separate window.
- *Mark questions to be reviewed*—The question screen displays a checkbox with the text “Mark for review” at the top-left corner. A question can be marked using this option. The marked questions can be quickly reviewed at the end of the exam.
- *Buttons to display the previous and next questions*—The test includes buttons to display the previous and next questions within the bottom section of the testing engine.
- *Buttons to end the exam and review marked questions*—The engine displays buttons to end the exam and to review the marked questions in the bottom section of the testing engine.
- *Remaining time*—The engine displays the time remaining for the exam at the top right of the screen.
- *Question number*—Each question displays its serial number.
- *Correct number of answer options*—Each question displays the correct number of options that should be selected from multiple options.

On behalf of all at Manning Publications, I wish you good luck and hope that you score very well on your exam.

Java basics

Exam objectives covered in this chapter	What you need to know
[1.2] Define the structure of a Java class.	Structure of a Java class, with its components: package and import statements, class declarations, comments, variables, and methods. Difference between the components of a Java class and that of a Java source code file.
[1.3] Create executable Java applications with a main method.	The right method signature for the <code>main</code> method to create an executable Java application. The arguments that are passed to the <code>main</code> method.
[1.4] Import other Java packages to make them accessible in your code.	Understand packages and import statements. Get the right syntax and semantics to import classes from packages and interfaces in your own classes.
[6.6] Apply access modifiers.	Application of access modifiers (<code>public</code> , <code>protected</code> , <code>default</code> , and <code>private</code>) to a class and its members. Determine the accessibility of code with these modifiers.
[7.6] Use abstract classes and interfaces.	The implication of defining classes, interfaces, and methods as <code>abstract</code> entities.
[6.2] Apply the static keyword to methods and fields.	The implication of defining fields and methods as <code>static</code> members.

Imagine you've set up a new IT organization that works with multiple developers. To ensure a smooth and efficient workflow, you'll define a structure for your organization and a set of departments with separate assigned responsibilities. These departments will interact with each other whenever required. Also, depending on

confidentiality requirements, your organization’s data will be available to employees on an as-needed basis, or you may assign special privileges to only some employees of the organization. This is an example of how organizations work with a well-defined structure and a set of rules to deliver the best results.

Similarly, Java has organized its workflow. The organization’s structure and components can be compared with Java’s class structure and components, and the organization’s departments can be compared with Java packages. Restricting access to all data in the organization can be compared to Java’s access modifiers. An organization’s special privileges can be compared to nonaccess modifiers in Java.

In the OCA Java SE 7 Programmer I exam, you’ll be asked questions on the structure of a Java class, packages, importing classes, and applying access and nonaccess modifiers. Given that information, this chapter will cover the following:

- Understanding the structure and components of a Java class
- Understanding executable Java applications
- Understanding Java packages
- Importing Java packages into your code
- Applying access and nonaccess modifiers

1.1 The structure of a Java class and source code file



[1.2] Define the structure of a Java class



NOTE When you see a certification objective callout such as the preceding one, it means that in this section, we’ll cover this objective. The same objective may be covered in more than one section in this chapter or in other chapters.

This section covers the structure and components of both a Java source code file (.java file) and a Java class (defined using the keyword `class`). It also covers the differences between a Java source code file and a Java class.

First things first. Start your exam preparation with a clear understanding of what is required from you in the certification exam. For example, try to answer the following query from a certification aspirant: “I come across the term ‘class’ with different meanings—`class Person`, the Java source code file—`Person.java`, and Java bytecode stored in `Person.class`. Which of these structures is on the exam?” To answer this question, take a look at figure 1.1, which includes the class `Person`, the files `Person.java` and `Person.class`, and the relationship between them.

As you can see in figure 1.1, a person can be defined as a class `Person`. This class should reside in a Java source code file (`Person.java`). Using this Java source code file, the Java compiler (`javac.exe` on Windows or `javac` on Mac OS X/Linux/UNIX) generates bytecode (compiled code for the Java Virtual Machine) and stores it in `Person.class`. The scope of this exam objective is limited to Java classes (class `Person`) and Java source code files (`Person.java`).

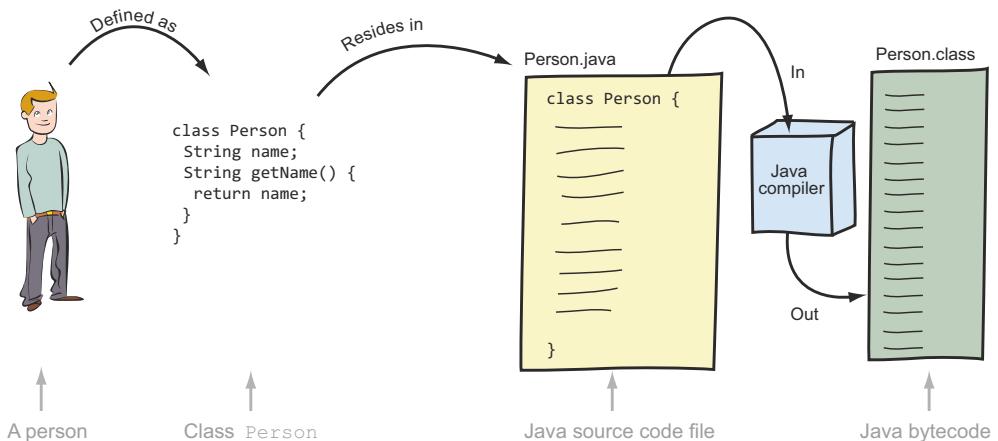


Figure 1.1 Relationship between the class Person, the files Person.java and Person.class, and how one transforms into another

1.1.1 Structure of a Java class

The OCA Java SE 7 Programmer I exam will question you on your understanding of the structure and components of a Java class defined using the keyword `class`. A class can define multiple components. All the Java components that you've heard of can be defined within a Java class. Figure 1.2 defines the components and structure of a Java class.

Here's a quick list of the components of a class (the ones that are on this exam), which we'll discuss in detail in this section:

- The package statement
- The import statement
- Comments
- Class declarations and definitions
- Variables
- Methods
- Constructors

Java class components

Package statement	— 1
Import statements	— 2
Comments	— 3a
Class declaration {	— 4
Variables	— 5
Comments	— 3b
Constructors	— 6
Methods	— 7
Nested classes	
Nested interfaces	
Enum	

} Not included in OCA Java SE 7
Programmer I exam

Figure 1.2 Components of a Java class

PACKAGE STATEMENT

All Java classes are part of a package. A Java class can be explicitly defined in a named package; otherwise it becomes part of a *default* package, which doesn't have a name.

A package statement is used to explicitly define which package a class is in. If a class includes a package statement, it must be the first statement in the class definition:

```
package certification;
class Course {
}
```

← The rest of the code
for class Course

← The package statement
should be the first
statement in a class

NOTE Packages are covered in detail in section 1.3 of this chapter.

The package statement cannot appear within a class declaration or after the class declaration. The following code will fail to compile:

```
class Course {
}
package certification;
```

← The rest of the code for class Course

← If you place the package statement after
the class definition, the code won't compile

The following code will also fail to compile, because it places the package statement within the class definition:

```
class Course {
    package com.cert;
}
```

← A package statement can't be placed within the curly
braces that mark the start and end of a class definition

Also, if present, the package statement must appear exactly once in a class. The following code won't compile:

```
package com.cert;
package com.exams;
class Course {
```

| A class can't define multiple
| package statements

IMPORT STATEMENT

Classes and interfaces in the same package can use each other without prefixing their names with the package name. But to use a class or an interface from another package, you must use its fully qualified name. Because this can be tedious and can make your code difficult to read, you can use the `import` statement to use the simple name of a class or interface in your code.

Let's look at this using an example class, `AnnualExam`, which is defined in the package `university`. Class `AnnualExam` is associated with the class `certification.ExamQuestion`, as shown using the Unified Modeling Language (UML) in figure 1.3.

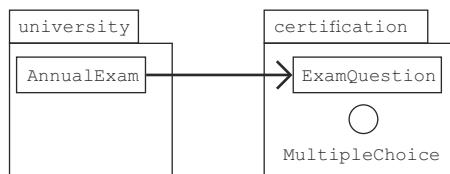


Figure 1.3 UML representation of the relationship between class `AnnualExam` and `ExamQuestion`

Here's the code for class AnnualExam:

```
package university;
import certification.ExamQuestion;

class AnnualExam {
    ExamQuestion eq;
}
```

Define a variable
of ExamQuestion

Note that the import statement follows the package statement but precedes the class declaration. What happens if the class AnnualExam isn't defined in a package? Will there be any change in the code if the class AnnualExam and ExamQuestion are related, as depicted in figure 1.4?

In this case, the class AnnualExam isn't part of an explicit package, but the class ExamQuestion is part of package certification. Here's the code for class AnnualExam:

```
import certification.ExamQuestion;
class AnnualExam {
    ExamQuestion eq;
}
```

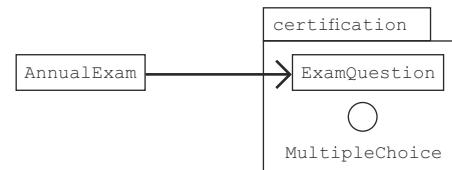


Figure 1.4 A UML representation of the relationship between the unpackaged class AnnualExam and ExamQuestion

Define a variable
of ExamQuestion

As you can see in the previous example code, the class AnnualExam doesn't define the package statement, but it defines the import statement to import the class certification.ExamQuestion.

If a package statement is present in a class, the import statement must follow the package statement. It's important to maintain the order of the occurrence of the package and import statements. Reversing this order will result in your code failing to compile:

```
import certification.ExamQuestion;
package university;
class AnnualExam {
    ExamQuestion eq;
}
```

The code won't compile because an
import statement can't be placed
before a package statement

We'll discuss import statements in detail in section 1.3 of this chapter.

COMMENTS

You can also add comments to your Java code. Comments can appear at multiple places in a class. A comment can appear before and after a package statement, before and after the class definition, before and within and after a method definition. Comments come in two flavors: multiline comments and end-of-line comments.

Multiline comments span multiple lines of code. They start with /* and end with */. Here's an example:

```
class MyClass {
    /*
        comments that span multiple
        lines of code
    */
}
```

Multiline comments start with /* and end with */

Multiline comments can contain any special characters (including Unicode characters). Here's an example:

```
class MyClass {
    /*
        Multi-line comments with
        special characters &%^*{}|\:;"
        ?/>.<,!@#$%^&*()
    */
}
```

Multiline comment with special characters in it

Most of the time, when you see a multiline comment in a Java source code file (.java file), you'll notice that it uses an asterisk (*) to start the comment in the next line. Please note that this isn't required—it's done more for aesthetic reasons. Here's an example:

```
class MyClass {
    /*
        * comments that span multiple
        * lines of code
    */
}
```

Multiline comments that start with * on a new line—don't they look well organized? The usage of * isn't mandatory; it's done for aesthetic reasons.

End-of-line comments start with // and, as evident by their name, they are placed at the end of a line of code. The text between // and the end of the line is treated as a comment, which you would normally use to briefly describe the line of code. Here's an example:

```
class Person {
    String fName;      // variable to store Person's first name
    String id;        // a 6 letter id generated by the database
}
```

Brief comment to describe variable fName

Brief comment to describe variable id

In the earlier section on the package statement, you read that a package statement, if present, should be the first line of code in a class. The only exception to this rule is the presence of comments. A comment can precede a package statement. The following code defines a package statement, with multiline and end-of-line comments:

```
/**
 * @author MGupta          // first name initial + last name
 * @version 0.1
 *
 * Class to store the details of a monument
 */
package uni;           // package uni
class Monument {
    int startYear;
```

① End-of-line comment within a multiline comment

② End-of-line comment

```

    String builtBy;      // individual/ architect
}
// another comment

```

←④ End-of-line comment at the beginning of a line

Line ① defines an end-of-line code comment within multiline code. This is acceptable. The end-of-line code comment is treated as part of the multiline comment, not as a separate end-of-line comment. Lines ② and ③ define end-of-line code comments. Line ④ defines an end-of-line code comment at the start of a line, after the class definition.

The multiline comment is placed before the package statement, which is acceptable because comments can appear anywhere in your code.

CLASS DECLARATION

The class declaration marks the start of a class. It can be as simple as the keyword `class` followed by the name of a class:

```

class Person {
//...           | Simplest class declaration: keyword
//...           | class followed by the class name
}

```

A class can define a lot of things here, but we don't
need these details to show the class declaration

Time to get more details. The declaration of a class is composed of the following parts:

- Access modifiers
- Nonaccess modifiers
- Class name
- Name of the base class, if the class is extending another class
- All implemented interfaces, if the class is implementing any interfaces
- Class body (class fields, methods, constructors), included within a pair of curly braces, {}

Don't worry if you don't understand this material at this point. I'll cover these details as we move through the exam preparation.

Let's look at the components of a class declaration using an example:

```
public final class Runner extends Person implements Athlete {}
```

The components of the preceding class can be pictorially depicted, as shown in figure 1.5. The following list summarizes the optional and compulsory components.

Compulsory

Keyword `class`

Name of the class

Class body, marked by the opening and closing curly braces, {}

Optional

Access modifier, such as `public`

Nonaccess modifier, such as `final`

Keyword `extends` together with the name of the base class

Keyword `implements` together with the name of the interfaces being implemented

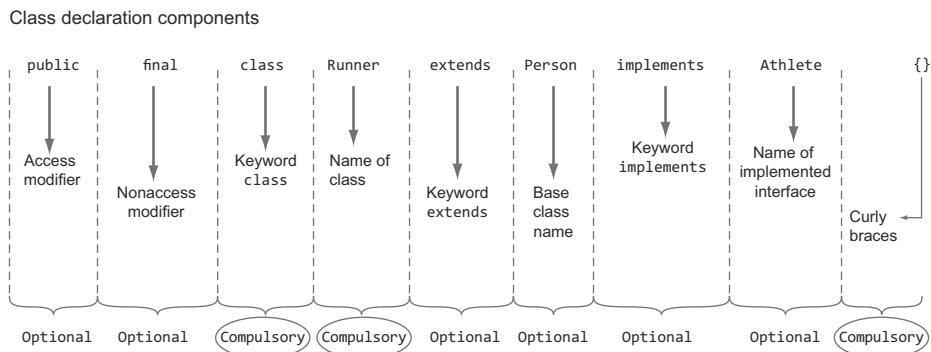


Figure 1.5 Components of a class declaration

We'll discuss the access and nonaccess modifiers in detail in sections 1.4 and 1.5 in this chapter.

CLASS DEFINITION

A class is a design used to specify the properties and behavior of an object. The properties of an object are implemented using *variables*, and the behavior is implemented using *methods*.

For example, consider a class as being like the design or specification of a mobile phone, and a mobile phone as being an object of that design. The same design can be used to create multiple mobile phones, just as the Java Virtual Machine (JVM) uses a class to create its objects. You can also consider a class as being like a mold that you can use to create meaningful and useful objects. A class is a design from which an object can be created.

Let's define a simple class to represent a mobile phone:

```
class Phone {
    String model;
    String company;
    Phone(String model) {
        this.model = model;
    }
    double weight;
    void makeCall(String number) {
        // code
    }
    void receiveCall() {
        // code
    }
}
```

Points to remember:

- A class name starts with the keyword `class`. Watch out for the case of the keyword `class`. Java is case sensitive. `class` (lowercase *c*) isn't the same as `Class` (uppercase *C*). You can't use the word `Class` (capital *C*) to define a class.
- The state of a class is defined using attributes or instance variables.

- The behavior is defined using methods. The methods will include the argument list (if any). Don't worry if you don't understand these methods. The methods are covered in detail later in this chapter.
- A class definition may also include comments and constructors.



NOTE A class is a design from which an object can be created.

VARIABLES

Revisit the previous example. Because the variables `model`, `company`, and `weight` are used to store the state of an object (also called an *instance*), they are called *instance variables* or *instance attributes*. Each object has its own copy of the instance variables. If you change the value of an instance variable for an object, the value for the same named instance variable won't change for another object. The instance variables are defined within a class but outside all methods in a class.

A single copy of a *class variable* or *static variable* is shared by all the objects of a class. The *static* variables are covered in section 1.5.3 with a detailed discussion of the nonaccess modifier *static*.

METHODS

Again, revisit the previous example. The methods `makeCall` and `receiveCall` are instance methods, which are generally used to manipulate the instance variables.

A *class method* or *static method* is used to work with the static variables, as discussed in detail in section 1.5.3.

CONSTRUCTORS

Class `Phone` in the previous example defines a single constructor. A class constructor is used to create and initialize the objects of a class. A class can define multiple constructors that accept different sets of method parameters.

1.1.2 Structure and components of a Java source code file

A Java source code file is used to define classes and interfaces. All your Java code should be defined in Java source code files (text files whose names end with `.java`). The exam covers the following aspects of the structure of a Java source code file:

- Definition of a class and an interface in a Java source code file
- Definition of single or multiple classes and interfaces within the same Java source code file
- Application of `import` and `package` statements to all the classes in a Java source code file

We've already covered the detailed structure and definition of classes in section 1.1.1. Let's get started with the definition of an interface.

DEFINITION OF INTERFACES IN A JAVA SOURCE CODE FILE

An interface is a grouping of related methods and constants, but the methods in an interface cannot define any implementation. An interface specifies a contract for the classes to implement.

Here's a quick example to help you to understand the essence of interfaces. No matter which brand of television each one of us has, every television provides the common functionality of changing the channel and adjusting the volume. You can compare the controls of a television set to an interface, and the design of a television set to a class that implements the interface controls.

Let's define this interface:

```
interface Controls {
    void changeChannel(int channelNumber);
    void increaseVolume();
    void decreaseVolume();
}
```

The definition of an interface starts with the keyword `interface`. An interface can define constants and methods. Remember, Java is case-sensitive, so you can't use the word `Interface` (with a capital *I*) to define an interface.

DEFINITION OF SINGLE AND MULTIPLE CLASSES IN A SINGLE JAVA SOURCE CODE FILE

You can define either a single class or an interface in a single Java source code file, or many such files. Let's start with a simple example: a Java source code file called `SingleClass.java` that defines a single class `SingleClass`:

```
class SingleClass {
    //.. we are not detailing this part
}
```

Contents of Java source code file `SingleClass.java`

Here's an example of a Java source code file, `Multiple1.java`, that defines multiple interfaces:

```
interface Printable {
    //.. we are not detailing this part
}
interface Movable {
    //.. we are not detailing this part
}
```

Contents of Java source code file `Multiple1.java`

You can also define a combination of classes and interfaces in the same Java source code file. Here's an example:

```
interface Printable {
    //.. we are not detailing this part
}
class MyClass {
    //.. we are not detailing this part
}
interface Movable {
    //.. we are not detailing this part
}
class Car {
    //.. we are not detailing this part
}
```

Contents of Java source code file `Multiple2.java`

There is no required order for the multiple classes or interfaces that can be defined in a single Java source code file.



EXAM TIP The classes and interfaces can be defined in any order of occurrence in a Java source code file.

If you define a public class or an interface in a class, its name should match the name of the Java source code file. Also, a source code file can't define more than one public class or interface. If you try to do so, your code won't compile, which leads to a small hands-on exercise for you that I call *Twist in the Tale*, as mentioned in the Preface. The answers to all these exercises are provided in the appendix.

About the Twist in the Tale exercises

For these exercises, I've tried to use modified code from the examples already covered in the chapter. The *Twist in the Tale* title refers to modified or tweaked code.

These exercises will help you understand how even small code modifications can change the behavior of your code. They should also encourage you to carefully examine all of the code in the exam. The reason for these exercises is that in the exam, you may be asked more than one question that seems to require the same answer. But on closer inspection, you'll realize that the questions differ slightly, and this will change the behavior of the code and the correct answer option!

Twist in the Tale 1.1

Modify the contents of the Java source code file Multiple.java, and define a public interface in it. Execute the code and see how it affects your code.

Question: Examine the following content of Java source code file Multiple.java and select the correct answers:

```
// Contents of Multiple.java
public interface Printable {
    //.. we are not detailing this part
}
interface Movable {
    //.. we are not detailing this part
}
```

Options:

- a A Java source code file cannot define multiple interfaces.
- b A Java source code file can only define multiple classes.
- c A Java source code file can define multiple interfaces and classes.
- d The previous class will fail to compile.

If you need help getting your system set up to write Java, refer to Oracle's "Getting Started" tutorial, <http://docs.oracle.com/javase/tutorial/getStarted/>.

Twist in the Tale 1.2

Question: Examine the content of the following Java source code file, Multiple2.java, and select the correct option.

```
// contents of Multiple2.java
interface Printable {
    ... we are not detailing this part
}
class MyClass {
    ... we are not detailing this part
}
interface Movable {
    ... we are not detailing this part
}
public class Car {
    ... we are not detailing this part
}
public interface Multiple2 {}
```

Options:

- a The code fails to compile.
- b The code compiles successfully.
- c Removing the definition of class Car will compile the code.
- d Changing class Car to a non-public class will compile the code.
- e Changing class Multiple2 to a non-public class will compile the code.

APPLICATION OF PACKAGE AND IMPORT STATEMENTS IN JAVA SOURCE CODE FILES

In the previous section, I mentioned that you can define multiple classes and interfaces in the same Java source code file. When you use a package or import statement within such Java files, both the package and import statements apply to all of the classes and interfaces defined in that source code file.

For example, if you include a package and an import statement in Java source code file Multiple.java (as in the following code), Car, Movable, and Printable will become part of the same package com.manning.code:

```
// contents of Multiple.java
package com.manning.code;
import com.manning.*;
interface Printable {}
interface Movable {}
class Car {}
```

Printable, Movable, and Car are part of package com.manning.code

All classes and interfaces defined in package com.manning are accessible to Printable, Movable, and Car



EXAM TIP Classes and interfaces defined in the same Java source code file can't be defined in separate packages. Classes and interfaces imported using the import statement are available to all the classes and interfaces defined in the same Java source code file.

In the next section, you'll create executable Java applications—classes that are used to define an entry point of execution for a Java application.

1.2 Executable Java applications



[1.3] Create executable Java applications with a main method

The OCA Java SE 7 Programmer I exam requires that you understand the meaning of an executable Java application and its requirements, that is, what makes a regular Java class an executable Java class.

1.2.1 Executable Java classes versus nonexecutable Java classes

“Doesn't the Java Virtual Machine execute all the Java classes when they are used? If so, what is a nonexecutable Java class?”

An executable Java class is a class which, when handed over to the JVM, starts its execution at a particular point in the class—the `main` method, defined in the class. The JVM starts executing the code that is defined in the `main` method. You cannot hand over a nonexecutable Java class to the JVM and ask it to start executing the class. In this case, the JVM won't know how to execute it because no entry point is marked, for the JVM, in a nonexecutable class.

Typically, an application consists of a number of classes and interfaces that are defined in multiple Java source code files. Of all these files, a programmer designates one of the classes as an executable class. The programmer can define the steps that the JVM should execute as soon as it launches the application. For example, a programmer can define an executable Java class that includes code to display the appropriate GUI window to a user and to open a database connection.

In figure 1.6, the classes `Window`, `UserData`, `ServerConnection`, and `UserPreferences` don't define a `main` method. Class `LaunchApplication` defines a `main` method and is an executable class.

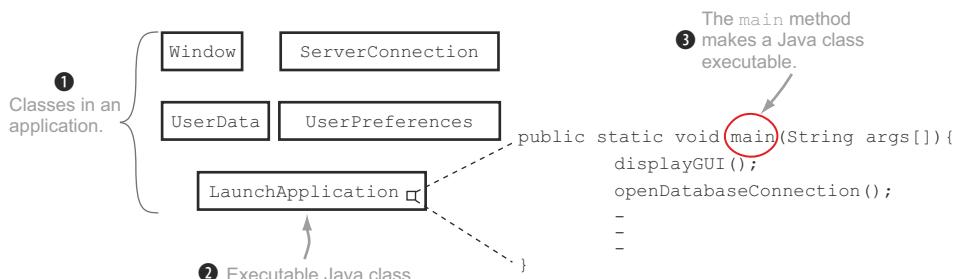


Figure 1.6 Class `LaunchApplication` is an executable Java class, but the rest of the classes—`Window`, `UserData`, `ServerConnection`, and `UserPreferences`—aren't.

1.2.2 Main method

The first requirement in creating an executable Java application is to create a class with a method whose signature (name and method arguments) match the `main` method, defined as follows:

```
public class HelloExam {
    public static void main(String args[]) {
        System.out.println("Hello exam");
    }
}
```

This `main` method should comply with the following rules:

- The method must be marked as a `public` method.
- The method must be marked as a `static` method.
- The name of the method must be `main`.
- The return type of this method must be `void`.
- The method must accept a method argument of a `String` array or a variable argument of type `String`.

Figure 1.7 illustrates the previous code and its related set of rules.

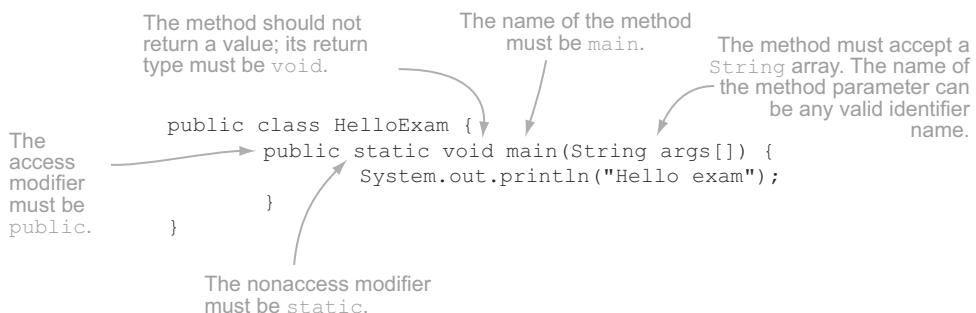


Figure 1.7 Ingredients of a correct main method

It's valid to define the method parameter passed to the `main` method as a variable argument (`varargs`) of type `String`:

```
public static void main(String... args)
```

It is valid to define args as a variable argument

To define a variable argument variable, the ellipsis (`...`) should follow the type of the variable and not the variable itself (a mistake made by lot of new programmers):

```
public static void main(String args...)
```

This won't compile. Ellipses should follow the data type, String.

As mentioned previously, the name of the String array passed to the main method need not be args to qualify it as the correct main method. Thus, the following examples are also correct definitions of the main method:

```
public static void main(String[] arguments)
public static void main(String[] HelloWorld)
```

The names of the method arguments are arguments and HelloWorld, which is acceptable

To define an array, the square brackets, [], can follow either the variable name or its type. The following is a correct method declaration of the main method:

```
public static void main(String[] args)
public static void main(String minnieMouse[])
```

The square brackets, [], can follow either the variable name or its type

It's interesting to note that the placement of the keywords public and static can be interchanged, which means that the following are both correct method declarations of the main method:

```
public static void main(String[] args)
static public void main(String[] args)
```

The placement of the keywords public and static is interchangeable

On execution, the code shown in figure 1.7 outputs the following:

```
Hello exam
```

Almost all Java developers work with an Integrated Development Environment (IDE). The OCA Java SE 7 Programmer I exam, however, expects you to understand how to execute a Java application, or an executable Java class, using the command prompt. If you need help getting your system set up to compile or execute Java applications using the command prompt, refer to Oracle's detailed instructions at <http://docs.oracle.com/javase/tutorial/getStarted/cupojava/index.html>.

To execute the code shown in figure 1.7, issue the command java HelloExam, as shown in figure 1.8.

We discussed how the main method accepts an array of String as the method parameter. But how and where do you pass the array to the main method? Let's modify the previous code to access and output values from this array. Here's the relevant code:

```
public class HelloExamWithParameters {
    public static void main(String args[]) {
        System.out.println(args[0]);
        System.out.println(args[1]);
    }
}
```

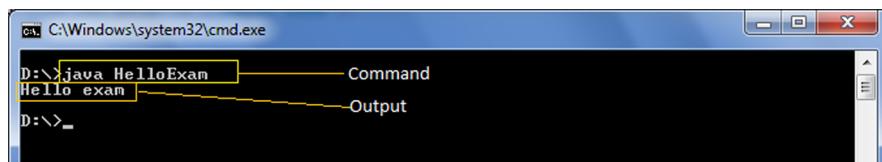


Figure 1.8 Using a command prompt to execute a Java application

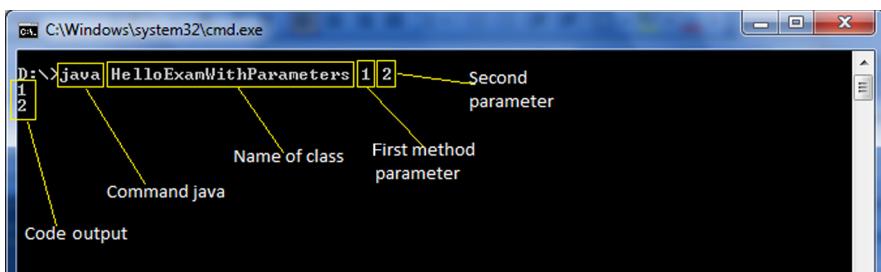


Figure 1.9 Passing command parameters to a `main` method

Execute the class in the preceding code at a command prompt, as shown in figure 1.9.

As you can see from the output shown in figure 1.9, the keyword `java` and the name of the class aren't passed on as command parameters to the `main` method. The OCA Java SE 7 Programmer I exam will test you on your knowledge of whether the keyword `java` and the class name are passed on to the `main` method.



EXAM TIP The method parameters that are passed on to the `main` method are also called command-line parameters or command-line values. As the name implies, these values are passed on to a method from the command line.

If you weren't able to follow the code with respect to the arrays and class `String`, don't worry; we'll cover the class `String` and arrays in detail in chapter 4.

Here's the next Twist in the Tale exercise for you. In this exercise, and in the rest of the book, you'll see the names Shreya, Harry, Paul, and Selvan, who are hypothetical programmers also studying for this certification exam. The answer is provided in the appendix.

Twist in the Tale 1.3

One of the programmers, Harry, executed a program that gave the output "java one". Now he's trying to figure out which of the following classes outputs these results. Given that he executed the class using the command `java EJava java one one`, can you help him figure out the correct option(s)?

- a class EJava {
 public static void main(String sun[]) {
 System.out.println(sun[0] + " " + sun[2]);
 }
 }
- b class EJava {
 static public void main(String phone[]) {
 System.out.println(phone[0] + " " + phone[1]);
 }
 }
- c class EJava {
 static public void main(String[] arguments) {

```

        System.out.println(arguments[0] + " " + arguments[1]);
    }
}

d class EJava {
    static void public main(String args[]) {
        System.out.println(args[0] + " " + args[1]);
    }
}

```

Confusion with command-line parameters

Programming languages like C pass on the name of a class as a command-line argument to the `main` method. Java doesn't do so. This is a simple but important point.

1.3 Java packages



[1.4] Import other Java packages to make them accessible in your code

In this section, you'll learn what Java packages are and how to create them. You'll use the `import` statement, which enables you to use simple names for classes and interfaces defined in separate packages.

1.3.1 The need for packages

Why do you think we need packages? First, answer this question: do you remember having known more than one Amit, Paul, Anu, or John to date? Harry knows more than one Paul (six, to be precise), whom he categorizes as managers, friends, and cousins. These are subcategorized by their location and relation, as shown in figure 1.10.

Similarly, you can use packages to group together a related set of classes and interfaces (I will not discuss enums here because they aren't covered on this exam). Packages also provide access protection and namespace management. You can create separate packages to define classes for separate projects, such as android games and online health-care systems. Further, you can create subpackages within these packages, such as separate subpackages for GUIs, database access, networking, and so on.

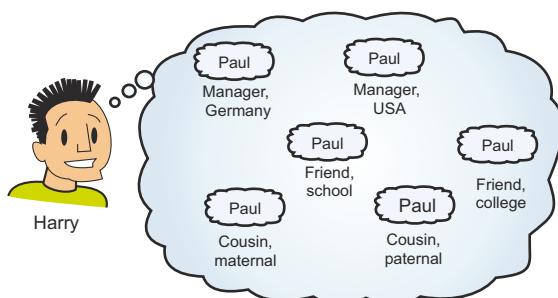


Figure 1.10 Harry knows six Pauls!

PRACTICAL TIP In real-life projects, you will never work with an unpackaged class or interface. Almost all organizations that develop software have strict package-naming rules, which are often documented.

The OCA Java SE 7 Programmer I exam covers importing packaged classes into other classes. But after 12 years of experience, I've learned that before starting to *import* other classes into your own code, it's important to understand what the packaged classes are, how packaged and nonpackaged classes differ, and why you need to import the packaged classes.

Packaged classes are part of a named package—a namespace—and they're defined as being part of a package by including a package statement in a class. All classes and interfaces are packaged. If you don't include an explicit package statement in a class or an interface, it's part of a *default* package.

1.3.2 Defining classes in a package using the package statement

You can define which classes and interfaces are in a package by using the package statement as the first statement in your class or interface. Here's an example:

```
package certification;
class ExamQuestion {
    //...code
}
```



**Variables and
methods**

The class in the previous code defines an `ExamQuestion` class in the `certification` package. You can define an interface, `MultipleChoice`, in a similar manner:

```
package certification;
interface MultipleChoice {
    void choice1();
    void choice2();
}
```

Figure 1.11 shows the UML representation of the package `certification`, with the class `ExamQuestion` and the interface `MultipleChoice`:

The name of the package in the previous examples is `certification`. You may use such names for small projects that contain only a few classes and interfaces, but it's common for organizations to use subpackages to define *all* their classes. For example, if folks at Oracle define a class to store exam questions for a Java Associate exam, they might use the package name `com.oracle.javacert.associate`. Figure 1.12 shows its UML representation, together with the corresponding class definition:

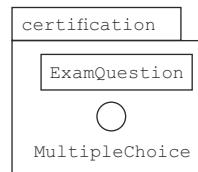


Figure 1.11
A UML representa-
tion of the package
`certification`,
class `Exam-`
`Question`,
and interface
`MultipleChoice`

```
package com.oracle.javacert.associate;
class ExamQuestion {
    // variables and methods
}
```

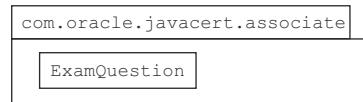


Figure 1.12 A subpackage and its corresponding class definition

The package name `com.oracle.javacert.associate` follows a package-naming convention recommended by Oracle and shown in table 1.1.

Table 1.1 Package-naming conventions used in the package name `com.oracle.javacert.associate`

Package or subpackage name	Its meaning
com	Commercial. A couple of the commonly used three-letter package abbreviations are gov—for government bodies edu—for educational institutions
oracle	Name of the organization
javacert	Further categorization of the project at Oracle
associate	Further subcategorization of Java certification

RULES TO REMEMBER

A few of important rules about packages:

- Per Java naming conventions, package names should all be in lowercase.
- The package and subpackage names are separated using a dot (.) .
- Package names follow the rules defined for valid identifiers in Java.
- For packaged classes and interfaces, the package statement is the first statement in a Java source file (a .java file). The exception is that comments can appear before or after a package statement.
- There can be a maximum of one package statement per Java source code file (.java file).
- All the classes and interfaces defined in a Java source code file will be defined in the same package. There is no way to package classes and interfaces defined within the same Java source code file in different packages.

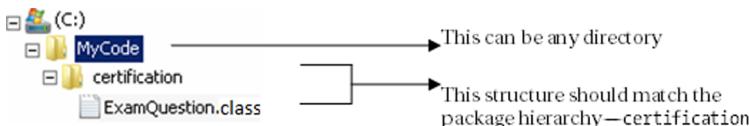


NOTE A fully qualified name for a class or interface is formed by prefixing its package name with its name (separated by a period). The fully qualified name of class `ExamQuestion` is `certification.ExamQuestion` in figure 1.11 and `com.oracle.javacert.associate.ExamQuestion` in figure 1.12.

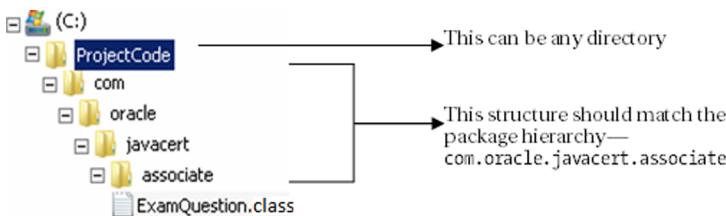
DIRECTORY STRUCTURE AND PACKAGE HIERARCHY

The hierarchy of the packaged classes should match the hierarchy of the directories in which these classes and interfaces are defined in the code. For example, the class `ExamQuestion` in the `certification` package should be defined in a directory with the name “`certification`.”

The name of the directory “`certification`” and its location are governed by the following rules:



For the package example shown in figure 1.12, note that there isn't any constraint on the location of the base directory in which the directory structure is defined. Examine the following image:



SETTING THE CLASSPATH FOR PACKAGED CLASSES

To enable the Java Runtime Environment (JRE) to find your classes, add the base directory that contains your packaged Java code to the classpath.

For example, to enable the JRE to locate the `certification.ExamQuestion` class from the previous examples, add the directory `C:\MyCode` to the classpath. To enable the JRE to locate the class `com.oracle.javacert.associate.ExamQuestion`, add the directory `C:\ProjectCode` to the classpath.

You don't need to bother setting the classpath if you're working with an IDE. But I strongly encourage you to learn how to work with a simple text editor and how to set a classpath. This can be particularly helpful with your projects at work. I have also witnessed many interviewers querying candidates on the need for classpaths.

1.3.3 Using simple names with import statements

The `import` statement enables you to use *simple names* instead of using *fully qualified names* for classes and interfaces defined in separate packages.

Let's work with a real-life example. Imagine your Home and your neighbor's Office. "LivingRoom" and "Kitchen" within your home can refer to each other without mentioning that they exist within the same home. Similarly, in an office, a Cubicle and a ConferenceHall can refer to each other without explicitly mentioning that they exist within the same office. But "Home" and "Office" can't access each other's rooms or cubicles without stating that they exist in a separate home or office. This situation is represented in figure 1.13.

To refer to the `LivingRoom` in `Cubicle`, you *must* specify its complete location, as shown in left part of the figure 1.14. As you can see in this figure, repeated references to the location of `LivingRoom` make the description of `LivingRoom` look tedious and redundant. To avoid this, you can display a notice in `Cubicle` that all occurrences of `LivingRoom` refer to `LivingRoom` in `Home`, and thereafter use its simple name, `Home`.

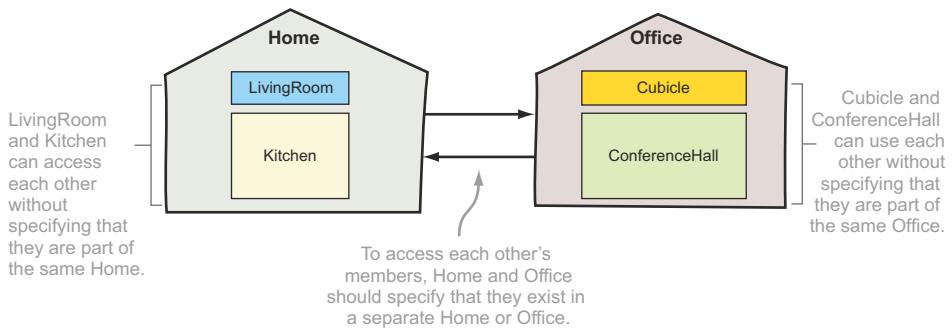


Figure 1.13 To refer to each other's members, Home and Office should specify that they exist in separate places.

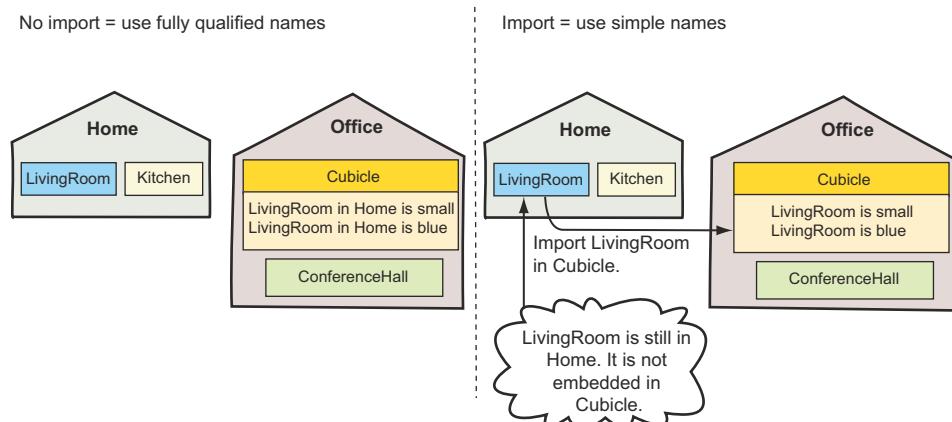


Figure 1.14 LivingRoom can be accessed in Cubicle by using its fully qualified name. It can also be accessed using its simple name if you also use the import statement.

and **Office** are like Java packages, and this notice is the equivalent of the `import` statement. Figure 1.14 shows the difference in using fully qualified names and simple names for **Home** in **Cubicle**.

Let's implement the previous example in code, where classes **LivingRoom** and **Kitchen** are defined in the package `home` and classes **Cubicle** and **ConferenceHall** are defined in the package `office`. The class **Cubicle** uses (is associated to) the class **LivingRoom** in the package `home`, as shown in figure 1.15.

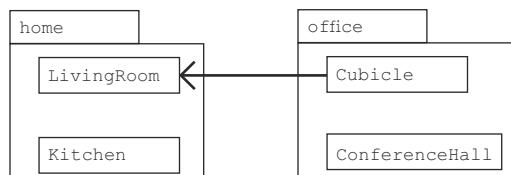


Figure 1.15 A UML representation of classes LivingRoom and Cubicle, defined in separate packages, with their associations

Class Cubicle can refer to class LivingRoom without using an import statement:

```
package office;
class Cubicle {
    home.LivingRoom livingRoom;
}
```

In the absence of an import statement, use the fully qualified name to access class LivingRoom

Class Cubicle can use the simple name for class LivingRoom by using the import statement:

```
package office;
import home.LivingRoom;

class Cubicle {
    LivingRoom livingRoom;
}
```

import statement

No need to use the fully qualified name of class LivingRoom



NOTE The import statement doesn't embed the contents of the imported class in your class, which means that *importing* more classes doesn't increase the size of your own class. It lets you use the simple name for a class or interface defined in a separate package.

1.3.4 Using packaged classes without using the import statement

It is possible to use a packaged class or interface without using the import statement, by using its fully qualified name:

```
class AnnualExam {
    certification.ExamQuestion eq;
```

Missing import statement

Define a variable of ExamQuestion by using its fully qualified name

This approach can clutter your code if you create multiple variables of interfaces and classes defined in other packages. Use this approach sparingly in actual projects.

For the exam, it's important to note that you can't use the import statement to access multiple classes or interfaces with the same names from different packages. For example, the Java API defines the class Date in two commonly used packages: java.util and java.sql. To define variables of these classes in a class, use their fully qualified names with the variable declaration:

```
class AnnualExam {
    java.util.Date date1;
    java.sql.Date date2;
```

Missing import statement

Variable of type java.util.Date
Variable of type java.sql.Date

An attempt to use an import statement to import both these classes in the same class will not compile:

```
import java.util.Date;
import java.sql.Date;
class AnnualExam { }
```

Code to import classes with the same name from different packages won't compile

1.3.5 Importing a single member versus all members of a package

You can import either a single member or all members (classes and interfaces) of a package using the `import` statement. First, revisit the UML notation of the `certification` package, as shown in figure 1.16.

Examine the following code for class `AnnualExam`:

```
import certification.ExamQuestion;           ← Imports only the
class AnnualExam {                         ← class ExamQuestion
    ExamQuestion eq;                      ← Compiles OK
    MultipleChoice mc;                   ← Will not compile
}
```

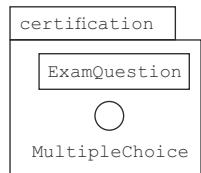


Figure 1.16
A UML representa-
tion of the
`certification`
package

By using the wildcard character, an asterisk (*), you can import all of the public members, classes, and interfaces of a package. Compare the previous class definition with the following definition of the class `AnnualExam`:

```
import certification.*;                     ← Imports all classes and
class AnnualExam {                         ← interfaces from certification
    ExamQuestion eq;                      ← Compiles OK
    MultipleChoice mc;                   ← This also compiles OK
}
```

Unlike in C or C++, *importing* a class doesn't add to the size of a Java .class file. An `import` statement enables Java to refer to the imported classes without embedding their source code in the target .class file.

When you work with an IDE, it may automatically add `import` statements for classes and interfaces that you reference in your code.

1.3.6 Can you recursively import subpackages?

You can't import classes from a subpackage by using an asterisk in the `import` statement.

For example, the following UML notation depicts the package `com.oracle.javacert` with the class `Schedule`, and two subpackages, `associate` and `webdeveloper`. Package `associate` contains class `ExamQuestion`, and package `webdeveloper` contains class `MarkSheet`, as shown in figure 1.17.

The following `import` statement will import only the class `Schedule`. It won't import the classes `ExamQuestion` and `MarkSheet`:

```
import com.oracle.javacert.*;
```

← Imports the class
`Schedule` only

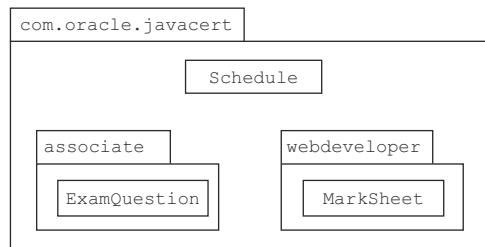
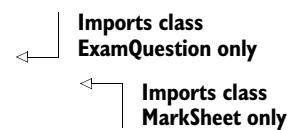


Figure 1.17 A UML representation of package
`com.oracle.javacert` and its subpackages

Similarly, the following `import` statement will import all the classes from the packages `associate` and `webdeveloper`:

```
import com.oracle.javacert.associate.*;
import com.oracle.javacert.webdeveloper.*;
```


Imports class ExamQuestion only
Imports class MarkSheet only

1.3.7 Importing classes from the default package

What happens if you don't explicitly package your classes or interfaces? In that case, they're packaged in a *default, no-name* package. This default package is automatically imported in the Java classes and interfaces defined within the same directory on your system.

For example, the classes `Person` and `Office`, which are not defined in an explicit package, can use each other if they are defined in the same directory:

```
class Person {
    // code
}
class Office {
    Person p;
}
```


Not defined in an explicit package


Class Person accessible in class Office

A class from a default package can't be used in any named packaged class, regardless of whether they are defined within the same directory or not.

1.3.8 Static imports

You can import an individual `static` member of a class or all its `static` members by using the `import static` statement.

In the following code, the class `ExamQuestion` defines a public static variable named `marks` and a public static method named `print`:

```
package certification;
public class ExamQuestion {
    static public int marks;
    public static void print() {
        System.out.println(100);
    }
}
```


public static variable marks


public static method print

The variable `marks` can be accessed in the class `AnnualExam` using the `import static` statement. The order of the keywords `import` and `static` can't be reversed:

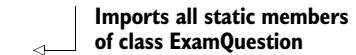
```
package university;
import static certification.ExamQuestion.marks;
class AnnualExam {
    AnnualExam() {
        marks = 20;
    }
}
```


Correct statement is import static, not static import


Access variable marks without prefixing it with its class name

To access all public static members of class `ExamQuestion` in class `AnnualExam`, you can use an asterisk with the `import static` statement:

```
package university;
import static certification.ExamQuestion.*;
```


Imports all static members of class ExamQuestion

```
class AnnualExam {
    AnnualExam() {
        marks = 20;
        print();
    }
}
```

Accesses variable marks and method print without prefixing them with their class names

Because the variable `marks` and method `print` are defined as public members, they are accessible to the class `AnnualExam` using the `import static` statement. These wouldn't be accessible to the class `AnnualExam` if they were defined using any other access modifiers. The accessibility of a class, an interface, and their methods and variables are determined by their access modifiers, which are covered in the next section.

1.4 Java access modifiers



[6.6] Apply access modifiers

In this section, we'll cover all of the access modifiers—public, protected, and private—as well as default access, which is the result when you don't use an access modifier. We'll also look at how you can use access modifiers to restrict the visibility of a class and its members in the same and separate packages.

1.4.1 Access modifiers

Let's start with an example. Examine the definitions of the classes `House` and `Book` in the following code and the UML representation shown in figure 1.18.

```
package building;
class House {}

package library;
class Book {}
```

With the current class definitions, the class `House` cannot access the class `Book`. Can you make the necessary changes (in terms of the access modifiers) to make the class `Book` accessible to the class `House`?

This one shouldn't be difficult. From the discussion of class declarations in section 1.1, you know that a top-level class can be defined only using the `public` or default access modifiers. If you declare the class `Book` using the access modifier `public`, it'll be accessible outside the package in which it is defined.



NOTE A top-level class is a class that isn't defined within any other class. A class that is defined within another class is called a *nested* or *inner class*. Nested and inner classes aren't on the OCA Java SE 7 Programmer I exam.



Figure 1.18 The nonpublic class `Book` cannot be accessed outside the package `library`.

WHAT DO THEY CONTROL?

Access modifiers control the accessibility of a class or an interface, including its members (methods and variables), by other classes and interfaces. For example, you can't access the *private* variables and methods of another class. By using the appropriate access modifiers, you can limit access to your class or interface, and their members, by other classes and interfaces.

CAN ACCESS MODIFIERS BE APPLIED TO ALL TYPES OF JAVA ENTITIES?

Access modifiers can be applied to classes, interfaces, and their members (instance and class variables and methods). Local variables and method parameters can't be defined using access modifiers. An attempt to do so will prevent the code from compiling.

HOW MANY ACCESS MODIFIERS ARE THERE: THREE OR FOUR?

Programmers are frequently confused about the number of access modifiers in Java because the *default access* isn't defined using an explicit keyword. If a Java entity (class, interface, method, or variable) isn't defined using an explicit access modifier, it is said to be defined using the *default access*, also called *package access*.

Java defines four access modifiers:

- `public` (least restrictive)
- `protected`
- `default`
- `private` (most restrictive)

To understand all of these access modifiers, we'll use the same set of classes: `Book`, `CourseBook`, `Librarian`, `StoryBook`, and `House`. Figure 1.19 depicts these classes using UML notation.

The classes `Book`, `CourseBook`, and `Librarian` are defined in the package `library`. The classes `StoryBook` and `House` are defined in the package `building`. Further, classes `StoryBook` and `CourseBook` (defined in separate packages) extend class `Book`. Using these classes, I'll show how the accessibility of a class and its members varies with different access modifiers, from unrelated to derived classes, across packages.

As we cover each of the access modifiers, we'll add a set of instance variables and a method to the class `Book` with the relevant access modifier. We'll then define code for the other classes that try to access class `Book` and its members.

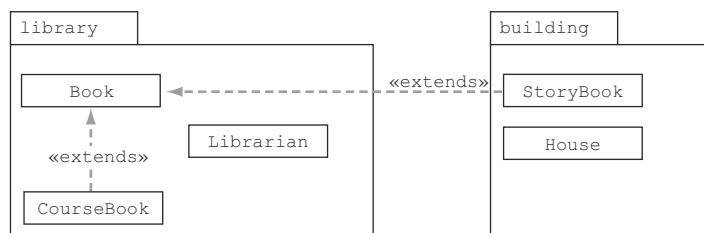


Figure 1.19 A set of classes and their relationships to help understand access modifiers

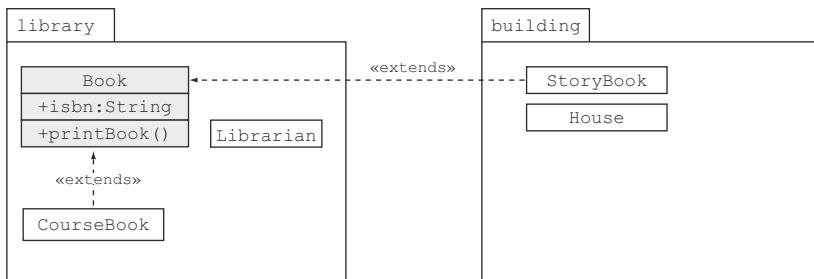


Figure 1.20 Understanding the public access modifier

1.4.2 Public access modifier

This is the least restrictive access modifier. Classes and interfaces defined using the public access modifier are accessible across all packages, from derived to unrelated classes.

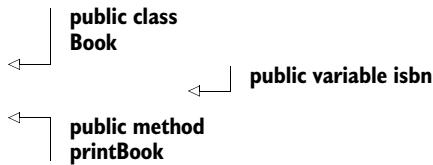
To understand the public access modifier, let's define the class Book as a public class and add a public instance variable (isbn) and a public method (printBook) to it. Figure 1.20 shows the UML notation.

Definition of class Book:

```

package library;
public class Book {
    public String isbn;
    public void printBook() {}
}

```



The public access modifier is said to be the least restrictive, so let's try to access the public class Book and its public members from class House. We'll use class House because House and Book are defined in separate packages and they're unrelated. Class House doesn't enjoy any advantages by being defined in the same package or being a derived class.

Here's the code for class House:

```

package building;
import library.Book;
public class House {
    House() {
        Book book = new Book();
        String value = book.isbn;
        book.printBook();
    }
}

```

Class Book is accessible
to class House

Method printBook is
accessible in House

Variable isbn is
accessible in House

As you may notice in the previous example, the class Book and its public members—instance variable isbn and method printBook—are accessible to the class House. They are also accessible to the other classes: StoryBook, Librarian, House, and CourseBook. Figure 1.21 shows the classes that can access a public class and its members.

	Same package	Separate package
Derived classes	✓	✓
Unrelated classes	✓	✓

Figure 1.21 Classes that can access a public class and its members

1.4.3 Protected access modifier

The members of a class defined using the protected access modifier are accessible to

- Classes and interfaces defined in the same package
- All derived classes, even if they're defined in separate packages

Let's add a protected instance variable `author` and method `modifyTemplate` to the class `Book`. Figure 1.22 shows the class representation.

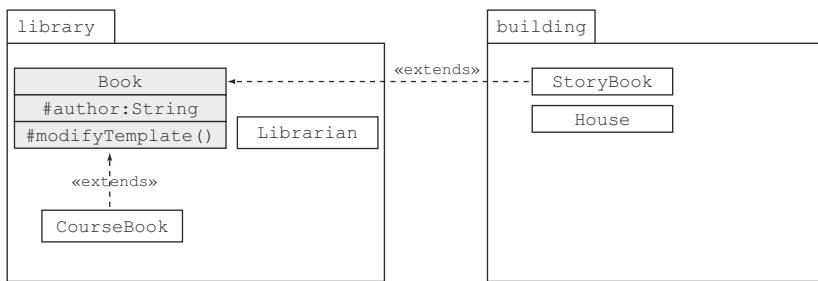


Figure 1.22 Understanding the protected access modifier

Here's the code for the class `Book` (I've deliberately left out its public members because they aren't required in this section):

```

package library;
public class Book {
    protected String author;
    protected void modifyTemplate() {}
}
  
```

Protected variable author

Protected method modifyTemplate

Figure 1.23 illustrates how classes from the same and separate packages, derived classes, and unrelated classes access the class `Book` and its protected members.

Class `House` throws a compilation error message for trying to access the method `modifyTemplate` and the variable `author`, as follows:

```

House.java:8: modifyTemplate() has protected access in library.Book
    book.modifyTemplate();
           ^
  
```

Notice that the derived classes `CourseBook` and `StoryBook` can access the class `Book`'s protected variable `author` and method `modifyTemplate` as if they were defined in their own classes. If class `StoryBook` tries to create an object of class `Book` and then tries to access its protected variable `author` and `modifyTemplate`, it will not compile:

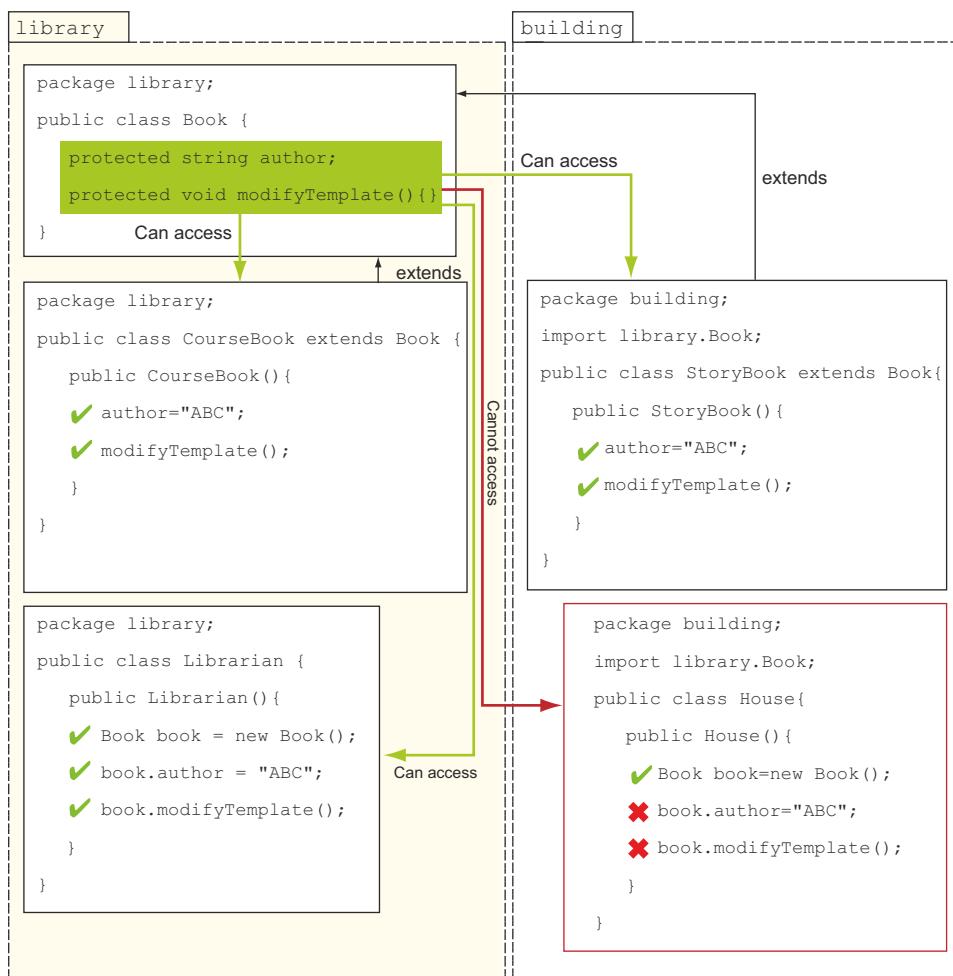


Figure 1.23 Access of protected members of the class Book in unrelated and derived classes, from the same and separate packages

```
package building;
import library.Book;
class StoryBook extends Book {
    StoryBook() {
        Book book = new Book();
        String v = book.author;
        book.modifyTemplate();
    }
}
```

Classes Book and StoryBook defined in separate packages

Protected members of class Book are not accessible in derived class StoryBook, if accessed using a new object of class Book



EXAM TIP A concise but not too simple way of stating the previous rule is this: a derived class can inherit and access protected members of its base class, regardless of the package in which it's defined. A derived class in a separate package can't access protected members of its base class using reference variables.

	Same package	Separate package
Derived classes	✓	✓
Unrelated classes	✓	✗

Figure 1.24 Classes that can access protected members

Figure 1.24 shows the classes that can access protected members of a class or interface.

1.4.4 Default access (package access)

The members of a class defined without using any explicit access modifier are defined with *package accessibility* (also called *default accessibility*). The members with package access are *only* accessible to classes and interfaces defined in the same package.

Let's define an instance variable `issueCount` and a method `issueHistory` with default access in class `Book`. Figure 1.25 shows the class representation with these new members.

Here's the code for the class `Book` (I've deliberately left out its public and protected members because they aren't required in this section):

```
package library;
public class Book {
    int issueCount;
    void issueHistory() {}
}
```

Public class Book
Variable issueCount with default access
Method issueHistory with default access

You can see how classes from the same package and separate packages, derived classes, and unrelated classes access the class `Book` and its members (the variable `issueCount` and the method `issueHistory`) in figure 1.26.

Because the classes `CourseBook` and `Librarian` are defined in the same package as the class `Book`, they can access the variables `issueCount` and `issueHistory`. Because the classes `House` and `StoryBook` don't reside in the same package as the class `Book`, they can't access the variables `issueCount` and `issueHistory`. The class `StoryBook` throws the following compilation error message:

```
StoryBook.java:6: issueHistory() is not public in library.Book; cannot be
accessed from outside package
    book.issueHistory();
               ^
```

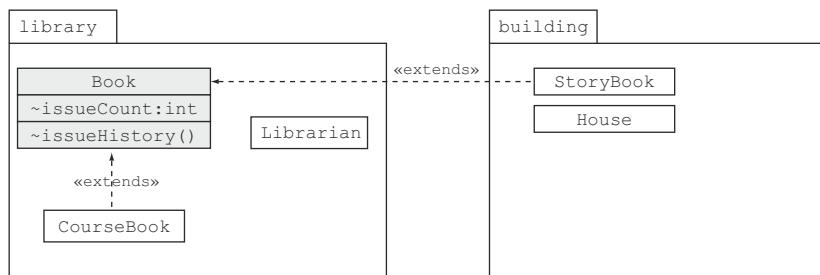


Figure 1.25 Understanding class representation for default access

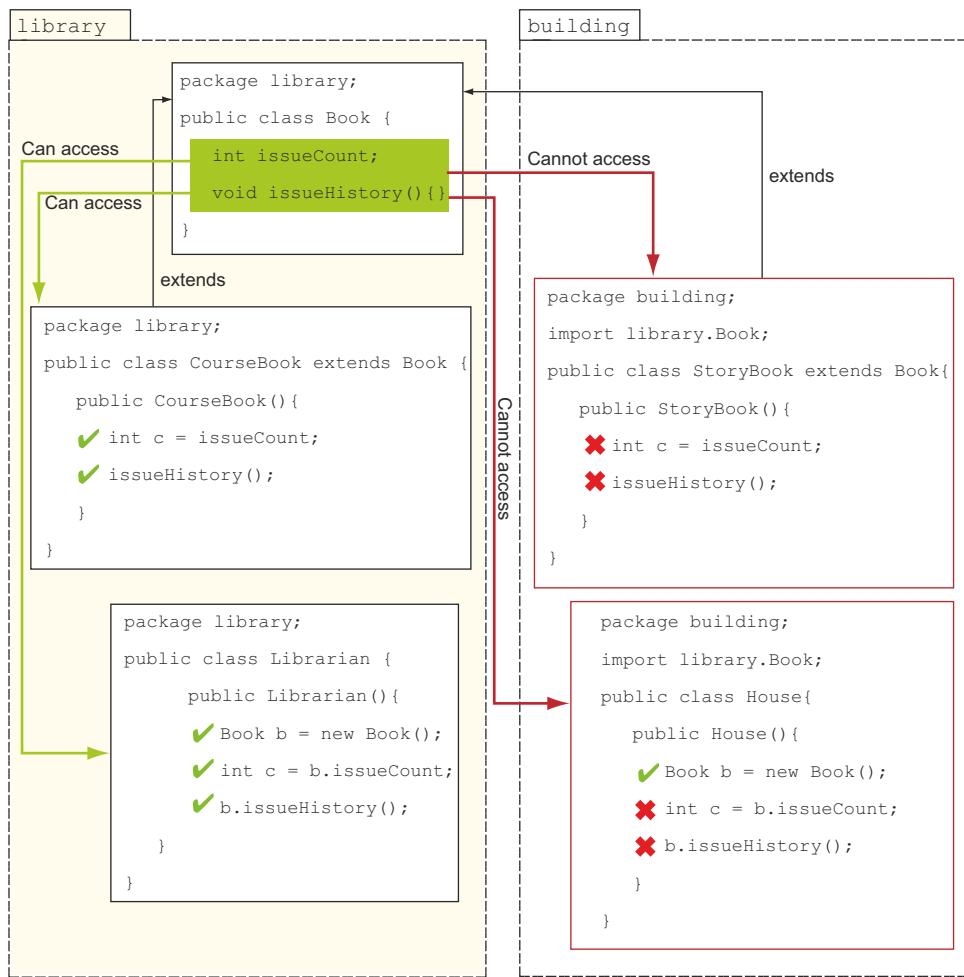


Figure 1.26 Access of members with default access to the class `Book` in unrelated and derived classes from the same and separate packages

The class `House` throws the following compilation error message (for trying to access `issueHistory()`):

```
House.java:9: cannot find symbol
symbol : method issueHistory()
location: class building.House
    issueHistory();
```

DEFINING A CLASS `BOOK` WITH DEFAULT ACCESS

What happens if we define a class with default access? What will happen to the accessibility of its members if the class itself has *default* (package) accessibility?

Let's consider this situation using an example: assume that Superfast Burgers opens a new outlet on a beautiful island and offers free meals to people from all over

How packages and class hierarchy affect default access to class members

From the compilation errors thrown by the Java compiler when trying to compile the classes `StoryBook` and `House`, you can see that the method `issueHistory` (defined in the class `Book`) is visible to its derived class `StoryBook` (defined in another package), but `StoryBook` cannot access it. The method `issueHistory` (defined in class `Book`) is not even visible to the unrelated class `House` defined in a separate package.

the world, which obviously includes inhabitants of the island. But the island is inaccessible by all means (air and water). Would the existence of this particular Superfast Burgers outlet make any sense to people who don't inhabit the island? An illustration of this example is shown in figure 1.27.

The island is like a package in Java, and the Superfast Burgers like a class defined with default access. In the same way that the Superfast Burgers cannot be accessed from outside the island in which it exists, a class defined with default (package) access is visible and accessible only from within the package in which it is defined. It can't be accessed from outside the package in which it resides.

Let's redefine the class `Book` with default (package) access, as follows:

```
package library;
class Book {
    //.. class members
}
```

← Class Book now
has default access

The behavior of the class `Book` remains the same for the classes `CourseBook` and `Librarian`, which are defined in the same package. But the class `Book` can't be accessed by classes `House` and `StoryBook`, which reside in a separate package.

Let's start with the class `House`. Examine the following code:

```
package building;
import library.Book;
public class House {}
```

← Class Book isn't accessible
in class House

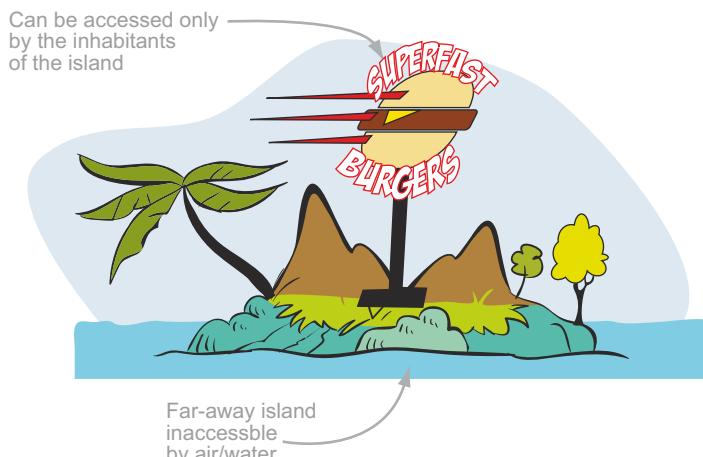


Figure 1.27 This Superfast Burgers cannot be accessed from outside the island because the island is inaccessible by air and water.

	Same package	Separate package
Derived classes	✓	✗
Unrelated classes	✓	✗

Figure 1.28 The classes that can access members with default (package) access

The class House generates the following compilation error message:

```
House.java:2: library.Book is not public in library; cannot be accessed from
    outside package
import library.Book;
```

Here's the code of the class StoryBook:

```
package building;
import library.Book;
class StoryBook extends Book {}
```

Annotations for StoryBook.java:

- A callout points to the word "Book" in the line "import library.Book;" with the text "Book isn't accessible in StoryBook".
- A callout points to the line "class StoryBook extends Book {}" with the text "StoryBook cannot extend Book".

Figure 1.28 shows which classes can access members of a class or interface with default (package) access.

Because a lot of programmers are confused about which members are made accessible by using the protected and default access modifiers, the following exam tip offers a simple and interesting rule to help you remember their differences.



EXAM TIP Default access can be compared to package-private (accessible only within a package) and protected access can be compared to package-private + *kids* ("kids" refer to derived classes). Kids can access protected methods only by inheritance and not by reference (accessing members by using the dot operator on an object).

1.4.5 Private access modifier

The private access modifier is the most restrictive access modifier. The members of a class defined using the private access modifier are accessible only to themselves. It doesn't matter whether the class or interface in question is from another package or has extended the class—private members are *not* accessible outside the class in which they're defined. private members are accessible only to the classes and interfaces in which they are defined.

Let's see this in action by adding a private method countPages to the class Book. Figure 1.29 depicts the class representation using UML.

Examine the following definition of the class Book:

```
package library;
class Book {
    private void countPages() {}
    protected void modifyTemplate() {
        countPages();
    }
}
```

Annotations for Book.java:

- A callout points to the line "private void countPages() {}" with the text "private method".
- A callout points to the line "countPages();" with the text "Only Book can access its own private method countPages".

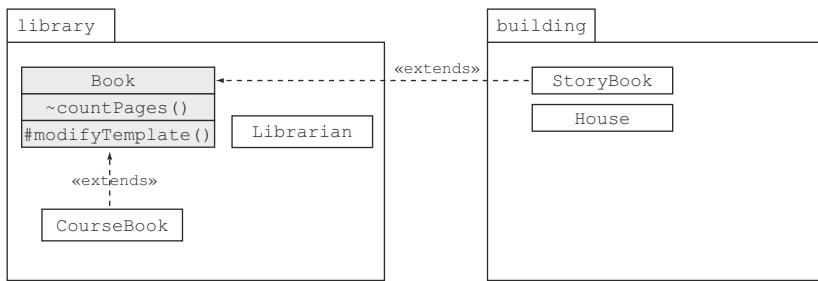


Figure 1.29 Understanding the private access modifier

None of the classes defined in any of the packages (whether derived or not) can access the private method `countPages`. But let's try to access it from the class `CourseBook`. I chose the class `CourseBook` because both of these classes are defined in the same package, and the class `CourseBook` extends the class `Book`. Here's the code of `CourseBook`:

```

package library;
class CourseBook extends Book {
    CourseBook() {
        countPages();
    }
}
  
```

**CourseBook
extends Book**

**CourseBook cannot access
private method countPages**

Because the class `CourseBook` tries to access private members of the class `Book`, it will not compile. Similarly, if any of the other classes (`StoryBook`, `Librarian`, `House`, or `CourseBook`) tries to access the private method `countPages()` of class `Book`, it will not compile. Figure 1.30 shows the classes that can access the private members of a class.

	Same package	Separate package
Derived classes	✗	✗
Unrelated classes	✗	✗

Figure 1.30 No classes can access private members of another class

Twist in the Tale 1.4

The following task was assigned to a group of programmers: “How can you declare a class `Curtain` in a package `building` so that it isn't visible outside the package `building`? ”

These are the answers submitted by Paul, Shreya, Harry, and Selvan. Which of these do you think is correct, and why? (You can check your Twist in the Tale answers in the appendix.)

Programmer name	Submitted code
Paul	package building; public class Curtain {}
Shreya	package building; protected class Curtain {}
Harry	package building; class Curtain {}
Selvan	package building; private class Curtain {}

Your job title may assign special privileges or responsibilities to you. For example, if you work as a Java developer, you may be responsible for updating your programming skills or earning professional certifications in Java. Similarly, you can assign special privileges, responsibilities, and behaviors to your Java entities by using *nonaccess modifiers*, which are covered in the next section.

1.5 Nonaccess modifiers



[7.6] Use abstract classes and interfaces



[6.2] Apply the static keyword to methods and fields

This section discusses the nonaccess modifiers `abstract`, `final`, and `static`. Access modifiers control the accessibility of your class and its members outside the class and the package. Nonaccess modifiers change the default properties of a Java class and its members.

For example, if you add the keyword `abstract` to the definition of a class, it'll be considered an abstract class. None of the other classes will be able to create objects of this class. Such is the magic of the nonaccess modifiers.

You can characterize your classes, interfaces, methods, and variables with the following nonaccess modifiers (though not all are applicable to each Java entity):

- `abstract`
- `static`
- `final`
- `synchronized`
- `native`
- `strictfp`
- `transient`
- `volatile`

The OCA Java SE 7 Programmer I exam covers only three of these nonaccess modifiers: `abstract`, `final`, and `static`, which I'll cover in detail. To ward off any confusion about the rest of the modifiers, I'll describe them briefly here:

- `synchronized`—A synchronized method can't be accessed by multiple threads concurrently. This constraint is used to protect the integrity of data that might be accessed and changed by multiple threads concurrently. You can't mark classes, interfaces, or variables with this modifier.
- `native`—A native method calls and makes use of libraries and methods implemented in other programming languages such as C or C++. You can't mark classes, interfaces, or variables with this modifier.
- `transient`—A transient variable isn't serialized when the corresponding object is serialized. The transient modifier can't be applied to classes, interfaces, or methods.
- `volatile`—A volatile variable's value can be safely modified by different threads. Classes, interfaces, and methods cannot use this modifier.
- `strictfp`—Classes, interfaces, and methods defined using this keyword ensure that calculations using floating-point numbers are identical on all platforms. This modifier can't be used with variables.

Now let's look at the three nonaccess modifiers that are on the exam.

1.5.1 Abstract modifier

When added to the definition of a class, interface, or method, the `abstract` modifier changes its default behavior. Because it is a nonaccess modifier, `abstract` doesn't change the accessibility of a class, interface, or method.

Let's examine the behavior of each of these with the `abstract` modifier.

ABSTRACT CLASS

When the `abstract` keyword is prefixed to the definition of a concrete class, it changes it to an abstract class, even if the class doesn't define any abstract methods. The following code is a valid example of an abstract class:

```
abstract class Person {  
    private String name;  
    public void displayName() { }  
}
```

An abstract class can't be instantiated, which means that the following code will fail to compile:

```
class University {  
    Person p = new Person();  
}
```

This line of code
won't compile

Here's the compilation error thrown by the previous class:

```
University.java:4: Person is abstract; cannot be instantiated
    Person p = new Person();
                           ^
1 error
```



EXAM TIP An abstract class may or may not define an abstract method; you can define an abstract class without any abstract methods. But a concrete class can't define an abstract method.

ABSTRACT INTERFACE

An interface is an abstract entity by default. The Java compiler automatically adds the keyword `abstract` to the definition of an interface. Thus, adding the keyword `abstract` to the definition of an interface is redundant. The following definitions of interfaces are the same:

```
interface Movable {}           ← Interface defined without the
abstract interface Movable {}   ← explicit use of keyword abstract
```

← Interface defined with the
explicit use of keyword abstract

ABSTRACT METHOD

An abstract method doesn't have a body. Usually, an abstract method is implemented by a derived class. Here's an example:

```
abstract class Person {
    private String name;
    public void displayName() { }           ← This isn't an abstract method.
    public abstract void perform();         ← It has an empty body: {}.
}
```

← This is an abstract method.
It isn't followed by {}.



EXAM TIP A method with an empty body isn't an abstract method.

ABSTRACT VARIABLES

None of the different types of variables (instance, static, local, and method parameters) can be defined as abstract.



EXAM TIP Don't be tricked by code that tries to apply the nonaccess modifier `abstract` to a variable. Such code won't compile.

1.5.2 Final modifier

The keyword `final` changes the default behavior of a class, variable, or method.

FINAL CLASS

A class that is marked `final` cannot be extended by another class. The class `Professor` will not compile if the class `Person` is marked as `final`, as follows:

```
final class Person {}
class Professor extends Person {}           ← Won't compile
```

FINAL INTERFACE

An interface cannot be marked as `final`. An interface is abstract by default and marking it with `final` will prevent your interface from compiling:

```
final interface MyInterface{}           ← Won't compile
```

FINAL VARIABLE

A `final` variable can't be reassigned a value. It can be assigned a value only once. See the following code:

```
class Person {  
    final long MAX_AGE;  
    Person() {  
        MAX_AGE = 99;           ← Compiles successfully: value  
    }                                assigned once to final variable  
}  
}
```

Compare the previous example with the following code, which tries to reassign a value to a `final` variable:

```
class Person {  
    final long MAX_AGE = 90;  
    Person() {  
        MAX_AGE = 99;           ← Won't compile;  
    }                                reassignment not allowed  
}  
}
```

It's easy to confuse reassigning a value to a `final` variable with *calling* a method on a `final` variable. If a reference variable is defined as a `final` variable, you can't reassign another object to it, but you can call methods on this variable:

```
class Person {  
    final StringBuilder name = new StringBuilder("Sh");  
    Person() {  
        name.append("reya");  
        name = new StringBuilder();           ← Can call methods  
    }                                on a final variable  
}  
}                                     ← Won't compile. You can't reassign  
                                         another object to a final variable.
```

FINAL METHOD

A `final` method defined in a base class can't be overridden by a derived class. Examine the following code:

```
class Person {  
    final void sing() {  
        System.out.println("la..la..la..");  
    }  
}  
class Professor extends Person {  
    void sing() {           ← Won't compile  
        System.out.println("Alpha.. beta.. gamma");  
    }  
}
```

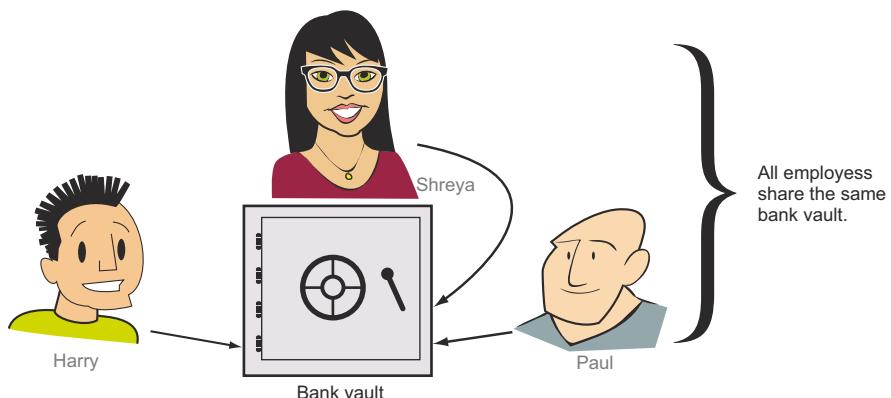


Figure 1.31 Comparing a shared bank vault with a static variable

If a method in a derived class has the same method signature as its base class's method, it is referred to as an *overridden method*. Overridden methods are discussed along with polymorphism in chapter 6.

1.5.3 Static modifier

The nonaccess modifier `static`, when applied to the definitions of variables, methods, classes, and interfaces, changes their default behavior. We'll examine each of them in following sections.

STATIC VARIABLES

`static` variables belong to a class. They are common to all instances of a class and aren't unique to any instance of a class. `static` attributes exist independently of any instances of a class and may be accessed even when no instances of the class have been created. You can compare a `static` variable with a shared variable. A `static` variable is shared by all of the objects of a class.

Think of a `static` variable as being like a common bank vault that's shared by the employees of an organization. Each of the employees accesses the same bank vault, so any change made by one employee is visible to all the other employees, as illustrated in figure 1.31.

Figure 1.32 defines a class `Emp` that defines a non-`static` variable name and a `static` variable `bankVault`.

It's time to test what we've been discussing up to this point. The following `TestEmp` class creates two objects of the class `Emp` (from figure 1.32) and modifies the value of the variable `bankVault` using these separate objects:

```
class Emp {
    String name;
    static int bankVault;
}
```

We want this value to be shared by all the objects of class Emp.

Figure 1.32 Definition of the class Emp with a static variable bankVault and non-static variable name

```

class TestEmp {
    public static void main(String[] args) {
        Emp emp1 = new Emp();
        Emp emp2 = new Emp();
        emp1.bankVault = 10;
        emp2.bankVault = 20;

        System.out.println(emp1.bankVault);
        System.out.println(emp2.bankVault);
        System.out.println(Emp.bankVault);
    }
}

```

Variable bankVault of variable emp1 is assigned a value of 10

Reference variables emp1 and emp2 refer to separate objects of class Emp

Variable bankVault of variable emp2 is assigned a value of 20

This will print 20 as well

This will print 20

This will also print 20

In the preceding code example, `emp1.bankVault`, `emp2.bankVault`, and `Emp.bankVault` all refer to the *same* static attribute: `bankVault`.



EXAM TIP A static variable can be accessed using the name of the object reference variable or the name of a class.

The `static` and `final` nonaccess modifiers can be used to define *constants* (variables whose value can't change). In the following code, the class `Emp` defines the constants `MIN_AGE` and `MAX_AGE`:

```

class Emp {
    public static final int MIN_AGE = 20;
    static final int MAX_AGE = 70;
}

```

Constant MIN_AGE

Constant MAX_AGE

Though you can define a constant as a non-static member, it's common practice to define constants as static members, as doing so allows the constant values to be used across objects and classes.

STATIC METHODS

static methods aren't associated with objects and can't use any of the instance variables of a class. You can define static methods to access or manipulate static variables:

```

class Emp {
    String name;
    static int bankVault;

    static int getBankVaultValue() {
        return bankVault;
    }
}

```

static method getBankVaultValue returns the value of static variable bankVault

You can also use static methods to define *utility methods*, which are methods that usually manipulate the method parameters to compute and return an appropriate value:

```

static double interest(double num1, double num2, double num3) {
    return (num1+num2+num3)/3;
}

```

A static method may not always define method parameters. The method `averageOfFirst100Integers` computes and returns the average of numbers 1 to 100:

```
static double averageOfFirst100Integers() {  
    int sum = 0;  
    for (int i=1; i <= 100; ++i) {  
        sum += i;  
    }  
    return (sum)/100;  
}
```

Method `averageOfFirst100Integers` doesn't define method parameters

The non-private static variables and methods are inherited by derived classes. The static members aren't involved in runtime polymorphism. You can't override the static members in a derived class, but you can redefine them.

Any discussion of static methods and their behavior can be quite confusing if you aren't aware of inheritance and derived classes. But don't worry if you don't understand all of it. I'll cover derived classes and inheritance in chapter 6. For now, note that a static method can be accessed using the name of the object reference variables and the class in a manner similar to static variables.



NOTE Even though you can use an object reference variable to access static members, it's not advisable to do so. Because static members belong to a class and not to individual objects, using object reference variables to access static members may make them appear to belong to an object. The proper way to access them is by using the class name.

WHAT CAN A STATIC METHOD ACCESS?

Neither static methods nor static variables can access the non-static variables and methods of a class. But the reverse is true: non-static variables and methods can access static variables and methods because the static members of a class exist even if no instances of the class exist. static members are forbidden from accessing instance methods and variables, which can exist only if an instance of the class is created.

Examine the following code:

```
class MyClass {  
    static int x = count();  
    int count() { return 10; }  
}
```

Compilation error

This is the compilation error thrown by the previous class:

```
MyClass.java:3: nonstatic method count() cannot be referenced from a static  
    context  
    static int x = count();  
               ^  
1 error
```

The following code is valid:

```
class MyClass {  
    static int x = result();  
    static int result() { return 20; }  
}
```

**static variable referencing
a static method**

```
int nonStaticResult() { return result(); }
```

Non-static method
using static method



EXAM TIP Static methods and variables can't access the instance members of a class.

Static classes and interfaces

Certification aspirants frequently ask questions about static classes and interfaces, so I'll quickly cover these in this section to ward off any confusion related to them. But note that static classes and interfaces are types of nested classes and interfaces that aren't covered by the OCA Java 7 Programmer I exam.

You can't prefix the definition of a top-level class or an interface with the keyword `static`. A top-level class or interface is one that isn't defined within another class or interface. The following code will fail to compile:

```
static class Person {}  
static interface MyInterface {}
```

But you can define a class and an interface as a static member of another class. The following code is valid:

```
class Person {  
    static class Address {}  
    static interface MyInterface {}  
}
```

Also known as a
static nested class

1.6 Summary

This chapter started with a look at the structure of a Java class. Although you should know how to work with Java classes, Java source code files (.java files), and Java bytecode files (.class files), the OCA Java SE 7 Programmer I exam will question you only on the structure and components of the first two—classes and source code—not on Java bytecode.

We discussed the components of a Java class and of Java source code files. A class can define multiple components, namely `import` and `package` statements, variables, constructors, methods, comments, nested classes, nested interfaces, annotations, and enums. A Java source code file (.java) can define multiple classes and interfaces.

We then covered the differences and similarities between executable and nonexecutable Java classes. An executable Java class defines the entry point (`main` method) for the JVM to start its execution. The `main` method should be defined with the required method signature; otherwise, the class will fail to be categorized as an executable Java class.

Packages are used to group together related classes and interfaces. They also provide access protection and namespace management. The `import` statement is used to import classes and interfaces from other packages. In the absence of an `import` statement, classes and interfaces should be referred to by their fully qualified names (complete package name plus class or interface name).

Access modifiers control the access of classes and their members within a package and across packages. Java defines four access modifiers: public, protected, default, and private. When default access is assigned to a class or its member, no access modifier is prefixed to it. The absence of an access modifier is equal to assigning the class or its members with default access. The least restrictive access modifier is public, and private is the most restrictive. protected access sits between public and default access, allowing access to derived classes outside of a package.

Finally, we covered the abstract and static nonaccess modifiers. A class or a method can be defined as an abstract member. abstract classes can't be instantiated. Methods and variables can be defined as static members. All the objects of a class share the same copy of static variables, which are also known as class-level variables.

1.7 Review notes

This section lists the main points covered in this chapter.

The structure of a Java class and source code file:

- The OCA Java SE 7 Programmer I exam covers the structure and components of a Java class and Java source code file (.java file). It doesn't cover the structure and components of Java bytecode files (.class files).
- A class can define multiple components. All the Java components you've heard of can be defined within a Java class: import and package statements, variables, constructors, methods, comments, nested classes, nested interfaces, annotations, and enums.
- The OCA Java SE 7 Programmer I exam doesn't cover the definitions of nested classes, nested interfaces, annotations, and enums.
- If a class defines a package statement, it should be the first statement in the class definition.
- The package statement can't appear within a class declaration or after the class declaration.
- If present, the package statement should appear exactly once in a class.
- The import statement uses simple names of classes and interfaces from within the class.
- The import statement can't be used to import multiple classes or interfaces with the same name.
- A class can include multiple import statements.
- If a class includes a package statement, all the import statements should follow the package statement.
- Comments are another component of a class. Comments are used to annotate Java code and can appear at multiple places within a class.
- A comment can appear before or after a package statement, before or after the class definition, and before, within, or after a method definition.
- Comments come in two flavors: multiline and end-of-line comments.

- Comments can contain any special characters (including characters from the Unicode charset).
- Multiline comments span multiple lines of code. They start with /* and end with */.
- End-of-line comments start with // and, as the name suggests, are placed at the end of a line of code. The text between // and the end of the line is treated as a comment.
- Class declarations and class definitions are components of a Java class.
- A Java class may define zero or more instance variables, methods, and constructors.
- The order of the definition of instance variables, constructors, and methods doesn't matter in a class.
- A class may define an instance variable before or after the definition of a method and still use it.
- A Java source code file (.java file) can define multiple classes and interfaces.
- A public class can be defined only in a source code file with the same name.
- package and import statements apply to all the classes and interfaces defined in the same source code file (.java file).

Executable Java applications:

- An executable Java class is a class that, when handed over to the Java Virtual Machine (JVM), starts its execution at a particular point in the class. This point of execution is the main method.
- For a class to be executable, the class should define a main method with the signature `public static void main(String args[])` or `public static void main(String... args)`. The positions of static and public can be interchanged, and the method parameter can use any valid name.
- A class can define multiple methods with the name main, provided that the signature of these methods doesn't match the signature of the main method defined in the previous point. These other methods with different signatures aren't considered the main method.
- The main method accepts an array of type String containing the method parameters passed to it by the JVM.
- The keyword java and the name of the class aren't passed on as command parameters to the main method.

Java packages:

- You can use packages to group together a related set of classes and interfaces.
- By default, all classes and interfaces in separate packages and subpackages aren't visible to each other.
- The package and subpackage names are separated using a period.
- All classes and interfaces in the same package are visible to each other.
- An import statement allows the use of simple names for packaged classes and interfaces defined in other packages.

- You can't use the `import` statement to access multiple classes or interfaces with the same names from different packages.
- You can import either a single member or all members (classes and interfaces) of a package using the `import` statement.
- You can't import classes from a subpackage by using the wildcard character, an asterisk (*), in the `import` statement.
- A class from a default package can't be used in any named packaged class, regardless of whether it's defined within the same directory or not.
- You can import an individual `static` member of a class or all its `static` members by using a `static import` statement.
- An `import` statement can't be placed before a package statement in a class. Any attempt to do so will cause the compilation of the class to fail.
- The members of default packages are accessible only to classes or interfaces defined in the same directory on your system.

Java access modifiers:

- The access modifiers control the accessibility of your class and its members outside the class and package.
- Java defines four access modifiers: `public`, `protected`, `default`, and `private`.
- The `public` access modifier is the least restrictive access modifier.
- Classes and interfaces defined using the `public` access modifier are accessible to related and unrelated classes outside the package in which they're defined.
- The members of a class defined using the `protected` access modifier are accessible to classes and interfaces defined in the same package and to all derived classes, even if they're defined in separate packages.
- The members of a class defined without using an explicit access modifier are defined with package accessibility (also called default accessibility).
- The members with package access are accessible only to classes and interfaces defined in the same package.
- A class defined using default access can't be accessed outside its package.
- The members of a class defined using a `private` access modifier are accessible only to the class in which they are defined. It doesn't matter whether the class or interface in question is from another package or has extended the class. Private members are not accessible outside the class in which they're defined.
- The `private` access modifier is the most restrictive access modifier.

Nonaccess modifiers:

- The nonaccess modifiers change the default properties of a Java class and its members.
- The OCA Java SE 7 Programmer I exam covers only two nonaccess modifiers: `abstract` and `static`.

- The `abstract` keyword, when prefixed to the definition of a concrete class, can change it to an abstract class, even if it doesn't define any abstract methods.
- An abstract class cannot be instantiated.
- An interface is an abstract entity by default. The Java compiler automatically adds the keyword `abstract` to the definition of an interface (which means that adding the keyword `abstract` to the definition of an interface is redundant).
- An abstract method doesn't have a body, which means it's implemented by the class that extends the class defining the abstract method.
- A variable can't be defined as an `abstract` variable.
- The `static` modifier can be applied to inner classes, inner interfaces, variables, and methods. Inner classes and interfaces aren't covered in this exam.
- A method can't be defined both as `abstract` and `static`.
- `static` attributes (fields and methods) are common to all instances of a class and aren't unique to any instance of a class.
- `static` attributes exist independent of any instances of a class and may be accessed even when no instances of the class have been created.
- `static` attributes are also known as *class fields* or *class methods* because they're said to belong to their class, not to any instance of that class.
- A `static` variable or method can be accessed using the name of a reference object variable or the name of a class.
- A `static` method or variable can't access non-`static` variables or methods of a class. But the reverse is true: non-`static` variables and methods can access static variables and methods.
- `static` classes and interfaces are a type of nested classes and interfaces but they aren't covered in the OCA Java SE 7 Programmer I exam.
- You can't prefix the definition of a top-level class or an interface with the keyword `static`. A top-level class or interface is one that isn't defined within another class or interface.

1.8 Sample exam questions

Q1-1. What are the valid components of a Java source file (choose all that apply):

- a package statement
- b import statements
- c methods
- d variables
- e Java compiler
- f Java Runtime Environment

Q1-2. The following numbered list of Java class components is not in any particular order. Select the correct order of their occurrence in a Java class (choose all that apply):

- 1 comments
- 2 import statement
- 3 package statement
- 4 methods
- 5 class declaration
- 6 variables
 - a 1, 3, 2, 5, 6, 4
 - b 3, 1, 2, 5, 4, 6
 - c 3, 2, 1, 4, 5, 6
 - d 3, 2, 1, 5, 6, 4

Q1-3. Which of the following examples define the correct Java class structure?

- a `#connect java compiler;`
`#connect java virtual machine;`
`class EJavaGuru {}`
- b `package java compiler;`
`import java virtual machine;`
`class EJavaGuru {}`
- c `import javavirtualmachine.*;`
`package javacompiler;`
`class EJavaGuru {`
 `void method1() {}`
 `int count;`
`}`
- d `package javacompiler;`
`import javavirtualmachine.*;`
`class EJavaGuru {`
 `void method1() {}`
 `int count;`
`}`
- e `#package javacompiler;`
`$import javavirtualmachine;`
`class EJavaGuru {`
 `void method1() {}`
 `int count;`
`}`
- f `package javacompiler;`
`import javavirtualmachine;`
`Class EJavaGuru {`
 `void method1() {}`
 `int count;`
`}`

Q1-4. Given the following contents of the Java source code file MyClass.java, select the correct options:

```
// contents of MyClass.java
package com.ejavaguru;
import java.util.Date;
class Student {}
class Course {}
```

- a The imported class, `java.util.Date`, can be accessed only in the class `Student`.
- b The imported class, `java.util.Date`, can be accessed by both the `Student` and `Course` classes.
- c Both of the classes `Student` and `Course` are defined in the package `com.ejavaguru`.
- d Only the class `Student` is defined in the package `com.ejavaguru`. The class `Course` is defined in the default Java package.

Q1-5. Given the following definition of the class `EJavaGuru`,

```
class EJavaGuru {
    public static void main(String[] args) {
        System.out.println(args[1]+":"+ args[2]+":"+ args[3]);
    }
}
```

what is the output of the previous class, if it is executed using the following command:

```
java EJavaGuru one two three four
```

- a one:two:three
- b EJavaGuru:one:two
- c java:EJavaGuru:one
- d two:three:four

Q1-6. Which of the following options, when inserted at `// INSERT CODE HERE`, will print out `EJavaGuru`?

```
public class EJavaGuru {
    // INSERT CODE HERE
    {
        System.out.println("EJavaGuru");
    }
}



- a public void main (String[] args)
- b public void main(String      args[])
- c static public void main      (String[] array)
- d public static void main (String args)
- e static public main (String args[])

```

Q1-7. Select the correct options:

- a You can start the execution of a Java application through the `main` method.
- b The Java compiler calls and executes the `main` method.
- c The Java Virtual Machine calls and executes the `main` method.
- d A class calls and executes the `main` method.

Q1-8. A class `Course` is defined in a package `com.ejavaguru`. Given that the physical location of the corresponding class file is `/mycode/com/ejavaguru/Course.class` and execution takes place within the `mycode` directory, which of the following lines of code, when inserted at `// INSERT CODE HERE`, will import the `Course` class into the class `MyCourse`?

```
// INSERT CODE HERE
class MyCourse {
    Course c;
}

a import mycode.com.ejavaguru.Course;
b import com.ejavaguru.Course;
c import mycode.com.ejavaguru;
d import com.ejavaguru;
e import mycode.com.ejavaguru*;
f import com.ejavaguru*;
```

Q1-9. Examine the following code:

```
class Course {
    String courseName;
}
class EJavaGuru {
    public static void main(String args[]) {
        Course c = new Course();
        c.courseName = "Java";
        System.out.println(c.courseName);
    }
}
```

Which of the following statements will be true if the variable `courseName` is defined as a `private` variable?

- a class `EJavaGuru` will print `Java`.
- b class `EJavaGuru` will print `null`.
- c class `EJavaGuru` won't compile.
- d class `EJavaGuru` will throw an exception at runtime.

Q1-10. Given the following definition of the class `Course`,

```
package com.ejavaguru.courses;
class Course {
    public String courseName;
}
```

what's the output of the following code?

```
package com.ejavaguru;
import com.ejavaguru.courses.Course;
class EJavaGuru {
    public static void main(String args[]) {
        Course c = new Course();
        c.courseName = "Java";
        System.out.println(c.courseName);
    }
}
```

- a The class EJavaGuru will print Java.
- b The class EJavaGuru will print null.
- c The class EJavaGuru won't compile.
- d The class EJavaGuru will throw an exception at runtime.

Q1-11. Given the following code, select the correct options:

```
package com.ejavaguru.courses;
class Course {
    public String courseName;
    public void setCourseName(private String name) {
        courseName = name;
    }
}
```

- a You can't define a method argument as a private variable.
- b A method argument should be defined with either public or default accessibility.
- c For overridden methods, method arguments should be defined with protected accessibility.
- d None of the above.

1.9 Answers to sample exam questions

Q1-1. What are the valid components of a Java source file (choose all that apply):

- a package statement
- b import statements
- c methods
- d variables
- e Java compiler
- f Java Runtime Environment

Answer: a, b, c, d

Explanation: The Java compiler and Java Runtime Environment aren't components of a Java source file.

Q1-2. The following numbered list of Java class components is not in any particular order. Select the correct order of their occurrence in a Java class (choose all that apply):

- 1 comments
- 2 import statement
- 3 package statement
- 4 methods
- 5 class declaration
- 6 variables
 - a 1, 3, 2, 5, 6, 4
 - b 3, 1, 2, 5, 4, 6
 - c 3, 2, 1, 4, 5, 6
 - d 3, 2, 1, 5, 6, 4

Answer: a, b, d

Explanation: The comments can appear anywhere in a class. They can appear before and after package and import statements. They can appear before or after a class, method, or variable declaration.

The first statement (if present) in a class should be a package statement. It can't be placed after an import statement or a declaration of a class.

The import statement should follow a package statement and be followed by a class declaration.

The class declaration follows the import statements, if present. It's followed by the declaration of the methods and variables.

Answer (c) is incorrect. None of the variables or methods can be defined before the definition of a class or interface.

Q1-3. Which of the following examples define the correct Java class structure?

- a #connect java compiler;
#connect java virtual machine;
class EJavaGuru {}
- b package java compiler;
import java virtual machine;
class EJavaGuru {}
- c import javavirtualmachine.*;
package javacompiler;
class EJavaGuru {
 void method1() {}
 int count;
}
- d package javacompiler;
import javavirtualmachine.*;
class EJavaGuru {
 void method1() {}
 int count;
}

```

e #package javacompiler;
$import javavirtualmachine;
class EJavaGuru {
    void method1() {}
    int count;
}

f package javacompiler;
import javavirtualmachine;
Class EJavaGuru {
    void method1() {}
    int count;
}

```

Answer: d

Explanation: Answer (a) is incorrect because `#connect` isn't a statement in Java. `#` is used to add comments in UNIX.

Option (b) is incorrect because a package name (`Java compiler`) cannot contain spaces. Also, `java virtual machine` isn't a valid package name to be imported in a class. The package name to be imported cannot contain spaces.

Option (c) is incorrect because a package statement should be placed before an `import` statement.

Option (e) is incorrect. `#package` and `$import` aren't valid statements or directives in Java.

Option (f) is incorrect. Java is case-sensitive, so the word `class` is not the same as the word `Class`. The correct keyword to define a class is `class`.

Q1-4. Given the following contents of the Java source code file `MyClass.java`, select the correct options:

```

// contents of MyClass.java
package com.ejavaguru;
import java.util.Date;
class Student {}
class Course {}

```

- a The imported class, `java.util.Date`, can be accessed only in the class `Student`.
- b **The imported class, `java.util.Date`, can be accessed by both the `Student` and `Course` classes.**
- c **Both of the classes `Student` and `Course` are defined in the package `com.ejavaguru`.**
- d Only the class `Student` is defined in the package `com.ejavaguru`. The class `Course` is defined in the default Java package.

Answer: b, c

Explanation: You can define multiple classes, interfaces, and enums in a Java source code file.

Option (a) is incorrect. The `import` statement applies to all the classes, interfaces, and enums defined within the same Java source code file.

Option (d) is incorrect. If a package statement is defined in the source code file, all of the classes, interfaces, and enums defined within it will exist in the same Java package.

Q1-5. Given the following definition of the class EJavaGuru,

```
class EJavaGuru {
    public static void main(String[] args) {
        System.out.println(args[1]+":"+ args[2]+":"+ args[3]);
    }
}
```

what is the output of the previous class, if it is executed using the command:

```
java EJavaGuru one two three four
```

- a one:two:three
- b EJavaGuru:one:two
- c java:EJavaGuru:one
- d **two:three:four**

Answer: d

Explanation: The command-line arguments passed to the `main` method of a class do not contain the word Java and the name of the class.

Because the position of an array is zero-based, the method argument is assigned the following values:

args[0] -> one
 args[1] -> two
 args[2] -> three
 args[3] -> four

The class prints `two:three:four`.

Q1-6. Which of the following options, when inserted at // INSERT CODE HERE, will print out EJavaGuru?

```
public class EJavaGuru {
    // INSERT CODE HERE
    {
        System.out.println("EJavaGuru");
    }
}

a public void main (String[] args)
b public void main(String      args[])
c static public void main (String[] array)
d public static void main (String args)
e static public main (String args[])
```

Answer: c

Explanation: Option (a) is incorrect. This option defines a valid method but not a valid `main` method. The `main` method should be defined as a `static` method, which is missing from the method declaration in option (a).

Option (b) is incorrect. This option is similar to the method defined in option (a), with one difference. In this option, the square brackets are placed after the name of the method argument. The `main` method accepts an array as a method argument, and to define an array, the square brackets can be placed after either the data type or the method argument name.

Option (c) is correct. Extra spaces in a class are ignored by the Java compiler.

Option (d) is incorrect. The `main` method accepts an array of `String` as a method argument. The method in this option accepts a single `String` object.

Option (e) is incorrect. It isn't a valid method definition and doesn't specify the return type of the method. This line of code will not compile.

Q1-7. Select the correct options:

- a You can start the execution of a Java application through the `main` method.**
- b The Java compiler calls and executes the `main` method.**
- c The Java Virtual Machine calls and executes the `main` method.**
- d A class calls and executes the `main` method.**

Answer: a, c

Explanation: The Java Virtual Machine calls and executes the `main` method.

Q1-8. A class `Course` is defined in a package `com.ejavaguru`. Given that the physical location of the corresponding class file is `/mycode/com/ejavaguru/Course.class` and execution takes place within the `mycode` directory, which of the following lines of code, when inserted at `// INSERT CODE HERE`, will import the `Course` class into the class `MyCourse`?

```
// INSERT CODE HERE
class MyCourse {
    Course c;
}

a import mycode.com.ejavaguru.Course;
b import com.ejavaguru.Course;
c import mycode.com.ejavaguru;
d import com.ejavaguru;
e import mycode.com.ejavaguru.*;
f import com.ejavaguru*;
```

Answer: b

Explanation: Option (a) is incorrect. The path of the imported class used in an `import` statement isn't related to the class's physical location. It reflects the package and subpackage that a class is in.

Options (c) and (e) are incorrect. The class's physical location isn't specified in the `import` statement.

Options (d) and (f) are incorrect. ejavaguru is a package. To import a package and its members, the package name should be followed by `.*`, as follows:

```
import com.ejavaguru.*;
```

Q1-9. Examine the following code:

```
class Course {
    String courseName;
}
class EJavaGuru {
    public static void main(String args[]) {
        Course c = new Course();
        c.courseName = "Java";
        System.out.println(c.courseName);
    }
}
```

Which of the following statements will be true if the variable `courseName` is defined as a private variable?

- a class EJavaGuru will print Java.
- b class EJavaGuru will print null.
- c **class EJavaGuru won't compile.**
- d class EJavaGuru will throw an exception at runtime.

Answer: c

Explanation: If the variable `courseName` is defined as a private member, it won't be accessible from the class `EJavaGuru`. An attempt to do so will cause it to fail at compile time. Because the code won't compile, it can't execute.

Q1-10. Given the following definition of the class `Course`,

```
package com.ejavaguru.courses;
class Course {
    public String courseName;
}
```

what's the output of the following code?

```
package com.ejavaguru;
import com.ejavaguru.courses.Course;
class EJavaGuru {
    public static void main(String args[]) {
        Course c = new Course();
        c.courseName = "Java";
        System.out.println(c.courseName);
    }
}
```

- a The class EJavaGuru will print Java.
- b The class EJavaGuru will print null.
- c **The class EJavaGuru will not compile.**
- d The class EJavaGuru will throw an exception at runtime.

Answer: c

Explanation: The class will fail to compile because a non-public class cannot be accessed outside a package in which it is defined. The class Course therefore can't be accessed from within the class EJavaGuru, even if it is explicitly imported into it. If the class itself isn't accessible, there's no point in accessing a public member of a class.

Q1-11. Given the following code, select the correct options:

```
package com.ejavaguru.courses;
class Course {
    public String courseName;
    public void setCourseName(private String name) {
        courseName = name;
    }
}
```

- a You can't define a method argument as a private variable.**
- b A method argument should be defined with either public or default accessibility.**
- c For overridden methods, method arguments should be defined with protected accessibility.**
- d None of the above.**

Answer: a

Explanation: You can't add an explicit accessibility keyword to the method parameters. If you do, the code won't compile.



Working with Java data types

Exam objectives covered in this chapter	What you need to know
[2.2] Differentiate between object reference variables and primitive variables.	The primitive data types in Java, including scenarios when a particular primitive data type should or can't be used. Similarities and differences between the primitive data types. Similarities and differences between primitive and object reference variables.
[2.1] Declare and initialize variables.	Declaration and initialization of primitives and object reference variables. Literal values for primitive and object reference variables.
[3.1] Use Java operators.	Use of assignment, arithmetic, relational, and logical operators with primitives and object reference variables. Valid operands for an operator. Output of an arithmetic expression. Determine the equality of two primitives.
[3.2] Use parentheses to override operator precedence.	How to override the default operator precedence by using parentheses.

Imagine that you've just purchased a new home! Unfortunately, it didn't come with all the kitchen stuff. You'll likely need to buy different-sized containers to store different types of food items, because one size can't fit all! Also, you might move around food items in your home—perhaps because of a change in the requirements over time (you wish to eat it or you wish to store it).

Your new kitchen is an analogy for how Java stores its data using different data types and manipulates the data using operators. The food items are like data types in Java, and the containers used to store the food are like variables in Java. The change in the requirements that triggers a change in the state of food items can be compared to the processing logic. The agents of change (fire, heat, or cooling) that change the state of the food items can be compared to Java operators. You need these agents of change so that you can process the raw food items to create delicacies.

In the OCA Java SE 7 Programmer I exam, you'll be asked questions on the various data types in Java, such as how to create and initialize them and what their similarities and differences are. The exam will also question you on using the Java operators. This chapter covers the following:

- Primitive data types in Java
- Literal values of primitive Java data types
- Object reference variables in Java
- Valid and invalid identifiers
- Usage of Java operators
- Modification of default operator precedence via parentheses

2.1 **Primitive variables**



[2.1] Declare and initialize variables



[2.2] Differentiate between object reference variables and primitive variables

In this section, you'll learn all the primitive data types in Java, their literal values, and the process of creating and initializing primitive variables. A variable defined as one of the primitive data types is a *primitive variable*.

Primitive data types, as the name suggests, are the simplest data types in a programming language. In the Java language, they're predefined. The names of the primitive types are quite descriptive of the values that they can store. Java defines the following eight primitive data types:

- char
- byte
- short
- int
- long
- float
- double
- boolean

Examine figure 2.1 and try to match the given value with the corresponding type.

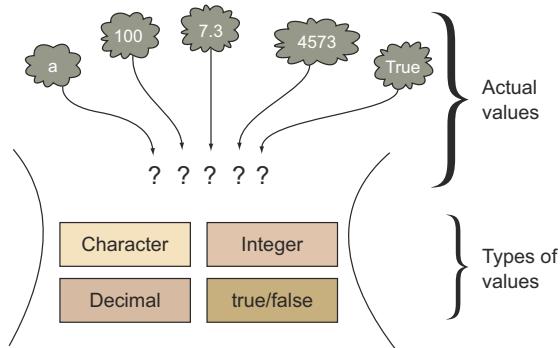


Figure 2.1 Matching a value with its corresponding type

This should be a simple exercise. Table 2.1 provides the answers.

Table 2.1 Matching a value with its corresponding data type

Character values	Integer values	Decimal values	true/false
a	100 4573	7.3	true

In the preceding exercise, I categorized the data that you need to store as follows: character, integer, decimal, and true/false values. This categorization will make your life simpler when confronted with selecting the most appropriate primitive data type to store a value. For example, to store an integer value, you need a primitive data type that is capable of storing integer values; to store decimal numbers, you need a primitive data type that can store decimal numbers. Simple, isn't it?

Let's map the types of data that the primitive data types can store, because it's always easy to group and remember information. The primitive data types can be categorized as follows: Boolean, character, and numeric (further categorized as integral and floating-point) types. Take a look at this categorization in figure 2.2.

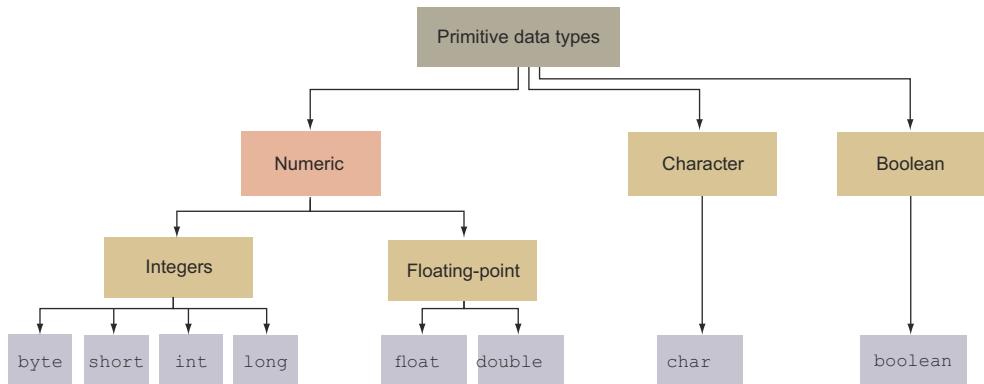


Figure 2.2 Categorization of primitive data types

This categorization in figure 2.2 will help you further associate each data type with the value that it can store. Let's start with the Boolean category.

2.1.1 Category: Boolean

The Boolean category has only one data type: `boolean`. A boolean variable can store one of two values: `true` or `false`. It is used in scenarios where only two states can exist. See table 2.2 for a list of questions and their probable answers.

Table 2.2 Suitable data that can be stored using a boolean data type

Question	Probable answers
Did you purchase the exam voucher?	Yes/No
Did you log in to your email account?	Yes/No
Did you tweet about your passion today?	Yes/No
Tax collected in financial year 2001–2002	Good question! But it can't be answered as yes/no.



EXAM TIP In this exam, the questions test your ability to select the best suitable data type for a condition that can only have two states: yes/no or true/false. The correct answer here is the `boolean` type.

Here's some code that defines `boolean` primitive variables:

```
boolean voucherPurchased = true;
boolean examPrepStarted = false;
boolean result = false;
boolean longDrive = true;
```

In some languages—such as JavaScript—you don't need to define the type of a variable before you use it. In JavaScript, the compiler defines the type of the variable according to the value that you assign to it. Java, in contrast, is a strongly typed language. You must declare a variable and define its type before you can assign a value to it. Figure 2.3 illustrates defining a `boolean` variable and assigning a value to it.

Another point to note here is the value that's assigned to a `boolean` variable. I used the literals `true` and `false` to initialize the `boolean` variables. A *literal* is a fixed value that doesn't need further calculations in order for it to be assigned to any variable. `true` and `false` are the only two `boolean` literals.

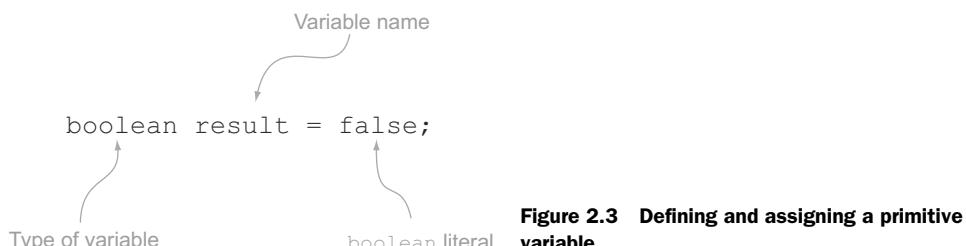


Figure 2.3 Defining and assigning a primitive variable



NOTE There are only two boolean literal values: true and false.

2.1.2 Category: Numeric

The numeric category defines two subcategories: integers and floating point (also called decimals). Let's start with the integers.

INTEGERS: BYTE, INT, SHORT, LONG

When you can count a value in whole numbers, the result is an integer. It includes both negative and positive numbers. Table 2.3 lists probable scenarios in which the data can be stored as integers.

Table 2.3 Data that can be categorized as numeric (nondecimal numbers) data type

Situation	Can be stored as integers?
Number of friends on Facebook	Yes
Number of tweets posted today	Yes
Number of photographs uploaded for printing	Yes
Your body temperature	Not always

You can use the byte, short, int, and long data types to store integer values. Wait a minute: why do you need so many types to store integers?

Each one of these can store a different range of values. The benefits of the smaller ones are obvious: they need less space in memory and are faster to work with. Table 2.4 lists all these data types, along with their sizes and the ranges of the values that they can store.

Table 2.4 Ranges of values stored by the numeric Java primitive data types

Data type	Size	Range of values
byte	8 bits	-128 to 127, inclusive
short	16 bits	-32,768 to 32,767, inclusive
int	32 bits	-2,147,483,648 to 2,147,483,647, inclusive
long	64 bits	-9,223,372,036,854,775,808 to 9,223,372,036,854,775,807, inclusive

The OCA Java SE 7 Programmer I exam may ask you questions about the range of integers that can be assigned to a byte data type, but it won't include questions on the ranges of integer values that can be stored by short, int, or long data types. Don't worry—you don't have to memorize the ranges for all these data types!

Here's some code that assigns literal values to primitive numeric variables within their acceptable ranges:

```
byte num = 100;
short sum = 1240;
int total = 48764;
long population = 214748368;
```

The default type of a nondecimal number is `int`. To designate an integer literal value as a `long` value, add the suffix `L` or `l` (`L` in lowercase), as follows:

```
long fishInSea = 764398609800L;
```

Integer literal values come in four flavors: binary, decimal, octal, and hexadecimal.

- *Binary number system*—A base-2 system, which uses only 2 digits, 0 and 1.
- *Octal number system*—A base-8 system, which uses digits 0 through 7 (a total of 8 digits). Here the decimal number 8 is represented as octal 10, decimal 9 as 11, and so on.
- *Decimal number system*—The base-10 number system that you use every day. It's based on 10 digits, from 0 through 9 (a total of 10 digits).
- *Hexadecimal number system*—A base-16 system, which uses digits 0 through 9 and the letters A through F (a total of 16 digits and letters). Here the number 10 is represented as A, 11 as B, 12 as C, 13 as D, 14 as E, and 15 as F.

Let's take quick look at how you can convert integers in the decimal number system to the other number systems. Figures 2.4, 2.5, and 2.6 show how to convert the decimal number 267 to the octal, hexadecimal, and binary number systems.

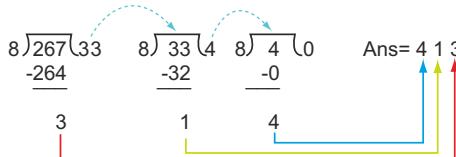


Figure 2.4 Converting an integer from decimal to octal

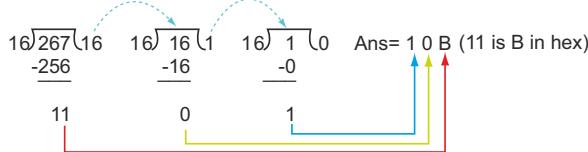


Figure 2.5 Converting an integer from decimal to hexadecimal

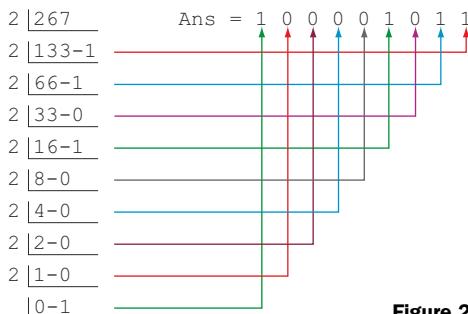


Figure 2.6 Converting an integer from decimal to binary



EXAM TIP In the OCA Java SE 7 Programmer I exam, you will not be asked to convert a number from the decimal number system to the octal and hexadecimal number systems and vice versa. But you can expect questions that ask you to select valid literals for integers. The previous figures will help you understand these number systems better and retain this information longer, which will in turn enable you to answer questions correctly during the exam.

You can assign integer literals in base decimal, binary, octal, and hexadecimal. For octal literals, use the prefix 0; for binary, use the prefix 0B or 0b; and for hexadecimal, use the prefix 0x or 0X. Here's an example of each of these:

267 in decimal number system	<pre>int baseDecimal = 267; int octVal = 0413; int hexVal = 0x10B; int binVal = 0b100001011;</pre>	267 in decimal number system is equal to 413 in octal number system	267 in decimal number system is equal to 10B in hexadecimal number system
		276 in decimal number system is equal to 100001011 in binary number system	

With Java version 7, you can also use underscores as part of the literal values, which helps group the individual digits or letters of the literal values and is much more readable. The underscores have no effect on the values. The following is valid code:

<pre>long baseDecimal = 100_267_760; long octVal = 04_13; long hexVal = 0x10_BA_75; long binVal = 0b1_0000_10_11;</pre>	More readable literal values in binary, decimal, octal, and hexadecimal that use underscores to group digits and letters
---	---

RULES TO REMEMBER

Pay attention to the use of underscores in the numeric literal values. Here are some of the rules:

- You can't start or end a literal value with an underscore.
- You can't place an underscore right after the prefixes 0b, 0B, 0x, and 0X, which are used to define binary and hexadecimal literal values.
- You can place an underscore right after the prefix 0, which is used to define an octal literal value.
- You can't place an underscore prior to an L suffix (the L suffix is used to mark a literal value as long).
- You can't use an underscore in positions where a string of digits is expected.

Because you are likely to be questioned on valid and invalid uses of underscores in literal values on the exam, let's look at some examples:

<pre>int intLiteral = _100; int intLiteral2 = 100_999_; long longLiteral = 100_L;</pre>	Can't start or end a literal value with an underscore	Can't place an underscore prior to suffix L
---	--	--

The following line of code will compile successfully but will fail at runtime:

```
int i = Integer.parseInt("45_98");
```

 **Invalid use of underscore where
a string of digits is expected**

Because a `String` value can accept underscores, the compiler will compile the previous code. But the runtime will throw an exception stating that an invalid format of value was passed to the method `parseInt`.

Here's the first Twist in the Tale exercise of this chapter for you to attempt. It uses multiple combinations of underscores in numeric literal values. See if you can get all of them right (answers in the appendix).

Twist in the Tale 2.1

Let's use the primitive variables `baseDecimal`, `octVal`, `hexVal`, and `binVal` defined earlier in this section and introduce additional code for printing the values of all these variables. Determine the output of the following code:

```
class TwistInTaleNumberSystems {
    public static void main (String args[]) {
        int baseDecimal = 267;
        int octVal = 0413;
        int hexVal = 0x10B;
        int binVal = 0b100001011;
        System.out.println (baseDecimal + octVal);
        System.out.println (hexVal + binVal);
    }
}
```

Here's another quick exercise—let's define and initialize some `long` primitive variables that use underscores in the literal values assigned to them. Determine which of these does this job correctly:

```
long var1 = 0_100_267_760;
long var2 = 0_x_4_13;
long var3 = 0b_x10_BA_75;
long var4 = 0b_10000_10_11;
long var5 = 0xa10_AG_75;
long var6 = 0x1_0000_10;
long var7 = 100__12_12;
```

FLOATING-POINT NUMBERS: FLOAT AND DOUBLE

You need floating-point numbers where you expect decimal numbers. For example, can you define the probability of an event occurring as an integer? Table 2.5 lists probable scenarios in which the corresponding data is stored as a floating-point number.

In Java, you can use the `float` and `double` primitive data types to store decimal numbers. `float` requires less space than `double`, but it can store a smaller range of values than `double`. A `float` data type also has less precision, so even some of the numbers that are in the range of a `float` still can't be accurately represented when using `double`. Table 2.6 lists the sizes and ranges of values for `float` and `double`.

Table 2.5 Data that is stored as floating-point numbers

Situation	Is the answer a floating-point number?
Orbital mechanics of a spacecraft	Yes (very precise values are required)
Probability of your friend request being accepted	Yes; probability is between 0.0 (none) to 1.0 (sure)
Speed of Earth revolving around the Sun	Yes
Magnitude of an earthquake on the Richter scale	Yes

Table 2.6 Range of values for decimal numbers

Data type	Size	Range of values
float	32 bits	+/-1.4E-45 to +/-3.4028235E+38, +/-infinity, +/-0, NaN
double	64 bits	+/-4.9E-324 to +/-1.7976931348623157E+308, +/-infinity, +/-0, NaN

Here's some code in action:

```
float average = 20.129F;
float orbit = 1765.65f;
double inclination = 120.1762;
```

Did you notice the use of the suffixes F and f while initializing the variables average and orbit in the preceding code? The default type of a decimal literal is double, but by suffixing a decimal literal value with F or f, you tell the compiler that the literal value should be treated like a float and not a double.

You can also assign a literal decimal value in scientific notation as follows:

```
double inclination2 = 1.201762e2;                            | I20.1762 is same as 1.201762e2 (the latter  
                                                                        is expressed in scientific notation)
```

You can also add the suffix D or d to a decimal number value to specify that it is a double value. But because the default type of a decimal number is double, the use of the suffix D or d is redundant. Examine the following line of code:

```
double inclination = 120.1762D;                            | I20.1762D is same as I20.1762
```

Starting with Java version 7, you can also use underscores with the floating-point literal values. The rules are generally the same as previously mentioned for numeric literal values; the following rules are specific to floating-point literals:

- You can't place an underscore prior to a D, d, F, or f suffix (these suffixes are used to mark a floating-point literal as double or float).
- You can't place an underscore adjacent to a decimal point.

Let's look at some examples that demonstrate the invalid use of underscores in floating-point literal values:

```
float floatLiteral = 100._48F;
double doubleLiteral = 100_.87;

float floatLiteral2 = 100.48_F;
double doubleLiteral2 = 100.87_d;
```

Can't use underscore adjacent to a decimal point

Can't use underscore prior to suffix F, f, D, or d

2.1.3 Category: Character

The character category defines only one data type: `char`. A `char` can store a single 16-bit Unicode character; that is, it can store characters from virtually all the existing scripts and languages, including Japanese, Korean, Chinese, Devanagari, French, German, Spanish, and others. Because your keyboard may not have keys to represent all these characters, you can use a value from `\u0000` (or 0) to a maximum value of `\uffff` (or 65,535) inclusive. The following code shows the assignment of a value to a `char` variable:

```
char c1 = 'D';
```

Use single quotes to assign a char, not double quotes

A very common mistake is using double quotes to assign a value to a `char`. The correct option is single quotes. Figure 2.7 shows a conversation between two (hypothetical) programmers, Paul and Harry.

What happens if you try to assign a `char` using double quotes? The code will fail to compile, with this message:

```
Type mismatch: cannot convert from String to char
```



EXAM TIP Never use double quotes to assign a letter to a `char` variable. Double quotes are used to assign a value to a variable of type `String`.

Internally, Java stores `char` data as an unsigned integer value (positive integer). It's therefore perfectly acceptable to assign a positive integer value to a `char`, as follows:

```
char c1 = 122;
```

Assign z to c1

The integer value 122 is equivalent to the letter `z`, but the integer value 122 is not equal to the Unicode value `\u0122`. The former is a number in base 10 (uses digits 0–9) and the latter is a number in base 16 (uses digits 0–9 and letters a–f). `\u` is used to mark



Figure 2.7 Never use double quotes to assign a letter as a `char` value.

the value as a Unicode value. You must use quotes to assign Unicode values to char variables. Here's an example:

```
char c2 = '\u0122';
System.out.println("c1 = " + c1);
System.out.println("c2 = " + c2);
```

Figure 2.8 shows the output of the preceding code on a system that supports Unicode characters.

c1 = z **Figure 2.8 The output of assigning a character using the integer value 122 versus the Unicode value \u0122**

As mentioned earlier, char values are unsigned integer values, so if you try to assign a negative number to one, the code will not compile. Here's an example:

```
char c3 = -122;                      ← Fails to compile
```

But you can forcefully assign a negative number to a char by casting it to char, as follows:

```
char c3 = (char)-122;                      ← Compiles successfully
System.out.println("c3 = " + c3);
```

In the previous code, note how the literal value `-122` is prefixed by `(char)`. This practice is called *casting*. Casting is the forceful conversion of one data type to another data type.

You can cast only compatible data types. For example, you can cast a char to an int and vice versa. But you can't cast an int to a boolean value or vice versa. When you cast a bigger value to a data type that has a smaller range, you tell the compiler that you know what you're doing, so the compiler proceeds by chopping off any extra bits that may not fit into the smaller variable. Use casting with caution—it may not always give you the correct converted values.

Figure 2.9 shows the output of the preceding code that cast a value to `c3` (the value looks weird!).

c3 = _ **Figure 2.9 The output of assigning a negative value to a character variable**

The char data type in Java doesn't allocate space to store the sign of an integer. If you try to forcefully assign a negative integer to char, the sign bit is stored as the part of the integer value, which results in the storage of unexpected values.



EXAM TIP The exam will test your understanding of the possible values that can be assigned to a variable of type char, including whether an assignment will result in a compilation error. Don't worry—it won't test you on the value that is actually displayed after assigning arbitrary integer values to a char!

2.1.4 Confusion with the names of the primitive data types

If you've previously worked in another programming language, there's a good chance that you might get confused with the names of the primitive data types in Java and other languages. For example, C defines a primitive short int data type. But

short and int are two separate primitive data types in Java. The OCA Java SE 7 Programmer I exam will test you on your ability to recognize the names of the primitive data types, and the answers to these questions may not be immediately obvious. An example follows:

Question: What is the output of the following code?

```
public class MyChar {  
    public static void main(String[] args) {  
        int myInt = 7;  
        bool result = true;  
        if (result == true)  
            do  
                System.out.println(myInt);  
            while (myInt > 10);  
    }  
}
```

- a It prints 7 once.
- b It prints nothing.
- c Compilation error.
- d Runtime error.

The correct answer is (c). This question tries to trick you with complex code that doesn't use any `if` constructs or `do-while` loops! As you can see, it uses an incorrect data type name, `bool`, to declare and initialize the variable `result`. Therefore, the code will fail to compile.



EXAM TIP Watch out for questions that use incorrect names for the primitive data types. For example, there isn't any `bool` primitive data type in Java. The correct data type is `boolean`. If you've worked with other programming languages, you might get confused trying to remember the exact names of all the primitive data types used in Java. Remember that just two of the primitive data types—`int` and `char`—are shortened; the rest of the primitive data types (`byte`, `short`, `long`, `float`, and `double`) are not.

2.2 Identifiers

Identifiers are names of packages, classes, interfaces, methods, and variables. Though identifying a valid identifier is not explicitly included in the OCA Java SE 7 Programmer I exam objectives, there's a good chance that you'll encounter a question similar to the following that will require you to identify valid and invalid identifiers:

Question: Which of the following lines of code will compile successfully?

- a `byte exam_total = 7;`
- b `int exam-Total = 1090;`

The correct answer is (a). Option (b) is incorrect because hyphens aren't allowed in the name of a Java identifier. Underscores are allowed. If you've worked with another programming language, this may be different from what you're used to.

2.2.1 Valid and invalid identifiers

Table 2.7 contains a list of rules that will enable you to correctly define valid (and invalid) identifiers, along with some examples.

Table 2.7 Ingredients of valid and invalid identifiers

Properties of valid Identifiers	Properties of invalid identifiers
Unlimited length Starts with a letter (a–z, upper- or lowercase), a currency sign, or an underscore Can use a digit (not at the starting position) Can use an underscore (in any position) Can use a currency sign (in any position): \$, £, ¢, ¥ and others	Same spelling as a Java reserved word or keyword (see table 2.8) Uses special characters: !, @, #, %, ^, &, *, (,), ', :, ;, [, /, \, } Starts with a Java digit (0–9)
Examples of valid identifiers	Examples of invalid identifiers
customerValueObject \$rate, £Value, _sine happy2Help, nullValue Constant	7world (identifier can't start with a digit) %value (identifier can't use special char %) Digital!, books@manning (identifier can't use special char ! or @) null, true, false, goto (identifier can't have the same name as a Java keyword or reserved word)

You can't define a variable with the same name as Java keywords or reserved words. As these names suggest, they're reserved for specific purposes. Table 2.8 lists Java keywords, reserved words, and literals that you can't use as an identifier name.

Table 2.8 Java keywords and reserved words that can't be used as names for Java variables

abstract	default	goto	package	this
assert	do	if	private	throw
boolean	double	implements	protected	throws
break	else	import	public	transient
byte	enum	instanceof	return	true
case	extends	int	short	try
catch	false	interface	static	void
char	final	long	strictfp	volatile
class	finally	native	super	while
const	float	new	switch	
continue	for	null	synchronized	

Let's combat some of the common mistakes when determining correct and incorrect variables using the following variable declarations:

```
int falsetrue;           ← Valid: combination of two or more keywords
int javaseminar, javaSeminar; ← Valid (but using both these together can be very confusing)
int DATA-COUNT;          ← Invalid: hyphen isn't allowed
int DATA_COUNT;           ← Valid: underscore is allowed
int car.count;            ← Invalid: a dot in a variable name is not allowed
int %ctr;                 ← Invalid: % sign isn't allowed
int ¥tofAnd$¢;            ← Valid (though strange)
```

Next, let's look at the object reference variables and how they differ from the primitive variables.

2.3 Object reference variables



[2.1] Declare and initialize variables



[2.2] Differentiate between object reference variables and primitive variables

The variables in Java can be categorized into two types: *primitive variables* and *reference variables*. In this section, along with a quick introduction to reference variables, we'll cover the basic differences between reference variables and primitive variables.

Reference variables are also known as *object reference variables* or *object references*. I use all of these terms interchangeably in this text.

2.3.1 What are object reference variables?

Objects are instances of classes, including both predefined and user-defined classes. For a reference type in Java, the variable name evaluates to the address of the location in memory where the object referenced by the variable is stored. An object reference is, in fact, a memory address that points to a memory area where an object's data is located.

Let's quickly define a barebones class, Person, as follows:

```
class Person {}
```

When an object is instantiated with the new operator, a heap-memory address value to that object is returned. That address is usually assigned to the reference variable. Figure 2.10 shows a line of code that creates a reference variable person of type Person and assigns an object to it.

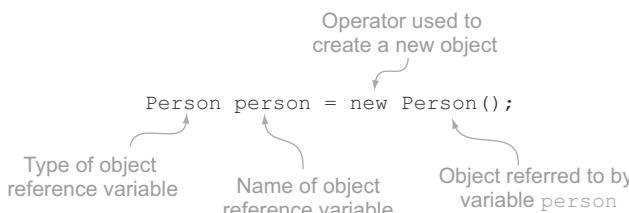


Figure 2.10 The creation and assignment of a reference variable

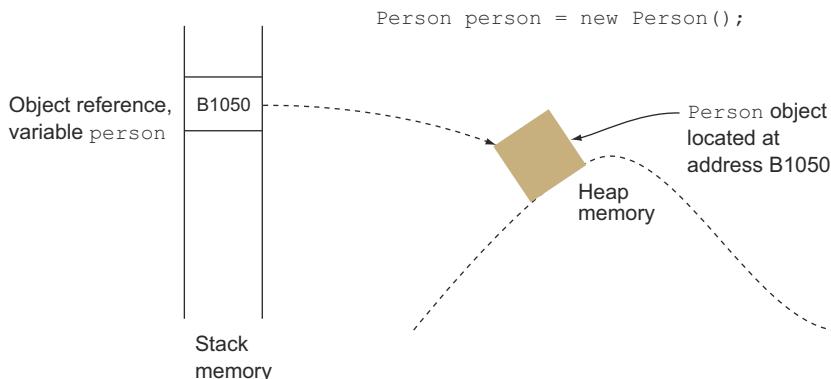


Figure 2.11 An object reference variable and the referenced object in memory

When the statement shown in figure 2.10 executes, three things happen:

- A new Person object is created.
- A variable named person is created in the stack with an empty (null) value.
- The variable person is assigned the memory address value where the object is located.

Figure 2.11 contains a pictorial representation of a reference variable and the object it refers to in memory.

You can think of an object reference variable as a *handle* to an object that allows you access to that object's attributes. The following analogy will help you understand object reference variables, the objects that they refer to, and their relationship. Think of objects as analogous to *dogs*, and think of object references as analogous to *leashes*. Although this analogy does not bear too much analysis, the following comparisons are valid:

- A leash not attached to a dog is a reference object variable with a null value.
- A dog without a leash is a Java object that's not referred to by any object reference variable.
- Just as an unleashed dog might be picked up by animal control, an object that is not referred to by a reference variable is liable to be garbage collected (removed from memory by the JVM).
- Several leashes may be tethered to a single dog. Similarly, several Java objects may be referenced by multiple object reference variables.

Figure 2.12 illustrates this analogy.

The literal value of all types of object reference variables is null. You can also assign a null value to a reference variable explicitly. Here's an example:

```
Person person = null;
```

In this case, the reference variable person can be compared to a leash without a dog.



NOTE The literal value for all types of object reference variables is null.

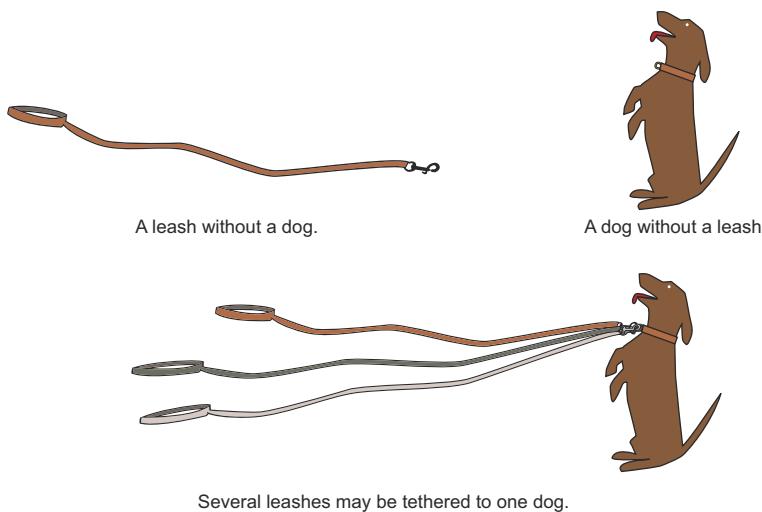


Figure 2.12 Dog leash analogy for understanding objects

2.3.2 Differentiating between object reference variables and primitive variables

Just as men and women are fundamentally different (according to John Gray, author of *Men Are from Mars, Women Are from Venus*), primitive variables and object reference variables differ from each other in multiple ways. The basic difference is that primitive variables store the actual values, whereas reference variables store the addresses of the objects they refer to.

Let's assume that a class `Person` is already defined. If you create an `int` variable `a`, and an object reference variable `person`, they will store their values in memory as shown in figure 2.13.

```
int a = 77;
Person person = new Person();
```

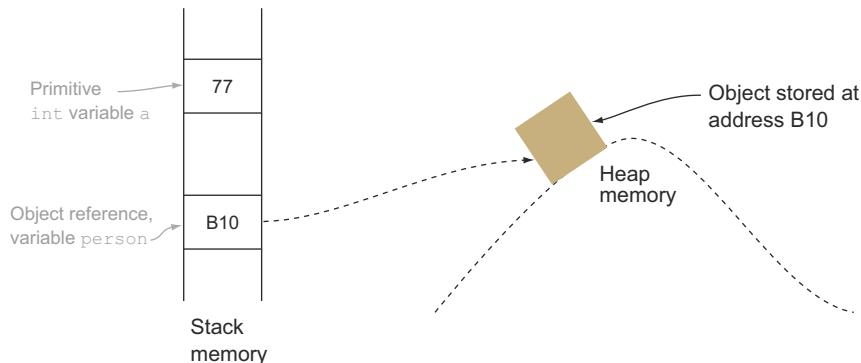


Figure 2.13 Primitive variables store the actual values, whereas object reference variables store the addresses of the objects they refer to.

Other important differences between primitive variables and object reference variables are shown in figure 2.14 as a conversation between a girl and a boy. The girl represents an object reference variable and the boy represents a primitive variable. (Don't worry if you don't understand all of these analogies. They'll make much more sense after you read related topics in later chapters.)

In the next section, you'll start manipulating these variables using operators.

2.4 Operators



In this section, you'll use different types of operators—assignment, arithmetic, relational, and logical—to manipulate the values of variables. You'll also write code to

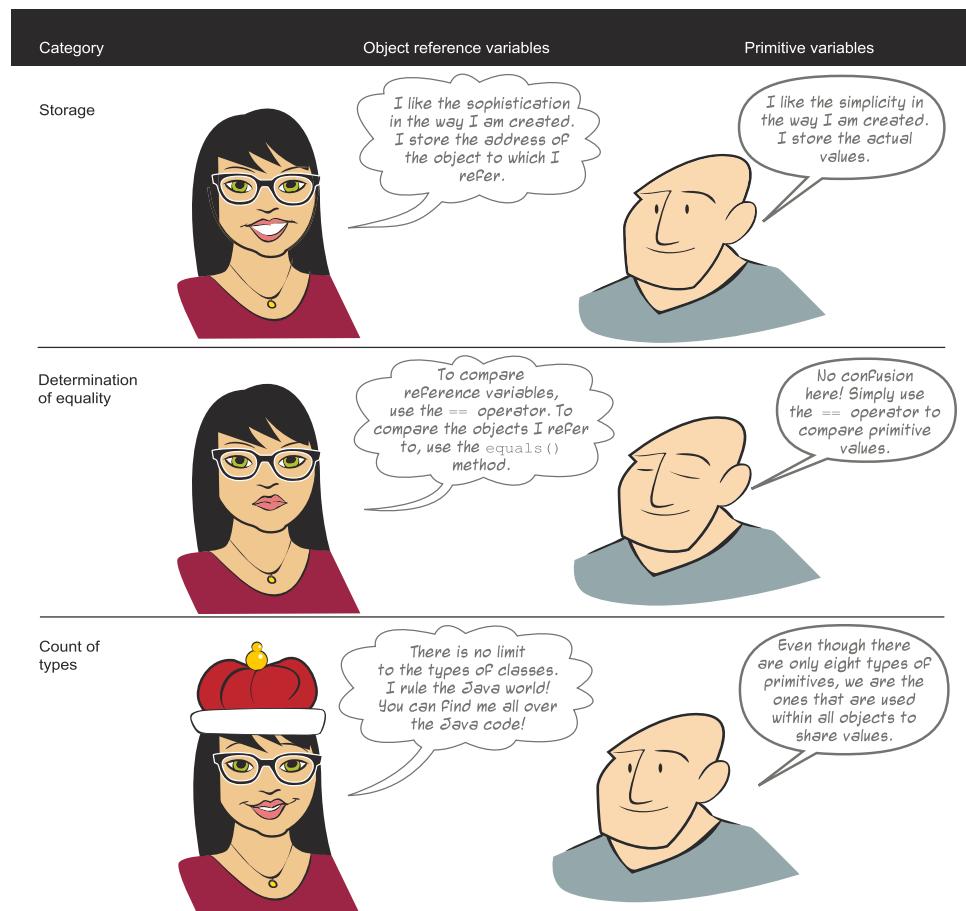


Figure 2.14 Differences between object reference variables and primitive variables

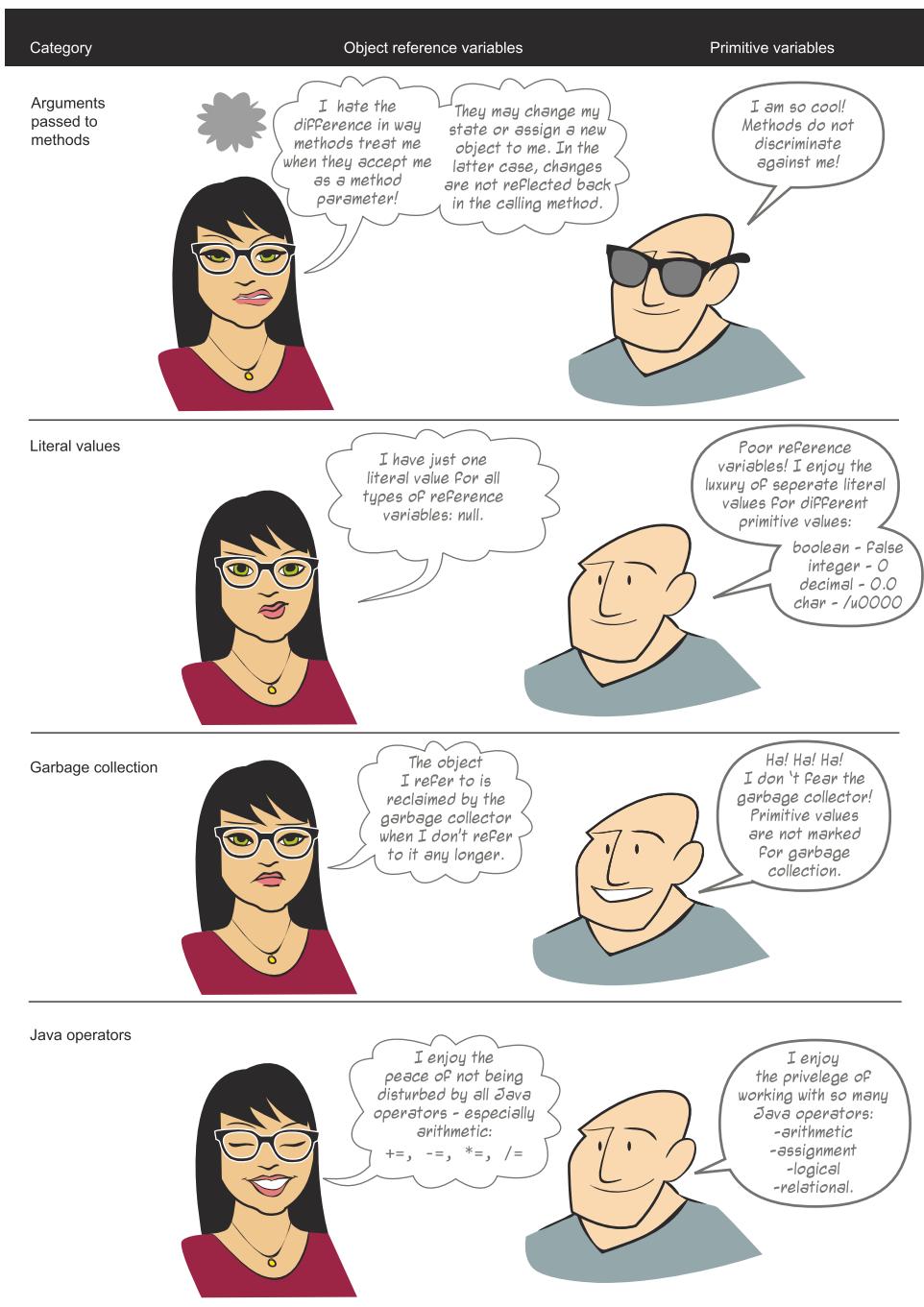


Figure 2.14 Differences between object reference variables and primitive variables (continued)

determine the equality of two primitive data types. You'll also learn how to modify the default precedence of an operator by using parentheses. For the OCA Java SE 7 Programmer I exam, you should be able to work with the operators listed in table 2.9.

Table 2.9 Operator types and the relevant operators

Operator type	Operators	Purpose
Assignment	=, +=, -=, *=, /=	Assign value to a variable
Arithmetic	+, -, *, /, %, ++, --	Add, subtract, multiply, divide, and modulus primitives
Relational	<, <=, >, >=, ==, !=	Compare primitives
Logical	!, &&,	Apply NOT, AND, and OR logic to primitives



NOTE Not all operators can be used with all types of operands. For example, you can determine whether a number is greater than another number, but you can't determine whether `true` is greater than `false` or a number is greater than `true`. Take note of this as you learn the usage of all the operators on the OCA Java SE 7 Programmer I exam.

2.4.1 Assignment operators

The assignment operators that you need to know for the exam are `=`, `+=`, `-=`, `*=`, and `/=`.

The simple assignment operator, `=`, is the most frequently used operator. It's used to initialize variables with values and to reassign new values to them.

The `+=`, `-=`, `*=`, and `/=` operators are short forms of addition, subtraction, multiplication and division with assignment. The `+=` operator can be read as “first add and then assign,” and `-=` can be read as “first subtract and then assign.” Similarly, `*=` can be read as “first multiply and then assign” and `/=` can be read as “first divide and then assign.” If you apply these operators to two operands, `a` and `b`, they can be represented as follows:

```
a -= b is equal to a = a - b
a += b is equal to a = a + b
a *= b is equal to a = a * b
a /= b is equal to a = a / b
```

Let's have a look at some valid lines of code:

OK to assign variables of same type

```
double myDouble2 = 10.2;
int a = 10;
int b = a;
float float1 = 10.2F;
float float2 = float1;
```

OK to assign literal 10.2 to variable of type double

OK to assign literal 10 to variable of type int

OK to assign literal 10.2F to variable of type float

OK to assign variables of same type

Reassign a value of 10 to both variables a and b

```
b += a;
a = b = 10;
b -= a;
a = b = 10;
b *= a;
a = b = 10;
b /= a;
```

OK; b is assigned a value of 20. b = 10 + 10.

OK; b is assigned a value of 10. b = 20 - 10.

b is assigned a value of 100. b = 10 * 10.

b is assigned a value of 1. b = 10 / 10.

Let's have a look at some invalid lines of code:

```
double myDouble2 = true;
boolean b = 'c';
boolean b1 = 0;
boolean b2 -= b1;
```

Ouch! You can't add or subtract boolean values

Ouch! boolean can't be assigned to double

Ouch! char can't be assigned to boolean

Ouch! boolean can't be assigned a literal value other than true or false

Now let's try to squeeze the variables that can store a larger range of values into variables with a shorter range. Try the following assignments:

```
long num = 100976543356L;
int val = num;
```

Compiler won't allow this

It's similar to what is shown in figure 2.15, where someone is forcefully trying to squeeze a bigger value (long) into a smaller container (int).

You can still assign a bigger value to a variable that can only store smaller ranges by explicitly casting the bigger value to a smaller value. By doing so, you tell the compiler that you know what you're doing. In that case, the compiler proceeds by chopping off any extra bits that may not fit into the smaller variable. Beware! This approach may not always give you the correct converted values.

Compare the previous assignment example (assigning a long to an int) with the following example that assigns a smaller value (int) to a variable (long) that is capable of storing bigger value ranges:

```
int intValue = 1009;
long longVal = intValue;
```

Allowed

An int can easily fit into a long because there's enough room for it (as shown in figure 2.16).



EXAM TIP You can't use the assignment operators to assign a boolean value to variables of type char, byte, int, short, long, float, or double, or vice versa.

You can also assign multiple values on the same line using the assignment operator. Examine the following lines of code:

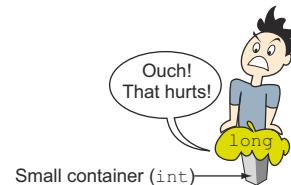


Figure 2.15 Assigning a bigger value (long) to a variable (int) that is only capable of storing smaller value range



Figure 2.16 Assigning a smaller value (int) to a variable (long) that is capable of storing a larger value range

Define and initialize variables on the same line

```
→ int a = 7, b = 10, c = 8;
a = b = c;
System.out.println(a);
```

Prints 8

Assignment starts from right; the value of c is assigned to b and the value of b is assigned to a

On line ①, the assignment starts from right to left. The value of variable c is assigned to the variable b, and the value of variable b (which is already equal to c) is assigned to the variable a. This is proved by the fact that line 3 prints 8, and not 7!

The next Twist in the Tale throws in a few twists with variable assignment and initialization. Let's see if you can identify the incorrect ones (answers in the appendix).

Twist in the Tale 2.2

Let's modify the assignment and initialization of the boolean variables used in previous sections. Examine the following code initializations and select the incorrect answers:

```
public class Foo {
    public static void main (String args[]) {
        boolean b1, b2, b3, b4, b5, b6;      // line 1
        b1 = b2 = b3 = true;                // line 2
        b4 = 0;                            // line 3
        b5 = 'false';                      // line 4
        b6 = yes;                          // line 5
    }
}
```

- a The code on line 1 will fail to compile.
- b Can't initialize multiple variables like the code on line 2.
- c The code on line 3 is correct.
- d Can't assign 'false' to a boolean variable.
- e The code on line 5 is correct.

2.4.2 Arithmetic operators

Let's take a quick look at each of these operators, together with a simple example, in table 2.10.

Table 2.10 Use of arithmetic operators with examples

Operator	Purpose	Usage	Answer
+	Addition	12 + 10	22
-	Subtraction	19 - 29	-10
*	Multiplication	101 * 45	4545
/	Division (quotient)	10 / 6 10.0 / 6.0	1 1.6666666666666667

Table 2.10 Use of arithmetic operators with examples (continued)

Operator	Purpose	Usage	Answer
%	Modulus (remainder in division)	10 % 6 10.0 % 6.0	4 4.0
++	Unary increment operator; increments value by 1	++10	11
--	Unary decrement operator; decrements value by 1	--10	9

++ AND -- (UNARY INCREMENT AND DECREMENT OPERATORS)

The operators ++ and -- are unary operators; they work with a single operand. They're used to increment or decrement the value of a variable by 1.

Unary operators can also be used in prefix and postfix notation. In *prefix notation*, the operator appears before its operand:

```
int a = 10;
++a;
```

Operator ++ in
prefix notation

In *postfix notation*, the operator appears after its operand:

```
int a = 10;
a++;
```

Operator ++ in
postfix notation

When these operators are not part of an expression, the postfix and prefix notations behave in exactly the same manner:

```
int a = 20;
int b = 10;
++a;
b++;
System.out.println(a);
System.out.println(b);
```

Assign 20 to a
Assign 10 to b
Prints 21
Prints 11

When a unary operator is used in an expression, its placement with respect to its operand decides whether its value will increment or decrement before the evaluation of the expression or after the evaluation of the expression. See the following code, where the operator ++ is used in prefix notation:

```
int a = 20;
int b = 10;
int c = a - ++b;
System.out.println(c);
System.out.println(b);
```

Assign 20 to a
Assign 10 to b
Assign 20 - (++b),
that is, 20 - 11, or 9, to c
Prints 9
Prints 11

In the preceding example, the expression `a - ++b` uses the increment operator (++) in prefix notation. Therefore, the value of variable `b` increments to 11 before it is subtracted from 20, assigning the result 9 to variable `c`.

When `++` is used in postfix notation with an operand, its value increments after it has been used in the expression:

```
int a = 20;           ← Assign 20 to a
int b = 10;           ← Assign 10 to b
int c = a - b++;     ← Assign 20 - (10++) , that
                     is, 20-10, or 10, to c
System.out.println(c);
System.out.println(b); ← Prints 11
```

The interesting part here is that the value of `b` is printed as 11 in both cases because the value of the variable increments (or decrements) as soon as the expression in which it's used is evaluated.

The same logic applies to the unary operator, `--`. Here's an example:

```
double d = 20.0;      ← Assign 20.0 to d
double e = 10.0;       ← Assign 10.0 to e
double f = d * --e;    ← Assign 20.0 * (--10.0), that is,
                      20.0 * 9.0, or 180.0, to c
System.out.println(f); ← Prints 180.0
System.out.println(e); ← Prints 9.0
```

Let's use the unary decrement operator (`--`) in postfix notation and see what happens:

```
double d = 20.0;      ← Assign 20.0 to d
double e = 10.0;       ← Assign 10.0 to e
double f = d * e--;    ← Assign 20.0 * (10.0--), that is,
                      20.0 * 10.0, or 200.0, to c
System.out.println(f); ← Prints 200.0
System.out.println(e); ← Prints 9.0
```

Let's check out some example code that uses unary increment and decrement operators in both prefix and postfix notation in the same line of code. What do you think the output of the following code will be?

```
int a = 10;
a = a++ + a + a-- - a-- + ++a;
System.out.println(a);
```

The output of this code is 32. The expression on the right-hand side evaluates from left to right, with the following values, which evaluate to 32:

```
a = 10 + 11 + 11 - 10 + 10;
```

The evaluation of an expression starts from left to right. For a prefix unary operator, the value of its operand increments or decrements just before its value is used in an expression. For a postfix unary operator, the value of its operand increments or decrements just after its value is used in an expression. Figure 2.17 illustrates what is happening in the preceding expression.

For the exam, it's important for you to have a good understanding of, and practice in, using postfix and prefix operators. In addition to the expressions shown in the previous examples, you can also find them in use as conditions in `if` statements, for loops, and `do-while` and `while` loops.

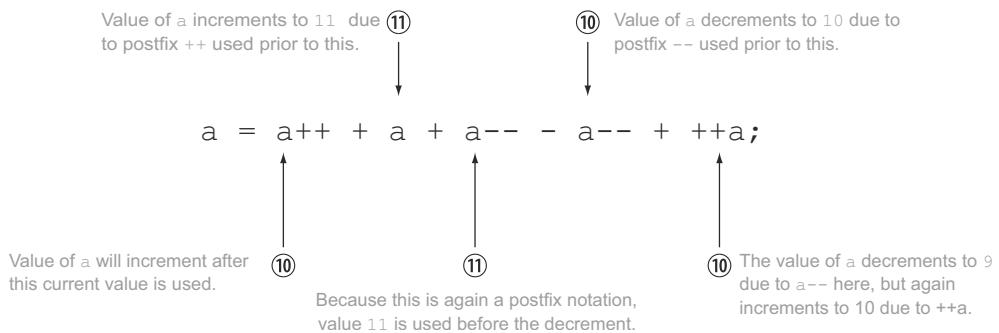


Figure 2.17 Evaluation of an expression that has multiple occurrences of unary operators in postfix and prefix notation

The next Twist in the Tale exercise will give you practice with unary operators used in prefix and postfix notation (answer in the appendix).

Twist in the Tale 2.3

Let's modify the expression used in figure 2.17 by replacing all occurrences of unary operators in prefix notation with postfix notations, and vice versa. So, `++a` changes to `a++`, and vice versa. Similarly, `--a` changes to `a--`, and vice versa. Your task is to evaluate the modified expression and determine the output of the following code:

```
int a = 10;
a = ++a + a + --a - --a + a++;
System.out.println (a);
```

Try to form the expression by replacing the values of variable `a` in the expression and explain each of them, the way it was done for you in figure 2.17.

2.4.3 Relational operators

Relational operators are used to check one condition. You can use these operators to determine whether a primitive value is equal to another value or whether it is less than or greater than the other value.

These relational operators can be divided into two categories:

- Comparing greater (`>`, `>=`) and lesser values (`<`, `<=`)
- Comparing values for equality (`==`) and nonequality (`!=`)

The operators `<`, `<=`, `>`, and `>=` work with all types of numbers, both integers (including `char`) and floating point, that can be added and subtracted. Examine the following code:

```
int i1 = 10;
int i2 = 20;
System.out.println(i1 >= i2);
```

Prints false

```
long long1 = 10;
long long2 = 20;
System.out.println(long1 <= long2);    ↪ Prints true
```

The second category of operators is covered in the following section.



EXAM TIP You cannot compare incomparable values. For example, you cannot compare a boolean with an int, a char, or a floating-point number. If you try to do so, your code will not compile.

COMPARING PRIMITIVES FOR EQUALITY (USING == AND !=)

The operators `==` (equal to) and `!=` (not equal to) can be used to compare all types of primitives: char, byte, short, int, long, float, double, and boolean. The operator `==` returns the boolean value `true` if the primitive values that you're comparing are equal, and `false` otherwise. The operator `!=` returns `true` if the primitive values that you're comparing are *not* equal, and `false` otherwise. For the same set of values, if `==` returns `true`, `!=` will return `false`. Sounds interesting!

Examine the following code:

```
int a = 10;
int b = 20;
System.out.println(a == b);    ↪ Prints false
System.out.println(a != b);    ↪ Prints true

boolean b1 = false;
System.out.println(b1 == true);    ↪ Prints false
System.out.println(b1 != true);    ↪ Prints true
System.out.println(b1 == false);    ↪ Prints true
System.out.println(b1 != false);    ↪ Prints false
```

Remember that you can't apply these operators to incomparable types. In the following code snippet, the code that compares an int variable to a boolean variable will fail to compile:

```
int a = 10;
boolean b1 = false;
System.out.println(a == b1);    ↪ Causes compilation error
```

Here's the compilation error:

```
incomparable types: int and boolean
System.out.println(a == b1);
^
```



EXAM TIP The result of the relational operation is always a boolean value. You can't assign the result of a relational operation to a variable of type char, int, byte, short, long, float, or double.

COMPARING PRIMITIVES USING THE ASSIGNMENT OPERATOR (=)

It's a very common mistake to use the assignment operator, `=`, in place of the equality operator, `==`, to compare primitive values. Before reading any further, check out the following code:

```

int a = 10;
int b = 20;
System.out.println(a == b);           ① Prints 20 (this is not
                                     a boolean value!)

boolean b1 = false;
System.out.println(b1 == true);
System.out.println(b1 == false);      ② Prints true
                                     ← Prints false

```

- ① in the previous example isn't comparing the variables `a` and `b`. It's assigning the value of the variable `b` to `a` and then printing out the value of the variable `a`, which is 20. Similarly, ② isn't comparing the variable `b1` with the boolean literal `true`. It's assigning the boolean literal `true` to variable `b1` and printing out the value of the variable `b1`.



NOTE You can't compare primitive values by using the assignment operator, `=`.

2.4.4 Logical operators

Logical operators are used to evaluate one or more expressions. These expressions should return a boolean value. You can use the logical operators AND, OR, and NOT to check multiple conditions and proceed accordingly. Here are a few real-life examples:

- *Case 1 (for managers)*—Request promotion if customer is extremely happy with the delivered project AND you think you deserve to be in your boss's seat!
- *Case 2 (for students)*—Accept job proposal if handsome pay and perks OR awesome work profile.
- *Case 3 (for entry-level Java programmers)*—If NOT happy with current job, change it.

In each of these example cases, you're making a decision (request promotion, accept job proposal, or change job) only if a set of conditions is satisfied. In case 1, a manager may request a promotion only if *both* the specified conditions are met. In case 2, a student may accept a new job if *either* of the conditions is true. In case 3, an entry-level Java programmer may change his or her current job if *not* happy with the current job; that is, if the specified condition (being happy with the current job) is false.

As illustrated in these examples, if you wish to proceed with a task when *both* the conditions are true, use the logical AND operator, `&&`. If you wish to proceed with a task when *either* of the conditions is true, use the logical OR operator, `||`. If you wish to wish to reverse the outcome of a boolean value, use the negation operator, `!`.

Time to look at some code in action:

```

int a = 10;
int b = 20;
System.out.println(a > 20 && b > 10);    ① Prints false
System.out.println(a > 20 || b > 10);      ② Prints true
System.out.println(! (b > 10));            ③ Prints false
System.out.println(! (a > 20));            ④ Prints true

```

- ① prints false because both the conditions, `a > 20` and `b > 10`, are not true. The first one (`a > 20`) is false. ② prints true because one of these conditions (`b > 10`) is true.

❸ prints false because the specified condition, $b > 10$, is true. ❹ prints true because the specified condition, $a > 20$, is false.

Table 2.11 will help you understand the result of using all these logical operators.

Table 2.11 Outcome of using boolean literal values with the logical operators AND, OR, and NOT

Operators <code>&&</code> (AND)	Operator <code> </code> (OR)	Operator <code>!</code> (NOT)
<code>true && true</code> → true	<code>true true</code> → true	<code>!true</code> → false
<code>true && false</code> → false	<code>true false</code> → true	<code>!false</code> → true
<code>false && true</code> → false	<code>false true</code> → true	
<code>false && false</code> → false	<code>false false</code> → false	
<code>true && true && false</code> → false	<code>false false true</code> → true	

Here's a summary of this table:

- *Logical AND (`&&`)*—Evaluates to true if *all* operands are true; false otherwise.
- *Logical OR (`||`)*—Evaluates to true if *any* or all of the operands is true.
- *Logical negation (`!`)*—Negates the boolean value. Evaluates to true for false, and vice versa.

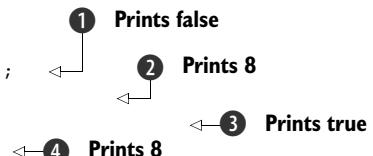
The operators `|` and `&` can also be used to manipulate individual bits of a number value, but I will not cover this usage here, because they are not on this exam.

&& AND `||` ARE SHORT-CIRCUIT OPERATORS

Another interesting point to note with respect to the logical operators `&&` and `||` is that they're also called *short-circuit* operators because of the way they evaluate their operands to determine the result. Let's start with the operator `&&`.

The `&&` operator returns true only if both the operands are true. If the first operand to this operator evaluates to false, the result can *never* be true. Therefore, `&&` does not evaluate the second operand. Similarly, the `||` operator does not evaluate the second operator if the first operand evaluates to true.

```
int marks = 8;
int total = 10;
System.out.println(total < marks && ++marks > 5);
System.out.println(marks);
System.out.println(total == 10 || ++marks > 10);
System.out.println(marks);
```



In the first print statement at ❶, because the first condition, `total < marks`, evaluates to false, the next condition, `++marks > 5`, is not even evaluated. As you can see ❷, the output value of `marks` is still 8 (the value to which it was initialized on line 1)! Similarly, in the next comparison ❸, because `total == 10` evaluates to true, the second condition, `++marks > 10`, isn't evaluated. Again, this can be verified when the value of `marks` is printed again ❹, and the output is 8.



NOTE All the relational and logical operators return a boolean value, which can be assigned to a primitive boolean variable.

The purpose of the next Twist in Tale is to encourage you to play with code that uses short-circuit operators. To determine whether a boolean expression passed as an operand to the short-circuit operators evaluates, you can apply a unary increment operator (in postfix notation) to the variable used in the expression. Compare the new variable value with the old value to verify whether the expression was evaluated (answers in the appendix).

Twist in the Tale 2.4

As you know, the short-circuit operators `&&` and `||` may not evaluate both their operands if they can determine the result of the expression by evaluating just the first operand. Examine the following code and circle the expressions that you think will evaluate. Draw a square around the expressions that you think may not execute. (For example, on line 1, both `a++ > 10` and `++b < 30` will evaluate.)

```
class TwistInTaleLogicalOperators {
    public static void main (String args[]) {
        int a = 10;
        int b = 20;
        int c = 40;

        System.out.println(a++ > 10 || ++b < 30);      // line1
        System.out.println(a > 90 && ++b < 30);
        System.out.println(!(c>20) && a==10 );
        System.out.println(a >= 99 || a <= 33 && b == 10);
        System.out.println(a >= 99 && a <= 33 || b == 10);

    }
}
```

Example use of the short-circuit operator `&&` in real projects

The logical operator `&&` is often used in code to check whether an object reference variable has been assigned a value before invoking a method on it:

```
String name = "hello";
if (name != null && name.length() > 0)
    System.out.println(name.toUpperCase());
```

2.4.5 Operator precedence

What happens if you use multiple operators within a single line of code with multiple operands? Which one should be treated like the king and given preference over the others?

Don't worry. Java already has a rule in place for just such a situation. Table 2.12 lists the precedence of operators: the operator on top has the highest precedence, and operators within the same group have the same precedence and are evaluated from left to right.

Table 2.12 Precedence of operators

Operator	Precedence
Postfix	Expression <code>++</code> , expression <code>--</code>
Unary	<code>++expression</code> , <code>--expression</code> , <code>+expression</code> , <code>-expression</code> , <code>!</code>
Multiplication	<code>*</code> (multiply), <code>/</code> (divide), <code>%</code> (remainder)
Addition	<code>+</code> (add), <code>-</code> (subtract)
Relational	<code><</code> , <code>></code> , <code><=</code> , <code>>=</code>
Equality	<code>==</code> , <code>!=</code>
Logical AND	<code>&&</code>
Logical OR	<code> </code>
Assignment	<code>=</code> , <code>+=</code> , <code>-=</code> , <code>*=</code> , <code>/=</code> , <code>%=</code>

Let's execute an expression that uses multiple operators (with different precedence) in an expression:

```
int int1 = 10, int2 = 20, int3 = 30;
System.out.println(int1 % int2 * int3 + int1 / int2);
```

① Prints 300

Because this expression ① defines multiple operators with different precedence, it's evaluated as follows:

```
((int1 % int2) * int3)) + (int1 / int2)
(((10 % 20) * 30)) + (10 / 20)
( (10           * 30)) + (0)
( 300 )
```

What if you don't want to evaluate the expression in this way? The remedy is simple: use parentheses to override the default operator precedence. Here's an example that adds int3 and int1 before multiplying by int2:

```
int int1 = 10, int2 = 20, int3 = 30;
System.out.println(int1 % int2 * (int3 + int1) / int2);
```

Prints 20!



NOTE You can use parentheses to override the default operator precedence. If your expression defines multiple operators and you are unsure how your expression will be evaluated, use parentheses to evaluate in your preferred order. The inner parentheses are evaluated prior to the outer ones.

2.5 Summary

In this chapter, we started with the primitive data types in Java, including examples of where to use each of the kinds and their literal values. We also categorized the primitives into character type, integer type, and floating type. Then we covered the ingredients of valid and invalid Java identifiers.

We discussed the operators used to manipulate primitives (limited to the ones required for the OCA Java SE 7 Programmer I exam). We also covered the conditions in which a particular operator can be used. For example, if you wish to check whether a set of conditions is true, you can use the logical operators. It's also important to understand the operand types that can be used for each of these operators. For example, you can't use boolean operands with the operators `>`, `>=`, `=<`, and `<`.

2.6 Review notes

Primitive data types:

- Java defines eight primitive data types: `char`, `byte`, `short`, `int`, `long`, `float`, `double`, and `boolean`.
- Primitive data types are the simplest data types.
- Primitive data types are predefined by the programming language. A user can't define a primitive data type in Java.
- It's helpful to categorize the primitive data types as Boolean, numeric, and character data types.

The Boolean data type:

- The `boolean` data type is used to store data with only two possible values. These two possible values may be thought of as yes/no, 0/1, true/false, or any other combination. The actual values that a `boolean` can store are `true` and `false`.
- `true` and `false` are literal values.
- A literal is a fixed value that doesn't need further calculations to be assigned to any variable.

Numeric data types:

- Numeric values can be stored either as integers or decimal numbers.
- `byte`, `short`, `int`, and `long` can be used to store integers.
- The `byte`, `short`, `int`, and `long` data types use 8, 16, 32, and 64 bits, respectively, to store their values.
- `float` and `double` can be used to store decimal numbers.
- The `float` and `double` data types use 32 and 64 bits, respectively, to store their values.
- The default type of integers—that is, nondecimal numbers—is `int`.
- To designate an integer literal value as a `long` value, add the suffix `L` or `l` to the literal value.

- Numeric values can be stored in binary, octal, decimal, and hexadecimal number formats. The OCA Java SE 7 Programmer I exam will not ask you to convert a number from one number system to another.
- Literal values in the decimal number system use digits from 0 to 9 (a total of 10 digits).
- Literal values in the octal number system use digits from 0 to 7 (a total of 8 digits).
- Literal values in the hexadecimal number system use digits from 0 to 9 and letters from A to F (a total of 16 digits and letters).
- Literal values in the binary number system use digits 0 and 1 (a total of 2 digits).
- The literal values in the octal number system start with the prefix 0. For example, 0413 in the octal number system is 267 in the decimal number system.
- The literal values in the hexadecimal number system start with the prefix 0x. For example, 0x10B in the hexadecimal number system is 267 in the decimal number system.
- The literal values in the binary number system start with the prefix 0b or 0B. For example, the decimal value 267 is 0B100001011 in the binary system.
- Starting with Java 7, you can use underscores within the Java literal values to make them more readable. 0B1_0000_10_11, _0_413, and 0x10_B are valid binary, octal, and hexadecimal literal values.
- The default type of a decimal number is double.
- To designate a decimal literal value as a float value, add the suffix F or f to the literal value.
- The suffixes D and d can be used to mark a literal value as a double value. Though it's allowed, doing so is not required because the default value of decimal literals is double.

Character primitive data types:

- A char data type can store a single 16-bit Unicode character; that is, it can store characters from virtually all the world's existing scripts and languages.
- You can use values from \u0000 (or 0) to a maximum of \uffff (or 65,535 inclusive) to store a char. Unicode values are defined in the hexadecimal number system.
- Internally, the char data type is stored as an unsigned integer value (only positive integers).
- When you assign a letter to a char, Java stores its integer equivalent value. You may assign a positive integer value to a char instead of a letter, such as 122.
- The literal value 122 is not the same as the Unicode value \u0122. The former is a decimal number and the latter is a hexadecimal number.
- Single quotes, not double quotes, are used to assign a letter to a char variable.

Valid identifiers:

- A valid identifier starts with a letter (a–z, upper- or lowercase), a currency sign, or an underscore. There is no limit to its length.
- A valid identifier can contain digits, but not in the starting place.
- A valid identifier can use the underscore and currency sign at any position of the identifier.
- A valid identifier can't have the same spelling as a Java keyword, such as `switch`.
- A valid identifier can't use any special characters, including !, @, #, %, ^, &, *, (,), ', :, ;, [, /, \, or }

Operators:

- The OCA Java SE 7 Programmer I exam covers assignment, arithmetic, relational, and logical operators.

Assignment operators:

- Assignment operators can be used to assign or reassign values to all types of variables.
- A variable can't be assigned to an incompatible value. For example, character and numeric values cannot be assigned to a boolean variable, and vice versa.
- `+=` and `-=` are short forms of addition/subtraction and assignment.
- `+=` can be read as “first add and then assign” and `-=` can be read as “first subtract and then assign.”

Arithmetic operators:

- Arithmetic operators can't be used with the `boolean` data type. Attempting to do so will make the code fail to compile.
- `++` and `--` are unary increment and decrement operators. These operators work with single operands.
- Unary operators can be used in prefix or postfix notation.
- When the unary operators `++` and `--` are used in prefix notation, the value of the variable increments/decrements just before the variable is used in an expression.
- When the unary operators `++` and `--` are used in postfix notation, the value of the variable increments/decrements just after the variable is used in an expression.
- By default, unary operators have a higher precedence than multiplication operators and addition operators.

Relational operators:

- Relational operators are used to compare values for equality (`==`) and non-equality (`!=`). They are also used to determine whether two numeric values are greater than (`>`, `>=`) or less than (`<`, `<=`) each other.
- You can't compare incomparable values. For example, you can't compare a `boolean` with an `int`, a `char`, or a floating-point number. If you try to do so, your code will not compile.

- The operators equal to (==) and not equal to (!=) can be used to compare all types of primitives: char, byte, short, int, long, float, double, and boolean.
- The operator == returns true if the primitive values being compared are equal.
- The operator != returns true if the primitive values being compared are *not* equal.
- The result of the relational operator is always a boolean value.

Logical operators:

- You can use the logical operators to determine whether a set of conditions is true or false and proceed accordingly.
- Logical AND (&&) evaluates to true if all operands are true, and false otherwise.
- Logical OR (||) evaluates to true if any or all of the operands is true.
- Logical negation (!) negates the boolean value. It evaluates to true for false, and vice versa.
- The result of a logical operation is always a boolean value.
- The logical operators && and || are also called short-circuit operators. If these operators can determine the output of the expression with the evaluation of the first operand, they don't evaluate the second operand.
- The && operator returns true only if both of the operands are true. If the first operand to this operator evaluates to false, the result can never be true. Therefore, && does not evaluate the second operand.
- Similarly, the || operator returns true if any of the operands is true. If the first operand to this operator evaluates to true, the result can never be false. Therefore, || does not evaluate the second operator.

2.7 Sample exam questions

Q2-1. Select all incorrect statements:

- a A programmer can't define a new primitive data type.
- b A programmer can define a new primitive data type.
- c Once assigned, the value of a primitive can't be modified.
- d A value can't be assigned to a primitive variable.

Q2-2. Which of the options are correct for the following code?

```
public class Prim {                                     // line 1
    public static void main(String[] args) {           // line 2
        char a = 'a';                                // line 3
        char b = -10;                                 // line 4
        char c = '1';                                // line 5
        integer d = 1000;                             // line 6
        System.out.println(++a + b++ * c - d);         // line 7
    }                                                 // line 8
}                                                 // line 9
```

- a Code at line 4 fails to compile.
- b Code at line 5 fails to compile.

- c Code at line 6 fails to compile.
- d Code at line 7 fails to compile.

Q2-3. What is the output of the following code?

```
public class Foo {
    public static void main(String[] args) {
        int a = 10;
        long b = 20;
        short c = 30;
        System.out.println(++a + b++ * c);
    }
}

a 611
b 641
c 930
d 960
```

Q2-4. Select the option(s) that is/are the best choice for the following:

_____ should be used to store a count of cars manufactured by a car manufacturing company. _____ should be used to store whether this car manufacturing company modifies the interiors on the customer's request. _____ should be used to store the maximum speed of a car.

- a long, boolean, double
- b long, int, float
- c char, int, double
- d long, boolean, float

Q2-5. Which of the following options contain correct code to declare and initialize variables to store whole numbers?

- a bit a = 0;
- b integer a2 = 7;
- c long a3 = 0x10C;
- d short a4 = 0512;
- e double a5 = 10;
- f byte a7 = -0;
- g long a8 = 123456789;

Q2-6. Select the options that, when inserted at // INSERT CODE HERE, will make the following code output a value of 11:

```
public class IncrementNum {
    public static void main(String[] args) {
        int ctr = 50;
        // INSERT CODE HERE
        System.out.println(ctr % 20);
    }
}
```

- a** `ctr += 1;`
- b** `ctr =+ 1;`
- c** `++ctr;`
- d** `ctr = 1;`

Q2-7. What is the output of the following code?

```
int a = 10;
int b = 20;
int c = (a * (b + 2)) - 10-4 * ((2*2) - 6;
System.out.println(c);
```

- a** 218
- b** 232
- c** 246
- d** Compilation error

Q2-8. What is true about the following lines of code?

```
boolean b = false;
int i = 90;
System.out.println(i >= b);
```

- a** Code prints true
- b** Code prints false
- c** Code prints $90 \geq \text{false}$
- d** Compilation error

Q2-9. Examine the following code and select the correct options:

```
public class Prim {                                     // line 1
    public static void main(String[] args) {          // line 2
        int num1 = 12;                                // line 3
        float num2 = 17.8f;                            // line 4
        boolean eJavaResult = true;                   // line 5
        boolean returnVal = num1 >= 12 && num2 < 4.567 // line 6
            || eJavaResult == true;
        System.out.println(returnVal);                // line 7
    }                                              // line 8
}                                              // line 9
```

- a** Code prints false
- b** Code prints true
- c** Code will print true if code on line 6 is modified to the following:

```
boolean returnVal = (num1 >= 12 && num2 < 4.567) || eJavaResult ==  
true;
```

- d** Code will print true if code on line 6 is modified to the following:

```
boolean returnVal = num1 >= 12 && (num2 < 4.567 || eJavaResult ==  
false);
```

Q2-10. If the functionality of the operators = and > were to be swapped in Java (for the code on line numbers 4, 5, and 6), what would be the result of the following code?

```
boolean myBool = false;                                // line 1
int yourInt = 10;                                     // line 2
float hisFloat = 19.54f;                               // line 3

System.out.println(hisFloat > yourInt);               // line 4
System.out.println(yourInt = 10);                      // line 5
System.out.println(myBool > false);                   // line 6
```

- a true
true
false
- b 10.0
false
false
- c false
false
false
- d Compilation error

2.8 Answers to sample exam questions

Q2-1. Select all incorrect statements:

- a A programmer can't define a new primitive data type.
- b A programmer can define a new primitive data type.
- c Once assigned, the value of a primitive can't be modified.
- d A value can't be assigned to a primitive variable.

Answer: b, c, d

Explanation: Only option (a) is a correct statement. Java primitive data types are predefined by the programming language. They can't be defined by a programmer.

Q2-2. Which of the options are correct for the following code?

```
public class Prim {                                         // line 1
    public static void main(String[] args) {                // line 2
        char a = 'a';                                      // line 3
        char b = -10;                                     // line 4
        char c = '1';                                      // line 5
        integer d = 1000;                                 // line 6
        System.out.println(++a + b++ * c - d);           // line 7
    }                                                       // line 8
}                                                       // line 9
```

- a Code at line 4 fails to compile.
- b Code at line 5 fails to compile.
- c Code at line 6 fails to compile.
- d Code at line 7 fails to compile.

Answer: a, c, d

Explanation:

Option (a) is correct. The code at line 4 fails to compile because you can't assign a negative value to a primitive char data type without casting.

Option (c) is correct. There is no primitive data type with the name "integer." The valid data types are int and Integer (a wrapper class with I in uppercase).

Option (d) is correct. The variable d remains undefined on line 7 because its declaration fails to compile on line 6. So the arithmetic expression `(++a + b++ * c - d)` that uses variable d fails to compile. There are no issues with using the variable c of the char data type in an arithmetic expression. The char data types are internally stored as unsigned integer values and can be used in arithmetic expressions.

Q2-3. What is the output of the following code?

```
public class Foo {
    public static void main(String[] args) {
        int a = 10;
        long b = 20;
        short c = 30;
        System.out.println(++a + b++ * c);
    }
}
a 611
b 641
c 930
d 960
```

Answer: a

Explanation: The prefix increment operator `(++)` used with the variable a will increment its value before it is used in the expression `++a + b++ * c`. The postfix increment operator `(++)` used with the variable b will increment its value *after* its initial value is used in the expression `++a + b++ * c`.

Therefore, the expression `++a + b++ * c`, evaluates with the following values:

`11 + 20 * 30`

Because the multiplication operator has a higher precedence than the addition operator, the values 20 and 30 are multiplied before the result is added to the value 11. The example expression evaluates as follows:

$$\begin{aligned} & (+a + b++ * c) \\ &= 11 + 20 * 30 \\ &= 11 + 600 \\ &= 611 \end{aligned}$$


EXAM TIP Although questions 2-2 and 2-3 seemed to test you on your understanding of operators, they actually tested you on different topics. Question 2-2 tested you on the name of the primitive data types. Beware! The real exam has a lot of such questions. A question that may seem to test you on threads may actually be testing you on the use of a do-while loop!

Q2-4. Select the option(s) that is/are the best choice for the following:

_____ should be used to store a count of cars manufactured by a car manufacturing company. _____ should be used to store whether this car manufacturing company modifies the interiors on the customer's request. _____ should be used to store the maximum speed of a car.

- a long, boolean, double
- b long, int, float
- c char, int, double
- d long, boolean, float

Answer: a, d

Explanation:

Options (a) and (d) are correct. Use a long data type to store big number values, a boolean data type to store yes/no values as true/false, and a double or float to store decimal numbers.

Option (b) is incorrect. You can't use an int to store yes/no or true/false values.

Option (c) is incorrect. You can't use a char data type to store very long values (such as the count of cars manufactured by the car manufacturer until a certain date). Also, it's conceptually incorrect to track counts using the char data type.

Q2-5. Which of the following options contain correct code to declare and initialize variables to store whole numbers?

- a bit a = 0;
- b integer a2 = 7;
- c long a3 = 0x10C;
- d short a4 = 0512;
- e double a5 = 10;
- f byte a7 = -0;
- g long a8 = 123456789;

Answer: c, d, f, g

Explanation:

Options (a) and (b) are incorrect. There are no primitive data types in Java with the names bit and integer. The correct names are byte and int.

Option (c) is correct. It assigns a hexadecimal literal value to the variable a3.

Option (d) is correct. It assigns an octal literal value to the variable a4.

Option (e) is incorrect. It defines a variable of type double, which is used to store decimal numbers, not integers.

Option (f) is correct. -0 is a valid literal value.

Option (g) is correct. 123456789 is a valid integer literal value that can be assigned to a variable of type long.

Q2-6. Select the options that, when inserted at // INSERT CODE HERE, will make the following code output a value of 11:

```
public class IncrementNum {
    public static void main(String[] args) {
        int ctr = 50;
        // INSERT CODE HERE
        System.out.println(ctr % 20);
    }
}

a ctr += 1;
b ctr =+ 1;
c ++ctr;
d ctr = 1;
```

Answer: a, c

Explanation: To output a value of 11, the value of the variable `ctr` should be 51 because $51\%20$ is 11. Operator `%` outputs the remainder from a division operation. The current value of the variable `ctr` is 50. It can be incremented by 1 using the correct assignment or increment operator.

Option (b) is incorrect. Java does not define a `=+` operator. The correct operator is `+=`.

Option (d) is incorrect because it's assigning a value of 1 to the variable `result`, not incrementing it by 1.

Q2-7. What is the output of the following code?

```
int a = 10;
int b = 20;
int c = (a * (b + 2)) - 10-4 * ((2*2) - 6;
System.out.println(c);

a 218
b 232
c 246
d Compilation error
```

Answer: d

Explanation: First of all, whenever you answer any question that uses parentheses to override operator precedence, check whether the number of opening parentheses matches the number of closing parentheses. This code will not compile because the number of opening parentheses does not match the number of closing parentheses.

Second, you may not have to answer complex expressions in the real exam. Whenever you see overly complex code, look for other possible issues in the code. Complex code may be used to distract your attention from the real issue.

Q2-8. What is true about the following lines of code?

```
boolean b = false;
int i = 90;
System.out.println(i >= b);
```

- a Code prints true
- b Code prints false
- c Code prints $90 \geq \text{false}$
- d **Compilation error**

Answer: d

Explanation: The code will fail to compile; hence, it can't execute. You can't compare incomparable types, such as a boolean value with a number.

Q2.9. Examine the following code and select the correct options:

```
public class Prim { // line 1
    public static void main(String[] args) { // line 2
        int num1 = 12; // line 3
        float num2 = 17.8f; // line 4
        boolean eJavaResult = true; // line 5
        boolean returnVal = num1 >= 12 && num2 < 4.567 // line 6
            || eJavaResult == true;
        System.out.println(returnVal); // line 7
    } // line 8
}
```

- a Code prints false
- b **Code prints true**
- c **Code will print true if code on line 6 is modified to the following:**

```
boolean returnVal = (num1 >= 12 && num2 < 4.567) || eJavaResult ==
true;
```

- d Code will print true if code on line 6 is modified to the following:

```
boolean returnVal = num1 >= 12 && (num2 < 4.567 || eJavaResult ==
false);
```

Answer: b, c

Explanation:

Option (a) is incorrect because the code prints true.

Option (d) is incorrect because the code prints false.

Both the short-circuit operators `&&` and `||` have the same operator precedence. In the absence of any parentheses, they are evaluated from left to right. The first expression, `num1 >= 12`, evaluates to true. The `&&` operator evaluates the second operand only if the first evaluates to true. Because `&&` returns true for its first operand, it evaluates the second operand, which is `(num2 < 4.567 || eJavaResult == true)`. The second operand evaluates to true; hence the variable `returnVal` is assigned true.

Q2.10. If the functionality of the operators `=` and `>` were to be swapped in Java (for the code on line numbers 4, 5, and 6), what would be the result of the following code?

```
boolean myBool = false; // line 1
int yourInt = 10; // line 2
float hisFloat = 19.54f; // line 3
```

```
System.out.println(hisFloat > yourInt);           // line 4
System.out.println(yourInt = 10);                  // line 5
System.out.println(myBool > false);               // line 6

a  true
true
false

b  10.0
false
false

c  false
false
false

d  Compilation error
```

Answer: b

Explanation: Because the question mentioned swapping the functionality of the operator `>` with `=`, the code on lines 4, 5, and 6 will actually evaluate to the following:

```
System.out.println(hisFloat = yourInt);
System.out.println(yourInt > 10);
System.out.println(myBool = false);
```

The result is shown in b.

Note that the expression `myBool = false` uses the assignment operator (`=`) and not a comparison operator (`==`). This expression assigns boolean literal `false` to `myBool`; it doesn't compare `false` with `myBool`. Watch out for similar (trick) assignments in the exam, which may *seem* to be comparing values.

Methods and encapsulation

Exam objectives covered in this chapter	What you need to know
[1.1] Define the scope of variables.	Variables can have multiple scopes: class, instance, method, and local. Accessibility of a variable in a given scope.
[2.4] Explain an object's life cycle.	Difference between when an object is declared, initialized, accessible, and eligible to be collected by Java's garbage collection. Garbage collection in Java.
[6.1] Create methods with arguments and return values.	Creation of methods with correct return types and method argument lists.
[6.3] Create an overloaded method.	Creation of methods with the same names, but a different set of argument lists.
[6.4] Differentiate between default and user-defined constructors.	A default constructor isn't the same as a no-argument constructor. Java defines a no-argument constructor when no user-defined constructors are created. User-defined constructors can be overloaded.
[6.5] Create and overload constructors.	Like regular methods, constructors can be overloaded.
[2.3] Read or write to object fields.	Object fields can be read and written to by using both instance variables and methods. Access modifiers determine the variables and methods that can be accessed to read from or write to object fields.

Exam objectives covered in this chapter	What you need to know
[2.5] Call methods on objects.	The correct notation to call methods on an object. Access modifiers affect the methods that can be called using a reference variable. Methods may or may not change the value of instance variables. Nonstatic methods can't be called on uninitialized objects.
[6.7] Apply encapsulation principles to a class.	Need for and benefits of encapsulation. Definition of classes that correctly implement the encapsulation principle.
[6.8] Determine the effect upon object references and primitive values when they're passed into methods that change the values.	Object references and primitives are treated in a different manner when passed into methods. Unlike reference variables, the values of primitives are never changed in the calling method when they're passed to methods.

Take a look around, and you'll find multiple examples of *well-encapsulated objects*. For instance, most of us use the services of a bank, which applies a set of well-defined processes that enable us to secure our money and valuables (a bank vault). The bank may require input from us to execute some of its processes, such as depositing money into our accounts. But the bank may or may not inform us about the results of other processes; for example, it may inform us about an account balance after a transaction, but it likely won't inform us about its recruitment plans for new employees.

In Java, you can compare a bank to a well-encapsulated class and the bank processes to Java methods. In this analogy, your money and valuables are like object fields in Java. You can also compare inputs that a bank process requires to Java's method parameters, and the bank process result to a Java method's return value. Finally, you can compare the set of steps that a bank executes when it opens a bank account to constructors in Java.

In the exam, you must answer questions about methods and encapsulation. This chapter will help you get the correct answers by covering the following:

- Defining the scope of variables
- Explaining an object's life cycle
- Creating methods with primitive and object arguments and return values
- Creating overloaded methods and constructors
- Reading and writing to object fields
- Calling methods on objects
- Applying encapsulation principles to a class

We'll start the chapter by defining the scope of the variables; we'll then cover the class constructors, including the differences between user-defined and default constructors and the ways in which they're useful.

3.1 Scope of variables



[1.1] Define the scope of variables

The scope of a variable specifies its life span. In this section, we'll cover the scopes of the variables and the domains in which they're accessible. Here are the available scopes of variables:

- Local variables (also known as method-local variables)
- Method parameters (also known as method arguments)
- Instance variables (also known as attributes, fields, and nonstatic variables)
- Class variables (also known as static variables)

Let's get started by defining local variables.

3.1.1 Local variables

Local variables are defined within a method. They may or may not be defined within code constructs such as `if-else` constructs, looping constructs, or switch statements. Typically, you'd use local variables to store the intermediate results of a calculation. Compared to the other three previously listed variable scopes, they have the shortest scope (life span).

Look at the following code, in which a local variable `avg` is defined within the method `getAverage()`:

```
class Student {
    private double marks1, marks2, marks3;
    private double maxMarks = 100;
    public double getAverage() {
        double avg = 0;
        avg = ((marks1 + marks2 + marks3) / (maxMarks*3)) * 100;
        return avg;
    }
    public void setAverage(double val) {
        avg = val;
    }
}
```

Instance variables

Local variable avg

This code won't compile because avg is inaccessible outside the method getAverage

As you can see, the variable `avg`, defined locally in the method `getAverage`, can't be accessed outside of it in the method `setAverage`. The scope of this local variable, `avg`, is depicted in figure 3.1. The unshaded area marks where `avg` is accessible and the shaded area is where it won't be available.



NOTE The life span of a variable is determined by its scope. If the scope of a variable is limited to a method, its life span is also limited to that method. You may notice that these terms are used interchangeably.

Let's define another variable, `avg`, local to the `if` block of an `if` statement (code that executes when the `if` condition evaluates to `true`):

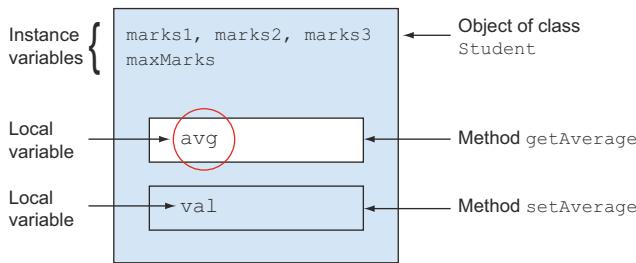


Figure 3.1 You can access the local variable `avg` only within the method `getAverage`.

```
public double getAverage() {
    if (maxMarks > 0) {
        double avg = 0;
        avg = (marks1 + marks2 + marks3) / (maxMarks*3) * 100;
        return avg;
    }
    else {
        avg = 0;
        return avg;
    }
}
```

Variable `avg` is local to if block

Variable `avg` can't be accessed because it's local to the if block.
Variables local to the if block can't be accessed in the else block

In this case, the scope of the local variable `avg` is reduced to the `if` block of the `if-else` statement defined within the `getAverage` method. The scope of this local variable `avg` is depicted in figure 3.2, where the unshaded area marks where `avg` is accessible, and the shaded part marks the area where it won't be available.

Similarly, loop variables aren't accessible outside of the loop body:

```
public void localVariableInLoop() {
    for (int ctr = 0; ctr < 5; ++ctr) {
        System.out.println(ctr);
    }
    System.out.println(ctr); // This line won't compile.
}
```

Variable `ctr` is defined within the for loop

Variable `ctr` isn't accessible outside the for loop. This line won't compile.



EXAM TIP The local variables topic is a favorite of OCA Java SE 7 Programmer I exam authors. You're likely to be asked a question that seems to be about a rather complex topic, such as inheritance or exception handling, but in fact it'll be testing your knowledge on the scope of a local variable.

The scope of a local variable depends on the location of its declaration within a method. The scope of local variables defined within a loop, `if-else`, or `switch` construct or within a code block (marked with `{ }`) is limited to these constructs.

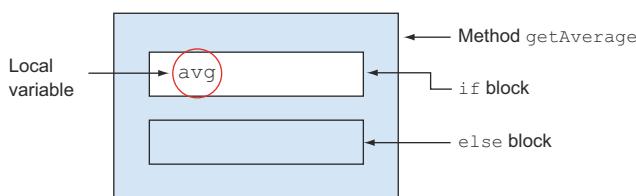


Figure 3.2 The scope of local variable `avg` is part of the if statement.

Local variables defined outside any of these constructs are accessible across the complete method.

The next section discusses the scope of method parameters.

3.1.2 Method parameters

The variables that accept values in a method are called *method parameters*. They're accessible only in the method that defines them. In the following example, a method parameter `val` is defined for the method `setTested`:

```
class Phone {
    private boolean tested;
    public void setTested(boolean val) { ←
        tested = val; ←
    }
    public boolean isTested() { ←
        val = false; ←
        return tested; ←
    }
}
```

Method parameter val is accessible only in method setTested

Variable val can't be accessed in method isTested

This line of code won't compile

In the previous code, you can access the method parameter `val` only within the method `setTested`. It can't be accessed in any other method.

The scope of the method parameter `val` is depicted in figure 3.3. The unshaded area marks where the variable is accessible, and the shaded part marks where it won't be available.

The scope of a method parameter may be as long as that of a local variable, or longer, but it can never be shorter. The following method, `isPrime`, defines a method parameter, `num`, and two local variables, `result` and `ctr`:

```
boolean isPrime(int num) { ←
    if (num <= 1) return false; ←
    boolean result = true; ←
    for (int ctr = num-1; ctr > 1; ctr--) { ←
        if (num%ctr == 0) result = false; ←
    } ←
    return result; ←
}
```

Method parameter num

Local variable result

Local variable ctr

The scope of the method parameter `num` is as long as the scope of the local variable `result`. Because the scope of the local variable `ctr` is limited to the `for` block, it's

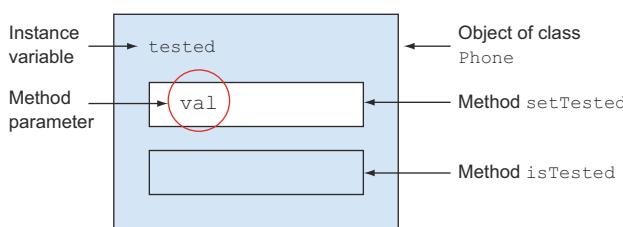


Figure 3.3 The scope of the method parameter `val`, which is defined in method `setTested`

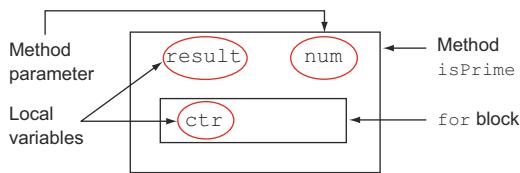


Figure 3.4 Comparison of the scope of method parameters and local variables

shorter than the method parameter num. The comparison of the scope of all of these three variables is shown in figure 3.4, where the scope of each variable (defined in an oval) is shown by the rectangle enclosing it.

Let's move on to instance variables, which have a larger scope than method parameters.

3.1.3 Instance variables

Instance is another name for an object. Hence, an *instance variable* is available for the life of an object. An instance variable is declared within a class, outside of all of the methods. It's accessible to all the nonstatic methods defined in a class.

In the following example, the variable tested is an instance variable—it's defined within the class Phone, outside of all of the methods. It can be accessed by all of the methods of class Phone:

```
class Phone {
    private boolean tested;
    public void setTested(boolean val) {
        tested = val;
    }
    public boolean isTested() {
        return tested;
    }
}
```

**Instance variable
tested**
**Variable tested is accessible
in method setTested**
**Variable tested is also
accessible in method isTested**

The scope of the instance variable tested is depicted in figure 3.5. As you can see, the variable tested is accessible across the object of class Phone, represented by the unshaded area. It's accessible in the methods setTested and isTested.



EXAM TIP The scope of an instance variable is longer than that of a local variable or a method parameter.

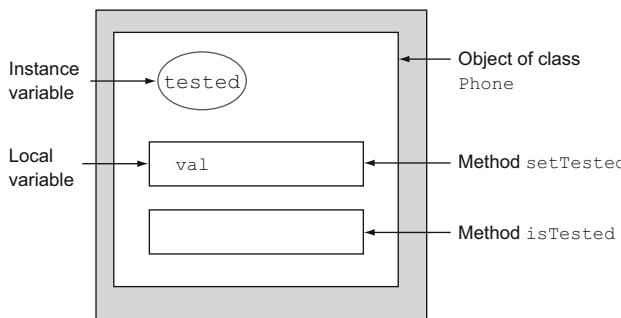


Figure 3.5 The instance variable tested is accessible across the object of class Phone

Class variables, covered in the next section, have the largest scope among all types of variables.

3.1.4 Class variables

A *class variable* is defined by using the keyword `static`. A class variable belongs to a class, not to individual objects of the class. A class variable is shared across all objects—objects don't have a separate copy of the class variables.

You don't even need an object to access a class variable. It can be accessed by using the name of the class in which it's defined:

```
package com.mobile;
class Phone {
    static boolean softKeyboard = true;
}
```

Class variable
`softKeyboard`

Let's try to access this variable in another class:

```
package com.mobile;
class TestPhone {
    public static void main(String[] args) {
        Phone.softKeyboard = false;

        Phone p1 = new Phone();
        Phone p2 = new Phone();

        System.out.println(p1.softKeyboard);
        System.out.println(p2.softKeyboard);
        p1.softKeyboard = true;

        System.out.println(p1.softKeyboard);
        System.out.println(p2.softKeyboard);
    }
}
```

Prints
false.

Accesses the class variable by using the name of the class. It can be accessed even before any of the class's objects exist.

Prints false. A class variable can be read by using objects of the class.

A change in the value of this variable will be reflected when the variable is accessed via objects or class name.

Prints
true.

As you can see in the previous code, the class variable `softKeyboard` is accessible using all of the following:

- `Phone.softKeyboard`
- `p1.softKeyboard`
- `p2.softKeyboard`

It doesn't matter whether you use the name of the class (`Phone`) or an object (`p1`) to access a class variable. You can change the value of a class variable using either of them because they all refer to a single shared copy.

The scope of the class variable `softKeyboard` is depicted in figure 3.6. As you can see, a single copy of this variable is accessible to all the objects of class `Phone`. The variable `softKeyboard` isn't defined within any object of class `Phone`, so it's accessible even without the existence of an object of class `Phone`. The class variable `softKeyboard` is made accessible by the JVM when it loads the `Phone` class into memory. The scope of the class variable `softKeyboard` depends on its access modifier and that of the `Phone`

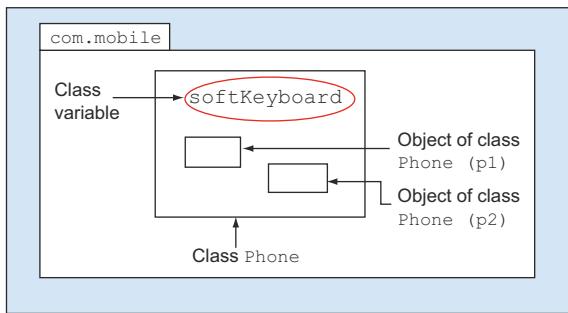


Figure 3.6 The scope of the class variable `softKeyboard` is limited to the package `com.mobile` because it's defined in class `Phone`, which is defined with default access. The class variable `softKeyboard` is shared and accessible across all objects of class `Phone`.

class. Because the class `Phone` and the class variable `softKeyboard` are defined using default access, they're accessible only within the package `com.mobile`.

COMPARING THE USE OF VARIABLES IN DIFFERENT SCOPES

Here is a quick comparison of the use of the local variables, method parameters, instance variables, and class variables:

- Local variables are defined within a method and are normally used to store the intermediate results of a calculation.
- Method parameters are used to pass values to a method. These values can be manipulated and may also be stored as the state of an object by assigning them to instance variables.
- Instance variables are used to store the state of an object. These are the values that need to be accessed by multiple methods.
- Class variables are used to store values that should be shared by all the objects of a class.

3.1.5 Overlapping variable scopes

In the previous sections on local variables, method parameters, instance variables, and class variables, did you notice that some of the variables are accessible in multiple places within an object? For example, all four variables will be accessible in a loop within a method.

This overlapping scope is shown in figure 3.7. The variables are defined in ovals and are accessible within all methods and blocks, as illustrated by their enclosing rectangles.

As shown in figure 3.7, an individual copy of `classVariable` can be accessed and shared by multiple objects (`object1` and `object2`) of a class. Both `object1` and `object2` have their own copy of the instance variable `instanceVariable1`, so `instanceVariable1` is accessible across all the methods of `object1`. The methods `method1` and `method2` have their own copies of `localVariable` and `methodParameter` when used with `object1` and `object2`.

The scope of `instanceVariable1` overlaps with the scope of `localVariable` and `methodParameter`, defined in `method1`. Hence, all three of these variables (`instanceVariable1`, `localVariable`, and `methodParameter`) can access each other in this

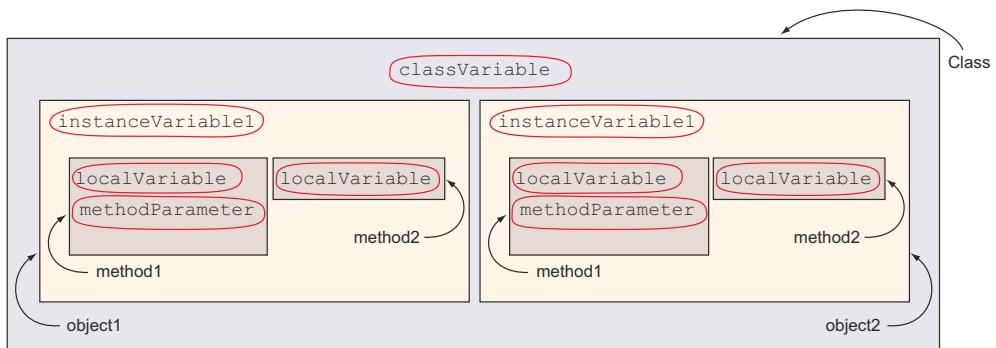


Figure 3.7 The scopes of variables can overlap

overlapped area. But `instanceVariable1` can't access `localVariable` and `methodParameter` outside `method1`.

COMPARING THE SCOPE OF VARIABLES

Figure 3.8 compares the life spans of local variables, method parameters, instance variables, and class variables.

As you can see in figure 3.8, local variables have the shortest scope or life span, and class variables have the longest scope or life span.



EXAM TIP Different local variables can have different scopes. The scope of local variables may be shorter than or as long as the scope of method parameters. The scope of local variables is less than the duration of a method if they're declared in a sub-block (within braces {}) in a method. This sub-block can be an `if` statement, a `switch` construct, a loop, or a `try-catch` block (discussed in chapter 7).

VARIABLES WITH THE SAME NAME IN DIFFERENT SCOPES

The fact that the scopes of variables overlap results in interesting combinations of variables within different scopes but with the same names. Some rules are necessary to

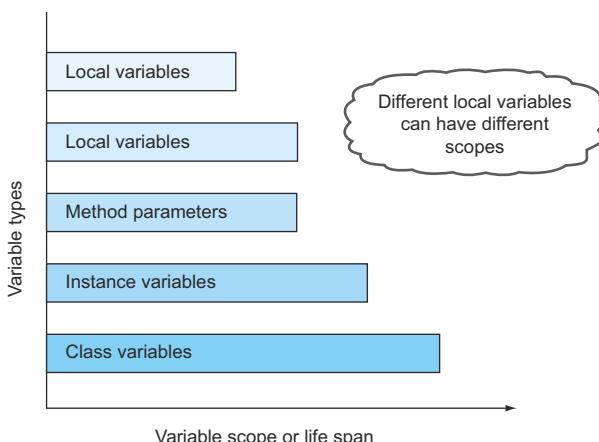


Figure 3.8 Comparing the scope, or life span, of all four variables

prevent conflicts. In particular, you can't define a static variable and an instance variable with the same name in a class:

```
class MyPhone {
    static boolean softKeyboard = true;
    boolean softKeyboard = true;
}
```

 **Won't compile. Class variable and instance variable can't be defined using the same name in a class**

Similarly, local variables and method parameters can't be defined with the same name. The following code defines a method parameter and a local variable with the same name, so it won't compile:

```
void myMethod(int weight) {
    int weight = 10;
}
```

 **Won't compile. Method parameter and local variable can't be defined using the same name in a method**

A class can define local variables with the same name as the instance or class variables. The following code defines a class variable and a local variable, `softKeyboard`, with the same name, and an instance variable and a local variable, `phoneNumber`, with the same name, which is acceptable:

```
class MyPhone {
    static boolean softKeyboard = true;
    String phoneNumber;

    void myMethod() {
        boolean softKeyboard = true;
        String phoneNumber;
    }
}
```

 **Class variable
softKeyboard**

 **Instance variable
phoneNumber**

 **Local variable softKeyboard can coexist with class variable softKeyboard**

 **Local variable phoneNumber can coexist with instance variable phoneNumber**

What happens when you assign a value to a local variable that has the same name as an instance variable? Does the instance variable reflect this modified value? This question provides the food for thought in this chapter's first Twist in the Tale exercise. It should help you remember what happens when you assign a value to a local variable when an instance variable already exists with the same name in the class (answer in the appendix).

Twist in the Tale 3.1

The class `Phone` defines a local variable and an instance variable, `phoneNumber`, with the same name. Examine the definition of the method `setNumber`. Execute the class on your system and select the correct output of the class `TestPhone` from the given options:

```
class Phone {
    String phoneNumber = "123456789";
    void setNumber () {
        String phoneNumber;
        phoneNumber = "987654321";
    }
}
class TestPhone {
```

```
public static void main(String[] args) {  
    Phone p1 = new Phone();  
    p1.setNumber();  
    System.out.println (p1.phoneNumber);  
}  
}  
  
a 123456789  
b 987654321  
c No output  
d The class Phone will not compile.
```

In this section, you worked with variables in different scopes. When variables go out of scope, they're no longer accessible by the remaining code. In the next section, you'll see how an object is created and made accessible and then inaccessible.

3.2 Object's life cycle



[2.4] Explain an object's life cycle

The OCA Java SE 7 Programmer I exam will test your understanding of how to determine when an object is or isn't accessible. The exam also tests your ability to determine the total number of objects that are accessible at a particular line of code. Primitives aren't objects, so they're not relevant in this section.

Unlike some other programming languages, such as C, Java doesn't allow you to allocate or deallocate memory yourself when you create or destroy objects. Java manages memory for allocating objects and reclaiming the memory occupied by unused objects.

The task of reclaiming unused memory is taken care of by Java's garbage collector, which is a low-priority thread. It runs periodically and frees up space occupied by unused objects.

Java also provides a method called `finalize`, which is accessible to all of the classes. The method `finalize` is defined in the class `java.lang.Object`, which is the base class of all Java classes. All Java classes can override the method `finalize`, which executes just before an object is garbage collected. In theory, you can use this method to free up resources being used by an object, although doing so isn't recommended because its execution is not guaranteed to happen.

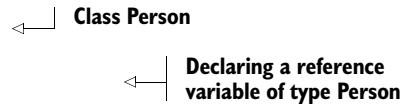
An object's life cycle starts when it's created and lasts until it goes out of its scope or is no longer referenced by a variable. When an object is accessible, it can be referenced by a variable and other classes can use it by calling its methods and accessing its variables. I'll discuss these stages in detail in the following subsections.

3.2.1 An object is born

An object comes into the picture when you use the keyword operator `new`. You can initialize a reference variable with this object. Note the difference between declaring a

variable and initializing it. The following is an example of a class Person and another class ObjectLifeCycle:

```
class Person {}  
class ObjectLifeCycle {  
    Person person;  
}
```



In the previous code, no objects of class Person are created in the class ObjectLifeCycle; it declares only a variable of type Person. An object is created when a reference variable is initialized:

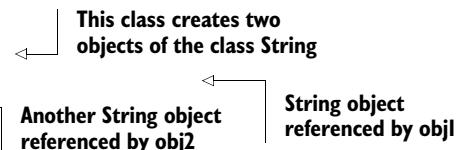
```
class ObjectLifeCycle2 {  
    Person person = new Person();  
}
```



The difference in variable declaration and object creation is illustrated in figure 3.9, where you can compare a baby name to a reference variable and a real baby to an object. The left box in figure 3.9 represents variable declaration, because the baby hasn't been born yet. The right box in figure 3.9 represents object creation.

Syntactically, an object comes into being by using the new operator. Because Strings can also be initialized using the = operator, the following code is a valid example of String objects being created:

```
class ObjectLifeCycle3 {  
    String obj1 = new String("eJava");  
    String obj2 = "Guru";  
}
```



What happens when you create a new object without assigning it to any reference variable? Let's create a new object of class Person in class ObjectLifeCycle2 without assigning it to any reference variable (modifications in **bold**):

```
class ObjectLifeCycle2 {  
    Person person = new Person();  
    ObjectLifeCycle2() {  
        new Person();  
    }  
}
```

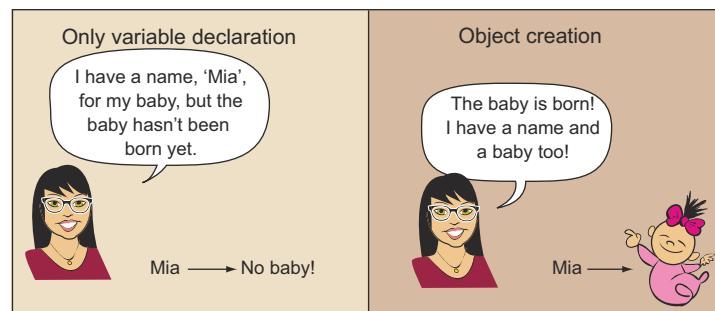


Figure 3.9 The difference between declaring a reference variable and initializing a reference variable

In the previous example, an object of class `Person` is created, but it can't be accessed using any reference variable. Creating an object in this manner will execute the relevant constructors of the class.



EXAM TIP Watch out for a count of the total objects created in any given code—the ones that can be accessed using a variable and the ones that can't be accessed using any variable. The exam may question you on the count of objects created.

In the next section, you'll learn what happens after an object is created.

3.2.2 Object is accessible

Once an object is created, it can be accessed using its reference variable. It remains accessible until it goes out of scope or its reference variable is explicitly set to `null`. Also, if you reassign another object to an initialized reference variable, the previous object becomes inaccessible. You can access and use an object within other classes and methods.

Take a look at the following definition of the class `Exam`:

```
class Exam {
    String name;
    public void setName(String newName) {
        name = newName;
    }
}
```

The class `ObjectLife1` declares a variable of type `Exam`, creates its object, calls its method, sets it to `null`, and then reinitializes it:

```
class ObjectLife1 {
    public static void main(String args[]) {
        Exam myExam = new Exam();
        myExam.setName("OCA Java Programmer 1");
        myExam = null;
        myExam = new Exam();
        myExam.setName("PHP");
    }
}
```

The previous example creates two objects of class `Exam` using the same reference variable `myExam`. Let's walk through what is happening in the example:

- ① creates a reference variable `myExam` and initializes it with an object of class `Exam`.
- ② calls method `setName` on the object referenced by the variable `myExam`.
- ③ assigns a value `null` to the reference variable `myExam` such that the object referenced by this variable is no longer accessible.
- ④ creates a new object of class `Exam` and assigns it to the reference variable `myExam`.
- ⑤ calls method `setName`, on the second `Exam` object, created in method `main`.

When ④ creates another object of class Exam and assigns it to the variable myExam, what happens to the first object created by ①? Because the first object can no longer be accessed using any variable, it's considered garbage by Java and deemed eligible to be sent to the garbage bin by Java's garbage collector. As mentioned earlier, the garbage collector is a low-priority thread that reclaims the space used by unused or unreferenced objects in Java.

So what happens when an object becomes inaccessible? You'll find out in the next section.

3.2.3 Object is inaccessible

In the previous section, you learned that an object can become inaccessible if it can no longer be referenced by any variable. An object can also become inaccessible if it goes out of scope:

```
public void myMethod() {
    int result = 88;
    if (result > 78) {
        Exam myExam1 = new Exam();
        myExam1.setName("Android");
    }
    else {
        Exam myExam2 = new Exam();
        myExam2.setName("MySQL");
    }
}
```

1 Scope of local variable myExam1
2 Start of else block
3 End of else block

The variable myExam1 is a local variable defined within the if block. Its scope starts from the line where it is declared until the end of the if block, marked with a closing brace, at ①. After this closing brace, the object referred by the variable myExam1 is no longer accessible. It goes out of scope and is marked as eligible for garbage collection by Java's garbage collector. Similarly, the object referred to by the variable myExam2 becomes inaccessible at the end of the else block, marked with a closing brace, at ③.



EXAM TIP An object is marked as eligible to be garbage collected when it can no longer be accessed, which can happen when the object goes out of scope. It can also happen when an object's reference variable is assigned an explicit null value or is reinitialized.

In the OCA Java SE 7 Programmer I exam, you're likely to answer questions on garbage collection for code that has multiple variable declarations and initializations. The exam may query you on the total number of objects that are eligible for garbage collection after a particular line of code.

As previously mentioned, the garbage collector is a low-priority thread that marks the objects eligible for garbage collection in the JVM and then clears the memory of these objects. You can determine only which objects are *eligible* to be garbage collected. You can *never* determine when a particular object *will* be garbage collected. A user can't control or determine the execution of a garbage collector. It's controlled by the JVM.

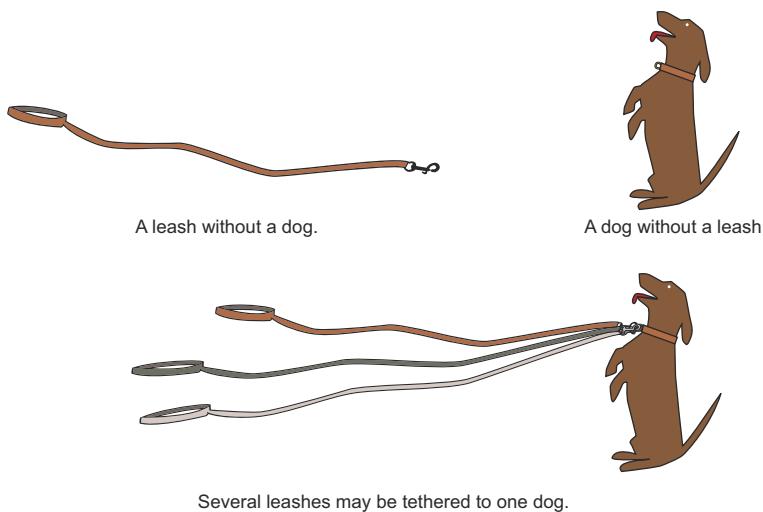


Figure 3.10 Comparing object reference variables and objects to dog leashes and leashed and unleashed dogs



EXAM TIP You can be sure only about which objects are marked for garbage collection. You can never be sure exactly when the object will be garbage collected. Watch for questions with wordings such as “which objects are sure to be collected during the next GC cycle,” for which the real answer can never be known.

Let’s revisit the dog leash and dog analogy I used in chapter 2 to define object reference variables. In figure 3.10, you can compare an object reference variable with a dog leash and a dog with an object. Review the following comparisons, which will help you to understand the life cycle of an object:

- An uninitialized reference variable can be compared to a dog leash without a dog.
- An initialized reference variable can be compared to a leashed dog.
- An unreferenced object can be compared to an unleashed dog.

You can compare Java’s garbage collector to animal control. The way animal control picks up untethered dogs is like how Java’s garbage collector reclaims the memory used by unreferenced objects.

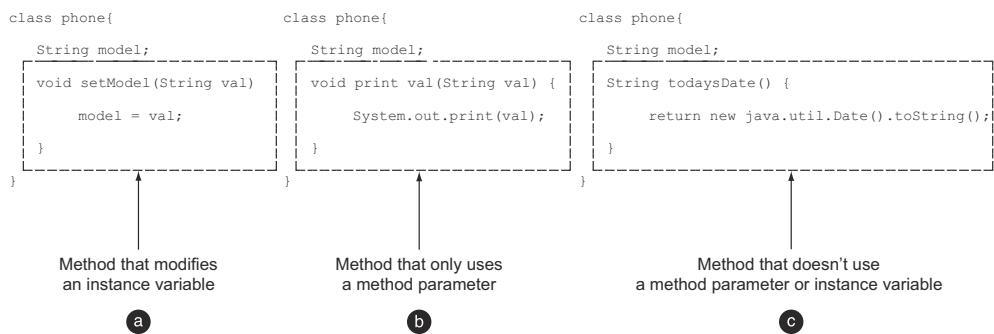
Now that you’re familiar with an object’s life cycle, you can create methods that accept primitive data types and objects as method arguments; these methods return a value, which can be either a primitive data type or an object.

3.3 **Create methods with arguments and return values**



[6.1] Create methods with arguments and return values

In this section, you’ll work with the definitions of methods, which may or may not accept input parameters and may or may not return any values.

**Figure 3.11** Different types of methods

A method is a group of statements identified with a name. Methods are used to define the behavior of an object. A method can perform different functions, as shown in figure 3.11:

- a** The method `setModel` accesses and modifies the state of the object `Phone`.
- b** The method `printVal` uses only the method parameter passed to it.
- c** The method `todaysDate` accesses another class (`java.util.Date`) from the Java API and returns its `String` presentation.

In the following subsections, you'll learn about the components of a method:

- Return type
- Method parameters
- `return` statement
- Access modifiers (covered in chapter 1)
- Nonaccess modifiers (covered in chapter 1)

Figure 3.12 shows the code of a method accepting method parameters and defining a return type and a `return` statement.

Let's get started with a discussion of the return type of a method.

3.3.1 **Return type of a method**

In this section, you'll work with the return type of a method. The return type of a method states the type of value that a method will return.

A method may or may not return a value. One that doesn't return a value has a return type of `void`. A method can return a primitive value or an object of any class. The name of the return type can be any of the eight primitive types defined in Java, the name of any class, or an interface.

In the following code, the method `setWeight` doesn't return any value, and the method `getWeight` returns a value:

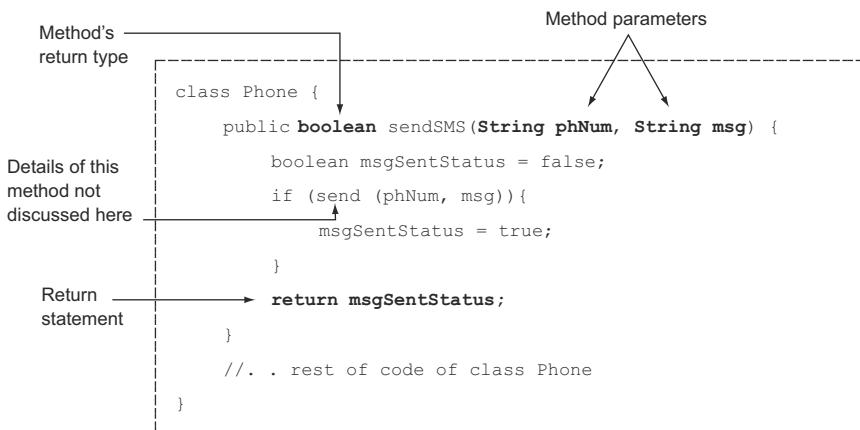


Figure 3.12 An example of a method that accepts method parameters and defines a return type and a return statement

```

class Phone {
    double weight;
    void setWeight(double val) {
        weight = val;
    }
    double getWeight() {
        return weight;
    }
}

```

Method with
return type void

Method with
return type double

If a method doesn't return a value, you can't assign the result of that method to a variable. What do you think is the output of the following class EJavaTestMethods, which uses the previous class Phone?

```

class EJavaTestMethods {
    public static void main(String args[]) {
        Phone p = new Phone();
        double newWeight = p.setWeight(20.0);
    }
}

```

Because the method
setWeight doesn't
return any value, this
line won't compile.

The previous code won't compile because the method `setWeight` doesn't return a value. Its return type is `void`. Because the method `setWeight` doesn't return a value, there's nothing to be assigned to the variable `newWeight`, so the code fails to compile.

If a method returns a value, the calling method may or may not bother to store the returned value from a method in a variable. Look at the following code:

```

class EJavaTestMethods2 {
    public static void main(String args[]) {
        Phone p = new Phone();
        p.getWeight();
    }
}

```

Method getWeight returns a
double value, but this value
isn't assigned to any variable

In the previous example, the value returned by the method `getWeight` isn't assigned to any variable, which isn't an issue for the Java compiler. The compiler will happily compile the code for you.



EXAM TIP You can optionally assign the value returned by a method to a variable. If you don't assign the returned value from a method, it's neither a compilation error nor a runtime exception.

The variable you use to accept the returned value from a method must be compatible with the returned value. Consider this example:

```
class EJavaTestMethods2 {
    public static void main(String args[]) {
        Phone p = new Phone();
        double newWeight = p.getWeight();
        int newWeight2 = p.getWeight(); ② Won't compile
    }
}
```

- 1 Will compile
- 2 Won't compile

In the preceding code, ① will compile successfully because the return type of the method `getWeight` is `double` and the type of the variable `newWeight` is also `double`. But ② won't compile because the `double` value returned from method `getWeight` can't be assigned to variable `newWeight2`, which is of type `int`.

We've discussed how to transfer a value out from a method. To transfer value into a method, you can use method arguments.

3.3.2 Method parameters

Method parameters are the variables that appear in the definition of a method and specify the type and number of values that a method can accept. In figure 3.13, the variables `phNum` and `msg` are the method parameters.

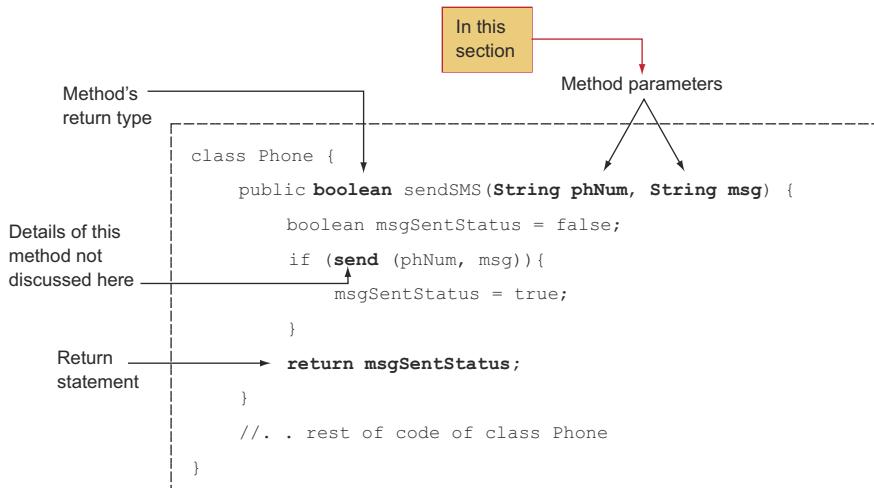


Figure 3.13 An example of a method that accepts method parameters and defines a return type and a return statement.

You can pass multiple values to a method as input. Theoretically, no limit exists on the number of method parameters that can be defined by a method, but practically it's not a good idea to define more than five or six method parameters. It's cumbersome to use a method with too many method parameters because you have to cross-check their types and purposes multiple times to ensure that you're passing the right values at the right positions.



NOTE Though the terms *method parameters* and *method arguments* are not the same, you may have noticed that they're used interchangeably by many programmers. *Method parameters* are the variables that appear in the definition of a method. *Method arguments* are the actual values that are passed to a method while executing it. In figure 3.13, variables `phNum` and `msg` are method parameters. If you execute this method as `sendMsg("123456", "Hello")`, then the String values "123456" and "Hello" are method arguments. As you know, you can pass literal values or variables to a method. Thus, method arguments can be literal values or variables.

A method may accept zero or multiple method arguments. The following example accepts two int values and returns their average as a double value:

```
double calcAverage(int marks1, int marks2) {  
    double avg = 0;  
    avg = (marks1 + marks2)/2.0;  
    return avg;  
}
```

**Multiple method parameters:
marks1 and marks2**

The following example shows a method that doesn't accept any method parameters:

```
void printHello() {  
    System.out.println("Hello");  
}
```

If a method doesn't accept any parameters, the parentheses that follow the name of the method are empty. Because the keyword `void` is used to specify that a method doesn't return a value, you may think it's correct to use the keyword `void` to specify that a method doesn't accept any method parameters, but this is incorrect. The following is an invalid definition of a method that accepts no parameters:

```
void printHello(void) {  
    System.out.println("Hello");  
}
```

Won't compile

You can define a parameter that can accept variable arguments (`varargs`) in your methods. Following is an example of class `Employee`, which defines a method `daysOffWork` that accepts variable arguments:

```
class Employee {  
    public int daysOffWork(int... days) {  
        int daysOff = 0;
```

```

        for (int i = 0; i < days.length; i++)
            daysOff += days[i];
        return daysOff;
    }
}

```

The ellipsis (...) that follows the data type indicates that the method parameter days may be passed an array or multiple comma-separated values. Re-examine the preceding code example and note the usage of the variable days in the method daysOffWork—it works like an array. When you define a variable-length argument for a method, Java creates an array behind the scenes to implement it.

You can define only one variable argument in a parameter list, and it should be the last variable in the parameter list. If you don't comply with these two rules, your code won't compile:

```

class Employee {
    public int daysOffWork(String... months, int... days) { ←
        int daysOff = 0;
        for (int i = 0; i < days.length; i++)
            daysOff += days[i];
        return daysOff;
    }
}

```

**Won't compile.
You can't define
multiple variables
that can accept
variable
arguments.**

If your method defines multiple method parameters, the variable that accepts variable arguments must be the last one in the parameter list:

```

class Employee {
    public int daysOffWork(int... days, String year) { ←
        int daysOff = 0;
        for (int i = 0; i < days.length; i++)
            daysOff += days[i];
        return daysOff;
    }
}

```

**Won't compile. If
multiple parameters
are defined, the
variable argument
must be the last in
the list.**



EXAM TIP In the OCA exam, you may be questioned on the valid return types for a method that doesn't accept any method parameters. Note that there are no valid or invalid combinations of the number and type of method parameters that can be passed to a method and the value that it can return. They're independent of each other.

You can pass any type and number of parameters to a method, including primitives, objects of a class, or objects referenced by an interface.

RULES TO REMEMBER

Points to note with respect to defining method parameters:

- You can define multiple parameters for a method.
- The method parameter can be a primitive type or objects referenced by a class or referenced by an interface.

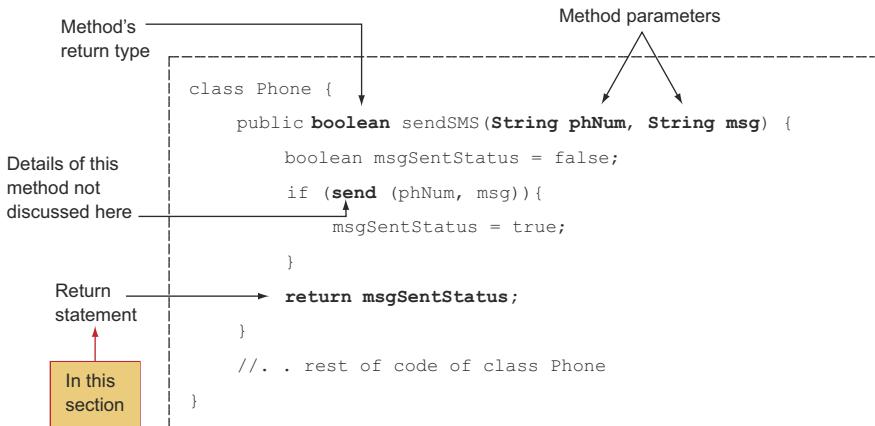


Figure 3.14 An example of a method that accepts method parameters and defines a return type and a return statement

- The method's parameters are separated by commas.
- Each method parameter is preceded by the name of its type. Each method parameter must have an explicit type declared with its name. You can't declare the type once and then list them separated by commas, as you can for variables.

3.3.3 Return statement

A return statement is used to exit from a method, with or without a value. For methods that define a return type, the `return` statement must be immediately followed by a return value. For methods that don't return a value, the `return` statement can be used without a return value to exit a method. Figure 3.14 illustrates the use of a `return` statement.

In this example, we'll revisit the previous example of method `calcAverage`, which returns a value of type `double`, using a `return` statement:

```

double calcAverage(int marks1, int marks2) {
    double avg = 0;
    avg = (marks1 + marks2)/2.0;
    return avg;
}
  
```

return statement

The methods that don't return a value (return type is `void`) are not required to define a `return` statement:

```

void setWeight(double val) {
    weight = val;
}
  
```

return statement not required for methods with return type void

But you can use the `return` statement in a method even if it doesn't return a value. Usually this statement is used to define an early exit from a method:

```
void setWeight(double val) {
    if (val < -1) return;
    weight = val;
}
```

This code compiles successfully.
Control exits the method if this condition is true.

Method with return type void can use return statement.

Also, the return statement must be the last statement to *execute* in a method, if present. The return statement transfers control out of the method, which means that there's no point in defining any code after it. The compiler will fail to compile such code:

```
void setWeight(double val) {
    return;
    weight = val;
}
```

The return statement
must be the last statement
to execute in a method

This code can't execute
due to the presence of the
return statement before it

Note that there's a difference in the return statement being the last statement in a method and being the last statement to execute in a method. The return statement need not be the *last statement* in a method, but it must be the *last statement to execute* in a method:

```
void setWeight(double val) {
    if (val < 0)
        return;           ←①
    else
        weight = val;
}
```

In the preceding example, the return statement ① isn't the last statement in this method. But it's the last statement to execute for method parameter values of less than zero.

RULES TO REMEMBER WHEN DEFINING A RETURN STATEMENT

Here are some items to note when defining a return statement:

- For a method that returns a value, the return statement must be followed immediately by a value.
- For a method that doesn't return a value (return type is void), the return statement must *not* be followed by a return value.
- If the compiler determines that a return statement isn't the last statement to *execute* in a method, the method will fail to compile.

RULES TO REMEMBER FOR DEFINING METHODS WITH ARGUMENTS AND RETURN TYPES

The previous list of rules will help you define a return statement in a method. Following is a set of rules to remember for the complete exam objective 6.1, "Create methods with arguments and return values":

- A method may or may not accept method arguments.
- A method may or may not return a value.

- A method returns a value by using the keyword `return`, followed by the name of a variable or an expression whose value is passed back to the calling method.
- The returned value from a method may or may not be assigned to a variable. If the value is assigned to a variable, the variable type must be compatible with the type of the return value.
- A `return` statement must be the last statement in a method. Statements placed after the `return` statements aren't reachable and fail to compile.
- A method can be an instance method (nonstatic) or a class method (static).
- A method can take zero or more parameters but can return only zero or one values.

Do you think we've covered all the rules for defining a method? Not yet! Do you think you can define multiple methods in a class with the same name? You can, but you need to be aware of some additional rules, which are discussed in the next section.

3.4 **Create an overloaded method**



[6.3] Create an overloaded method

Overloaded methods are methods with the same name but different method parameter lists. In this section, you'll learn how to create and use overloaded methods.

Imagine that you're delivering a lecture and need to instruct the audience to take notes using paper, a smart phone, or a laptop—whichever is available to them for the day. One way to do this is give the audience a list of instructions as follows:

- Take notes using paper.
- Take notes using smartphones.
- Take notes using laptops.

Another method is to instruct them to “take notes” and then provide them with the paper, a smartphone, or a laptop they’re supposed to use. Apart from the simplicity of the latter method, it also gives you the flexibility to add other media on which to take notes (such as one’s hand, some cloth, or the wall) without needing to remember the list of all the instructions.

This second approach, providing one set of instructions (with the same name) but a different set of input values can be compared to overloaded methods in Java, as shown in figure 3.15.

Again, overloaded methods are methods that are defined in the same class with the same name but with different method argument lists. As shown in figure 3.15, overloaded methods make it easier to add methods with similar functionality that work with different sets of input values.

Let's work with an example from the Java API classes that we all use frequently: `System.out.println()`. The `println` method accepts multiple types of method parameters:

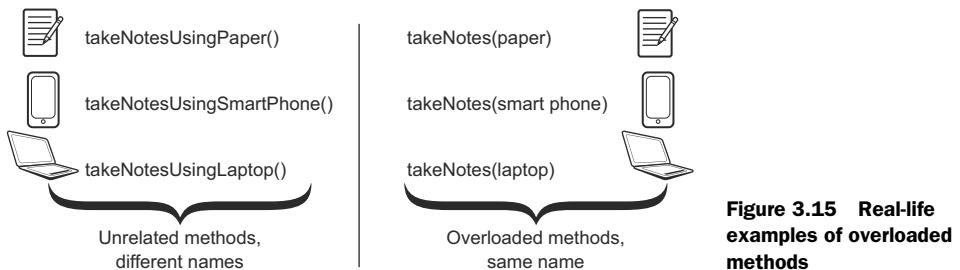


Figure 3.15 Real-life examples of overloaded methods

```

int intValue = 10;
boolean boolVal = false;
String name = "eJava";
System.out.println(intValue);   ← Prints an int value
System.out.println(boolVal);   ← Prints a boolean value
System.out.println(name);      ← Prints a string value
    
```

When you use the method `println`, you know that whatever you pass to it as a method argument will be printed to the console. Wouldn't it be crazy to use methods like `printlnInt`, `printlnBool`, and `printlnString` for the same functionality? I think so, too.

RULES TO REMEMBER FOR DEFINING OVERLOADED METHODS

Here are a few rules for defining overloaded methods:

- Overloaded methods must have different method parameters from one another.
- Overloaded methods may or may not define a different return type.
- Overloaded methods may or may not define different access modifiers.
- Overloaded methods can't be defined by only changing their return type or access modifiers.

Next, I'll describe in detail the method parameters that are passed to overloaded methods, their return types, and access modifiers.

3.4.1 Argument list

Overloaded methods accept different lists of arguments. The argument lists can differ in terms of any of the following:

- Change in the number of parameters that are accepted
- Change in the types of parameters that are accepted
- Change in the positions of the parameters that are accepted (based on parameter type, not variable names)

Following is an example of the overloaded method `calcAverage`, which accepts different numbers of method parameters:

```

double calcAverage(int marks1, double marks2) {
    return (marks1 + marks2)/2.0;
}
    
```

← Two method arguments

```
double calcAverage(int marks1, int marks2, int marks3) { ←
    return (marks1 + marks2 + marks3)/3.0;
}
```

Three method arguments

The previous code is an example of the simplest flavor of overloaded methods. You can also define overloaded methods in which the difference in the argument list is in the types of the parameters that are accepted:

```
double calcAverage(int marks1, double marks2) { ←
    return (marks1 + marks2)/2.0;
}
double calcAverage(char marks1, char marks2) { ←
    return (marks1 + marks2)/2.0;
}
```

Arguments: int, double
Arguments: char, char

The methods are also correctly overloaded if they change only the positions of the parameters that are passed to them:

```
double calcAverage(double marks1, int marks2) { ←
    return (marks1 + marks2)/2.0;
}
double calcAverage(int marks1, double marks2) { ←
    return (marks1 + marks2)/2.0;
}
```

Arguments: double, int
Arguments: int, double

Although you might argue that the arguments being accepted are one and the same, with only their positions differing, the Java compiler treats them as different argument lists. Hence, the previous code is a valid example of overloaded methods.

But an issue arises when you try to execute this method using values that can be passed to both versions of the overloaded methods. In this case, the code will fail to compile:

```
class MyClass {
    double calcAverage(double marks1, int marks2) { ←
        return (marks1 + marks2)/2.0;
    }
    double calcAverage(int marks1, double marks2) { ←
        return (marks1 + marks2)/2.0;
    }
    public static void main(String args[]) {
        MyClass myClass = new MyClass();
        myClass.calcAverage(2, 3);
    }
}
```

1 **Method parameters: double and int**
2 **Method parameters: int and double**
3 **Compiler can't determine which overloaded method calcAverage should be called**

In the previous code, ① defines the method `calcAverage`, which accepts two method parameters: a `double` and an `int`. ② defines the overloaded method `calcAverage`, which accepts two method parameters: an `int` and a `double`. Because an `int` literal value can be passed to a variable of type `double`, literal values 2 and 3 can be passed to

both the overloaded methods declared at ❶ and ❷. Because this method call is dubious, ❸ fails to compile.

3.4.2 Return type

Methods can't be defined as overloaded methods if they differ only in their return types:

```
double calcAverage(int marks1, int marks2) {           ← Return type of method
    return (marks1 + marks2)/2.0;
}
int calcAverage(int marks1, int marks2) {             ← Return type
    return (marks1 + marks2)/2.0;
}
```

The previous methods can't be termed overloaded methods. If they're defined within the same class, they won't compile. The code also won't compile if one of the methods is defined in a subclass or derived class.

3.4.3 Access modifier

Methods can't be defined as overloaded methods if they only differ in their access modifiers:

```
public double calcAverage(int marks1, int marks2) {   ← Access—public
    return (marks1 + marks2)/2.0;
}
private double calcAverage(int marks1, int marks2) {   ← Access—private
    return (marks1 + marks2)/2.0;
}
```

If you define overloaded `calcAverage` methods as shown in the preceding code, the code won't compile.

HOW TO REMEMBER THE RULES OF DEFINING OVERLOADED METHODS

An interesting way to remember the preceding rules for overloaded methods is illustrated in figure 3.16 with faces that have varying shapes. These faces also differ in the shapes of their noses and lips, and the number and shapes of their hairs. These faces are like methods and their parts are like the different parts of a method:

- Shape of face (triangle, oval, square) = method name
- Shape of nose = method's return type
- Shape of lips = method's access modifier
- Hair = method parameters

Your task is to encircle all the methods (faces) that you think overload the method (face) in the center. To get you started, I have circled one of the faces.

In the next section, you'll create special methods called constructors, which are used to create objects of a class.

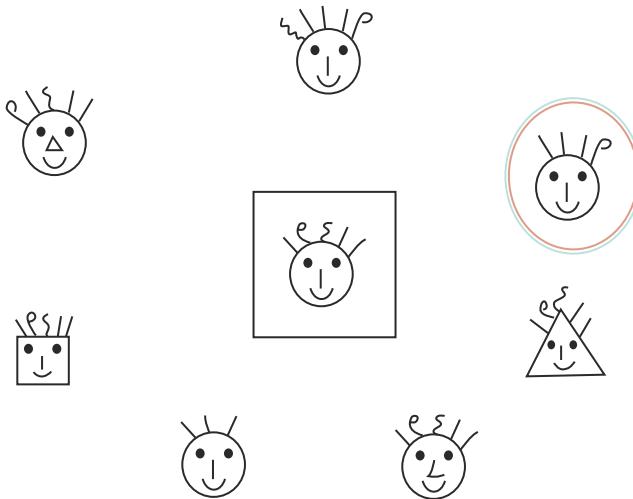


Figure 3.16 An interesting exercise to remember method-overloading rules

3.5 Constructors of a class

-  [6.4] Differentiate between default and user-defined constructors

-  [6.5] Create and overload constructors

In this section, you'll create constructors, learn the differences between default and user-defined constructors, and create overloaded constructors.

What happens when you open a new bank account? Depending on the services your bank provides, you may be assigned a new bank account number, provided with a checkbook, and given access to a new online account the bank has created for you. These details are created and returned to you as part of setting up your new bank account.

Compare these steps with what a constructor does in Java, as illustrated in figure 3.17.

Constructors are special methods that create and return an object of the class in which they're defined. Constructors have the same name as the name of the class in which they're defined, and they don't specify a return type—not even void.

A constructor can accomplish the following tasks:

- Call the base class's constructor; this can be an implicit or explicit call.
- Initialize all of the instance variables of a class with their default values.

Constructors come in two flavors: user-defined constructors and default constructors, which we'll cover in detail in the next sections.

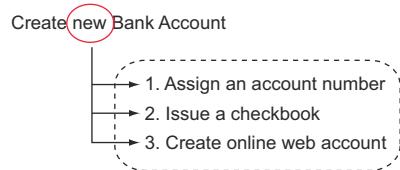


Figure 3.17 The series of steps that may be executed when you create a new bank account. These steps can be compared with what a constructor does in Java.

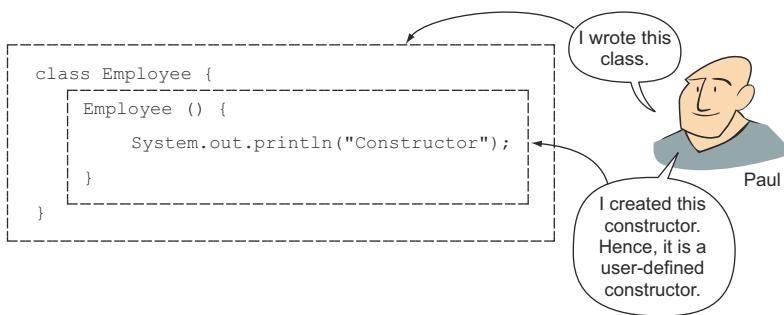


Figure 3.18 A class, `Employee`, with a constructor defined by the user Paul

3.5.1 User-defined constructors

The author of a class has full control over the definition of the class. An author may or may not define a constructor in a class. If the author does define a constructor in a class, it's known as a *user-defined constructor*. Here the word "user" doesn't refer to another person or class that uses this class, but instead refers to the person who created the class. It's called "user-defined" because it's not created by the Java compiler.

Figure 3.18 shows a class `Employee` that defines a constructor.

Here is a class, `Office`, which creates an object of class `Employee`:

```

class Office {
    public static void main(String args[]) {
        Employee emp = new Employee();
    }
}

```

① Constructor is called on object creation

In the previous example, ① creates an object of class `Employee` using the keyword `new`, which triggers the execution of the `Employee` class constructor. The output of the class `Office` is as follows:

Constructor

Because a constructor is called as soon as an object is created, you can use it to assign default values to the instance variable of your class, as follows (modified and additional code is highlighted in bold):

```

class Employee {
    String name;
    int age;
    Employee() {
        age = 20;
        System.out.println("Constructor");
    }
}

```

Instance variable

Initialize age

Let's create an object of class `Employee` in class `Office` and see if there's any difference:

```

class Office {
    public static void main(String args[]) {

```

```

Employee emp = new Employee();
System.out.println(emp.age);
}
}

```

Access and print the value of variable age

The output of the previous code is as follows:

```
Constructor
20
```

Because a constructor is a method, you can also pass method parameters to it, as follows (changes are highlighted in bold):

```

class Employee {
    String name;
    int age;
    Employee(int newAge, String newName) {
        name = newName;
        age = newAge;
        System.out.println("Constructor");
    }
}

```

You can use this constructor in the class `Office` by passing to it the required method arguments, as follows:

```

class Office {
    public static void main(String args[]) {
        Employee emp = new Employee(30, "Pavni Gupta");
    }
}

```

Revisit the use and declaration of the previously mentioned constructors. Note that a constructor is called when you create an object of a class. A constructor does have an implicit return type, which is the class in which it's defined. It creates and returns an object of its class, which is why you can't define a return type for a constructor. Also note that you can define constructors using any of the four access modifiers.



EXAM TIP You can define a constructor using all four access modifiers: `public`, `protected`, `default`, and `private`.

What happens if you define a return type for a constructor? Java will treat it as another method, not a constructor, which also implies that it won't be called implicitly when you create an object of its class:

```

class Employee {
    void Employee() {
        System.out.println("Constructor");
    }
}
class Office {
    public static void main(String args[]) {
        Employee emp = new Employee();
    }
}

```

1 Doesn't call method Employee with return type void

In the previous example, ❶ won't call the method `Employee` with the return type `void` defined in the class `Employee`. Because the method `Employee` defines its return type as `void`, it's no longer treated as a constructor.

If the class `Employee` defines the return type of the method `Employee` as `void`, how can Java use it to create an object? The method (with the return type `void`) is reduced to the state of another method in the class `Employee`. This logic applies to all of the other data types: if you define the return type of a constructor to be any data type—such as `char`, `int`, `String`, `long`, `double`, or any other class—it'll no longer be treated as a constructor.

How do you execute such a method? By calling it explicitly, as in the following code (modified code is in bold):

```
class Employee {
    void Employee() {
        System.out.println("not a Constructor now");
    }
}
class Office {
    public static void main(String args[]) {
        Employee emp = new Employee();
        emp.Employee();           ← Prints "not a
                                Constructor now"
    }
}
```

Note that the previous method is called like any other method defined in class `Employee`. It doesn't get called automatically when you create an object of class `Employee`. As you can see in the previous code, it's perfectly fine to define a method that's not a constructor in a class with the same name. Interesting.

But note that the authors of the OCA exam also found this interesting, and you're likely to get a few tricky questions regarding this concept. Don't worry: with the right information under your belt, you're sure to answer them correctly.



EXAM TIP A constructor must not define any return type. Instead, it creates and returns an object of the class in which it's defined. If you define a return type for a constructor, it'll no longer be treated as a constructor. Instead, it'll be treated as a regular method, even though it shares the same name as its class.

INITIALIZER BLOCKS VERSUS CONSTRUCTORS

An *initializer block* is defined within a class, not as a part of a method. It executes for every object that's created for a class. In the following example, the class `Employee` defines an initializer block:

```
class Employee {
    {
        System.out.println("Employee:initializer");
    }
}
```

Initializer block

In the following code, the class `TestEmp` creates an object of class `Employee`:

```
class TestEmp {
    public static void main(String args[]) {
        Employee e = new Employee();
    }
}
```

Prints
"Employee:initializer"

If you define both an initializer and a constructor for a class, both of these will execute. The initializer block will execute prior to the constructor:

```
class Employee {
    Employee() {
        System.out.println("Employee:constructor");
    }
    {
        System.out.println("Employee:initializer");
    }
}
class TestEmp {
    public static void main(String args[]) {
        Employee e = new Employee();
    }
}
```

Creates an object of class
Employee; calls both the
initializer block and the
constructor

Constructor

Initializer block

The output of the class `TestEmp` is as follows:

```
Employee:initializer
Employee:constructor
```

Do the previous examples leave you wondering why we need both an initializer block and a constructor, if both of these execute upon the creation of an object? Initializer blocks are used to initialize the variables of anonymous classes. An *anonymous class* is a type of inner class. In the absence of a name, anonymous classes can't define a constructor and rely on an initializer block to initialize their variables upon the creation of an object of their class. Because inner classes are not on this exam, I won't discuss how to use an initializer block with an anonymous inner class.

A lot of action can happen within an initializer block: It can create local variables. It can access and assign values to instance and static variables. It can call methods and define loops, conditional statements, and try-catch-finally blocks. Unlike constructors, an initializer block can't accept method parameters.



NOTE Loops and conditional statements are covered in chapter 5, and try-catch-finally blocks are covered in chapter 7.

3.5.2 **Default constructor**

In the previous section on user-defined constructors, I discussed how a constructor is used to create an object. What happens if you don't define any constructor in a class?

The following code is an example of the class `Employee` that doesn't define a constructor:

```
class Employee {
    String name;
    int age;
}
```

No constructor is defined
in class Employee

You can create objects of this class in another class (Office), as follows:

```
class Office {
    public static void main(String args[]) {
        Employee emp = new Employee();
    }
}
```

Class Employee doesn't
define a constructor,
but this code compiles
successfully

In this case, which method creates the object of the class Employee? Figure 3.19 shows what happens when a class (Employee) is compiled that doesn't define any constructor. In the absence of a user-defined constructor, Java inserts a *default constructor*. This constructor doesn't accept any method arguments. It calls the constructor of the super (parent) class and assigns default values to all the instance variables.

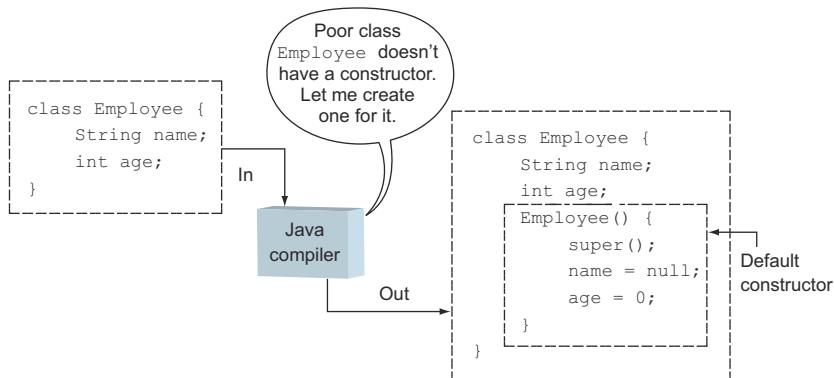


Figure 3.19 When the Java compiler compiles a class that doesn't define a constructor, the compiler creates one for it.

What happens if you add another constructor to the class `Employee`, as in the following example?

```
class Employee {
    String name;
    int age;
    Employee(int newAge, String newName) {
        name = newName;
        age = newAge;
        System.out.println("User defined Constructor");
    }
}
```

User-defined
constructor

In this case, upon recompilation, the Java compiler will notice that you've defined a constructor in the class `Employee`. It won't add a default constructor to it, as shown in figure 3.20.

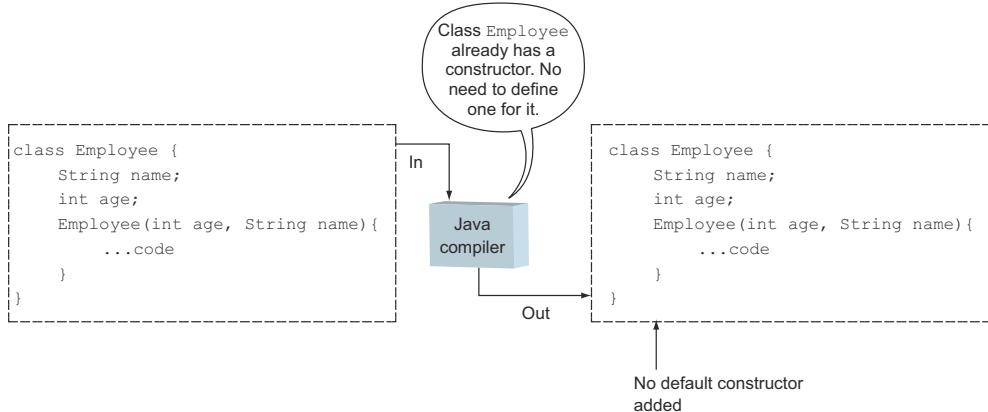


Figure 3.20 When a class with a constructor is compiled, the Java compiler doesn't add a default constructor to it.

In the absence of a no-argument constructor, the following code will fail to compile:

```

class Office {
    public static void main(String args[]) {
        Employee emp = new Employee(); ← Won't compile
    }
}

```



EXAM TIP Java defines a default constructor if and only if you don't define a constructor. If a class doesn't define a constructor, the compiler will add a default, no-argument constructor to the class. But if you modify the class later by adding a constructor to it, the Java compiler will remove the default, no-argument constructor that it initially added to the class.

3.5.3 Overloaded constructors

In the same way in which you can overload methods in a class, you can also overload the constructors in a class. *Overloaded constructors* follow the same rules as discussed in the previous section for overloaded methods. Here's a quick recap:

- Overloaded constructors must be defined using different argument lists.
- Overloaded constructors can't be defined by just a change in the access modifiers.

Because constructors don't define a return type, there's no point to defining invalid overloaded constructors with different return types.

The following is an example of an `Employee` class that defines four overloaded constructors:

```

class Employee {
    String name;
    int age;
    Employee() {
        name = "John";
    }
    Employee(String name) {
        this.name = name;
    }
    Employee(int age) {
        this.age = age;
    }
    Employee(int age, String name) {
        this.age = age;
        this.name = name;
    }
}

```

1 No-argument constructor

```

        age = 25;
    }
Employee(String newName) {
    name = newName;
    age = 25;
}
Employee(int newAge, String newName) {
    name = newName;
    age = newAge;
}
Employee(String newName, int newAge) {
    name = newName;
    age = newAge;
}
}

```

Annotations:

- ① Constructor with no arguments
- ② Constructor with one String argument
- ③ Constructor with two arguments—int and String
- ④ Constructor with two arguments—String and int

In the previous code, ① defines a constructor that doesn't accept any method arguments. ② defines another constructor that accepts a single method argument. Note the constructors defined at ③ and ④. Both of these accept two method arguments, String and int. But the placement of these two method arguments is different in ③ and ④, which is acceptable and valid for overloaded constructors and methods.

INVOKING AN OVERLOADED CONSTRUCTOR FROM ANOTHER CONSTRUCTOR

It's common to define multiple constructors in a class and reuse their functionality across constructors. Unlike overloaded methods, which can be invoked using the name of a method, overloaded constructors are invoked by using the keyword `this`—an implicit reference that's accessible to all objects that refer to an object itself:

```

class Employee {
    String name;
    int age;
    Employee() {
        this(null, 0);
    }
    Employee(String newName, int newAge) {
        name = newName;
        age = newAge;
    }
}

```

Annotations:

- ① No-argument constructor
- ② Invokes constructor that accepts two method arguments
- ③ Constructor that accepts two method arguments

The code at ① creates a no-argument constructor. At ②, this constructor calls the overloaded constructor by passing to it values null and 0. ③ defines an overloaded constructor that accepts two method arguments.

Because a constructor is defined using the name of its class, it's a common mistake to try to invoke a constructor from another constructor using the class's name:

```

class Employee {
    String name;
    int age;
    Employee() {
        Employee(null, 0);
    }
}

```

Annotation:

- ④ Won't compile—you can't invoke a constructor within a class by using the class's name.

```
Employee(String newName, int newAge) {
    name = newName;
    age = newAge;
}
}
```

Also, when you invoke an overloaded constructor using the keyword `this`, it must be the first statement in your constructor:

```
class Employee {
    String name;
    int age;
    Employee() {
        System.out.println("No-argument constructor");
        this(null, 0);
    }
    Employee(String newName, int newAge) {
        name = newName;
        age = newAge;
    }
}
```

**Won't compile—
the call to the
overloaded
constructor must
be the first
statement in a
constructor.**

That's not all: you can't call a constructor from any other method in your class. None of the other methods of the class `Employee` can invoke its constructor.

RULES TO REMEMBER

Here's a quick list of rules to remember for the exam for defining and using overloaded constructors:

- Overloaded constructors must be defined using different argument lists.
- Overloaded constructors can't be defined by just a change in the access modifiers.
- Overloaded constructors may be defined using different access modifiers.
- A constructor can call another overloaded constructor by using the keyword `this`.
- A constructor can't invoke a constructor by using its class's name.
- If present, the call to another constructor must be the first statement in a constructor.

The next Twist in the Tale exercise hides an important concept within its code, which you can get to know only if you execute the modified code (answer in the appendix).

Twist in the Tale 3.2

Let's modify the definition of the class `Employee` that I used in the section on overloaded constructors, as follows:

```
class Employee {
    String name;
    int age;
    Employee() {
        this ();
    }
    Employee (String newName, int newAge) {
```

```

        name = newName;
        age = newAge;
    }
}

```

What is the output of this modified code, and why?

Now that you've seen how to create methods, constructors, and their overloaded variants, we'll turn to how all of these can be used to access and modify object fields in the next section.

3.6 Accessing object fields



[2.3] Read or write to object fields



[2.5] Call methods on objects

In this section, you'll read, initialize, and modify object fields. You'll also learn the correct notation used to call methods on objects. Access modifiers also determine whether you can call a method on an object.

3.6.1 What is an object field?

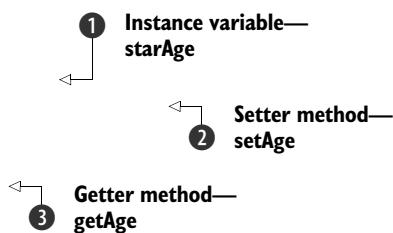
An *object field* is another name for an instance variable defined in a class. I've often seen certification aspirants who are confused over whether the object fields are the same as instance variables of a class.

Here's an example of the class Star:

```

class Star {
    double starAge;
    public void setAge(double newAge) {
        starAge = newAge;
    }
    public double getAge() {
        return starAge;
    }
}

```



In the previous example, ① defines an instance variable, `starAge`. ② defines a *setter* method, `setAge`. A *setter* method is used to set the value of a variable. ③ defines a *getter* method, `getAge`. A *getter* method is used to retrieve the value of a variable. In this example, the object field is `starAge`, not `age` or `newAge`. The name of an object field is not determined by the name of its *getter* or *setter* methods.

3.6.2 Read and write object fields

The OCA Java SE 7 Programmer I exam will test you on how to read values from and write them to fields of an object, which can be accomplished by any of following:

JavaBeans properties and object fields

The reason for the confusion over the name of the object field is that Java classes can also be used to define visual components called *JavaBeans*, which are used in visual environments. These classes are supposed to define getter and setter methods to retrieve and set the properties of the visual components. If a visual Java-Bean component defines a property such as `age`, then the name of its getter and setter methods would be `getAge` and `setAge`. For a JavaBean, you don't have to worry about the name of the variable that's used to store the value of this property. In a JavaBean, an object field `thisIsMyAge` can be used to store the value of its *property* `age`.

Note that the JavaBeans I mentioned aren't Enterprise JavaBeans. Enterprise JavaBeans are used in enterprise applications written in Java, which run on servers.

- Using methods to read and write object fields
- Using constructors to write values to object fields
- Directly accessing instance variables to read and write object fields

This exam objective (2.3) will also test your understanding of how to assign different values to the same object fields for multiple objects. Let's start with an example:

```
class Employee {
    String name;
    int age;
    Employee() {
        age = 22;
    }
    public void setName(String val) {
        name = val;
    }
    public void printEmp() {
        System.out.println("name = " + name + " age = " + age);
    }
}
```

In class `Employee`, ① defines two object fields: `name` and `age`. It defines a (no-argument) constructor. And ② assigns a value of 22 to its field `age`. This class also defines a method `setName` where ③ assigns the value passed to it to the object field `name`. The method `printEmp` is used to print the values of object fields `name` and `age`.

The following is the definition of a class, `Office`, which creates two instances, `e1` and `e2`, of the class `Employee` and assigns values to its fields. Let's look at the output of the class `Office`:

```
class Office {
    public static void main(String args[]) {
        Employee e1 = new Employee();
        Employee e2 = new Employee();
        e1.name = "Selvan";
        e2.setName("Harry");
```

```

        e1.printEmp();
        e2.printEmp();
    }
}

```

This is the output of the previous code:

```

name = Selvan age = 22
name = Harry age = 22

```

Figure 3.21 defines object diagrams (a diagram with the name and type of an object, the name of the object's fields, and their corresponding values), which will help you to better understand the previous output.

You can access the object field name of the object of class Employee either by using its variable name or by using the method setName. The following line of code assigns a value Selvan to the field name of object e1:

```
e1.name = "Selvan";
```

The following line of code uses the method setName to assign a value of Harry to the field name of object e2:

```
e2.setName("Harry");
```

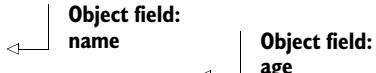
Because the constructor of the class Employee assigns a value of 22 to the variable age, objects e1 and e2 both contain the same value, 22.

What happens if you don't assign any value to an object field and try to print out its value? All the instance variables (object fields) are assigned their default values if you try to access or read their values before writing any values to them:

```

class Employee {
    String name;
    int age;
    public void printEmp() {
        System.out.println("name = " + name + " age = " + age);
    }
}
class Office {
    public static void main(String args[]) {
        Employee e1 = new Employee();
        e1.printEmp();
    }
}

```



The diagram shows two separate boxes, each representing an object. The left box is labeled 'e1:Employee' and the right box is labeled 'e2:Employee'. Both boxes have two entries: 'Object field: name' and 'Object field: age'. Arrows point from the labels to the corresponding values: 'name = Selvan' and 'age = 22' for e1, and 'name = Harry' and 'age = 22' for e2.

The output of the previous code is as follows (the default value of an object is null and int is 0):

```
name = null age = 0
```

What happens if you change the access modifier of the variable name to private, as shown here (modified code in bold)?

```

class Employee {
    private String name;
    int age;
    Employee() {
        age = 22;
    }
    public void setName(String val) {
        name = val;
    }
    public void printEmp() {
        System.out.println("name = " + name + " age = " + age);
    }
}

```

You won't be able to set the value of the object field name as follows:

```
e1.name = "Selvan";
```

This line of code won't compile. Instead, it complains that the variable name has private access in the class Employee and can't be accessed from any other class:

```
Office.java:6:  name has private access in Employee
    e1.name = "Selvan";
```

When you answer questions on reading values from and writing them to an object field, watch out for the following points, which will help you escape traps laid by the authors of the OCA Java SE 7 Programmer I exam:

- Access modifier of the object field
- Access modifiers of methods used to read and write value of the object field
- Constructors that assign values to object fields

3.6.3 Calling methods on objects

You can call methods defined in a class using an object reference variable. In this exam objective, the OCA Java SE 7 Programmer I exam will specifically test you on the following:

- The correct notation used to call a method on an object reference variable
- The right number of method parameters that must be passed to a method
- The return value of a method that's assigned to a variable

Java uses the dot notation (.) to execute a method on a reference variable. Suppose the class Employee is defined as follows:

```

class Employee {
    private String name;
    public void setName(String val) {
        name = val;
    }
}

```

You can create an object of class Employee and call the method setName on it like this:

```
Employee e1 = new Employee();
e1.setName("Java");
```

The following method invocations aren't valid in Java:

```
e1->setName("Java");
e1->.setName("Java");
e1-setName("Java");
```

Invalid method invocations

When you call a method, you must pass to it the exact number of method parameters that are defined by it. In the previous definition of the `Employee` class, the method `setName` defines a method parameter of type `String`. You can pass a literal value or a variable to a method, as a method parameter. The following code invocations are correct:

```
Employee e1 = new Employee();
String anotherVal = "Harry";
e1.setName("Shreya");
e1.setName(anotherVal);
```

Passing literal value as method parameter

Passing variable as method parameter

If the parameter list of the called method defines a variable argument at the rightmost position, you can call the method with a variable number of arguments. Let's add a method `daysOffWork` in the class `Employee` that accepts a variable list of arguments (modifications in bold):

```
class Employee {
    private String name;
    public void setName(String val) {
        name = val;
    }
    public int daysOffWork(int... days) {
        int daysOff = 0;
        for (int i = 0; i < days.length; i++)
            daysOff += days[i];
        return daysOff;
    }
}
```

You can call this method using a variable list of arguments:

```
Class Test {
    public static void main(String args[]) {
        Employee e = new Employee();
        System.out.println(e.daysOffWork(1, 2, 3, 4)); ←
        System.out.println(e.daysOffWork(1, 2, 3)); ←
    }
}
```

Call method daysOffWork with four method arguments

Call method daysOffWork with three method arguments

The output of the previous code is as follows:

```
10
6
```

Let's add a method `getName` to the class `Employee` that returns a `String` value (changes in bold):

```
class Employee {
    private String name;
    public void setName(String val) {
        name = val;
    }
}
```

```
public String getName() {
    return name;
}
```

You can assign the `String` value returned from the method `getName` to a `String` variable or pass it on to another method, as follows:

```
Employee e1 = new Employee();
Employee e2 = new Employee();
String name = e1.getName(); ← Assign method's return
e2.setName(e1.getName()); ← value to a variable
                           Pass the method's return
                           value to another method
```

In the previous code, the return type of method `setName` is `void`; therefore, you can't use it to assign a value to a variable:

```
Employee e1 = new Employee();
String name = e1.setName(); ← Won't compile
```

Also, you can't assign a return value of a method to an incompatible variable, as follows:

```
Employee e1 = new Employee();
int val = e1.getName(); ← You can't assign the String returned from
                           method getName to an int variable
```

You can read and write object fields either by using methods or by directly accessing the instance variables of a class. But it's not a good idea to enable access to the instance variables outside a class.

In the next section, you'll see the risks of exposing instance variables outside a class and the benefits of a well-encapsulated class.

3.7 *Apply encapsulation principles to a class*



[6.7] Apply encapsulation principles to a class

As the heading of this section suggests, we'll apply the encapsulation principle to a class. A well-encapsulated object doesn't expose its internal parts to the outside world. It defines a set of methods that enable the users of the class to interact with it.

As an example from the real world, you can compare a bank to a well-encapsulated class. A bank doesn't expose its internal parts—for example, its vaults and bank accounts—to the outside world, just as a well-encapsulated class in Java shouldn't expose the variables that it uses to store the state of an object outside of that object. The way a bank defines a set of procedures (such as key access to vaults and verification before money withdrawals) to protect its internal parts is much like the way a well-encapsulated class defines methods to access its variables.

3.7.1 *Need for encapsulation*

The private members of a class—its variables and methods—are used to hide information about a class. Why would you need to hide information in a class? Compare a class with yourself. Do you want anyone else to know about all of your weaknesses? Do you

want anyone else to be able to control your mind? The same applies to a class that you define in Java. A class may need a number of variables and methods to store an object's state and define its behavior. But it wouldn't like all the other classes to know about it.

Let's work with an example to help you get the hang of this concept. Here's the definition of a class Phone:

```
class Phone {
    String model;
    String company;
    double weight;
    void makeCall(String number) {
    }
    void receiveCall() {
    }
}
```

Because the variable `weight` isn't defined as a `private` member, any other class can access it and write any value to it, as follows:

```
class Home {
    public static void main() {
        Phone ph = new Phone();
        ph.weight = -12.23;
    }
}
```

3.7.2 Apply encapsulation

In the previous section, you might have noticed that the object fields of a class that isn't well encapsulated are exposed outside of the class. This approach enables the users of the class to assign arbitrary values to the object fields.

Should this be allowed? For example, going back to the example of the `Phone` class discussed in the previous section (3.7.1), how can the weight of a phone be a negative value?

Let's resolve this issue by defining the variable `weight` as a `private` variable in class `Phone`, as follows (irrelevant changes have been omitted):

```
class Phone {
    private double weight;
}
```

But now this variable won't be accessible in class `Home`. Let's define methods using this variable, which can be accessible outside the class `Phone` (changes in bold):

```
class Phone {
    private double weight;
    public void setWeight(double val) {
        if (val > 0 && val < 1000) {
            weight = val;
        }
    }
}
```

```

    public double getWeight() {
        return weight;
    }
}

```

The method `setWeight` doesn't assign the value passed to it as a method parameter to the instance variable `weight` if it's a negative value or a value greater than 1,000. This behavior is known as exposing object functionality using public methods.

Let's see how this method is used to assign a value to the variable `weight` in the class `Home`:

```

class Home {
    public static void main(String[] args) {
        Phone ph = new Phone();
        ph.setWeight(-12.23);
Prints 0.0 → System.out.println(ph.getWeight());
        ph.setWeight(77712.23);
Prints 0.0 → System.out.println(ph.getWeight());
        ph.setWeight(12.23);
        System.out.println(ph.getWeight());
    }
}

```

Note that when the class `Home` tries to set the value of the variable to `-12.23` or `77712.23` (out-of-range values), those values aren't assigned to the `Phone`'s private variable `weight`. It accepts the value `12.23`, which is within the defined range.

On the OCA Java SE 7 Programmer I exam, you may also find the term "information hiding." *Encapsulation* is the concept of defining variables and the methods together in a class. *Information hiding* originated from the application and purpose of the concept of encapsulation. These terms are also used interchangeably.



EXAM TIP The terms *encapsulation* and *information hiding* are used interchangeably. By exposing object functionality only through methods, you can prevent your private variables from being assigned any values that don't fit your requirements. One of the best ways to create a well-encapsulated class is to define its instance variables as private variables and allow access to these variables using public methods.

The next Twist in the Tale exercise has a little hidden trick about determining a correctly encapsulated class. Let's see if you can find it (answer in the appendix).

Twist in the Tale 3.3

Let's modify the definition of the class `Phone` that I previously used to demonstrate the encapsulation principle in this section. Given the following definition of class `Phone`, which of the options, when replacing the code on lines 1–3, makes it a well-encapsulated class?

```

class Phone {
    public String model;
    double weight; //LINE1
    public void setWeight(double w) { weight = w; } //LINE2
    public double getWeight() { return weight; } //LINE3
}

a public double weight;
private void setWeight(double w) { weight = w; }
private double getWeight() { return weight; }

b public double weight;
void setWeight(double w) { weight = w; }
double getWeight() { return weight; }

c public double weight;
protected void setWeight(double w) { weight = w; }
protected double getWeight() { return weight; }

d public double weight;
public void setWeight(double w) { weight = w; }
public double getWeight() { return weight; }

e None of the above.

```

Well-encapsulated classes don't expose their instance variables outside their class. What happens when the methods of these classes modify the state of the method arguments that are passed to them? Is this acceptable behavior? I'll discuss what happens in the next section.

3.8 Passing objects and primitives to methods



[6.8] Determine the effect upon object references and primitive values when they are passed into methods that change the values

In this section, you'll learn the difference between passing object references and primitives to a method. You'll determine the effect upon object references and primitive values when they're passed into methods that change the values.

Object references and primitives behave in a different manner when they're passed to a method because of the differences in how these two data types are internally stored by Java. Let's start with passing primitives to methods.

3.8.1 Passing primitives to methods

The value of a primitive data type is copied and passed on to a method. Hence, the variable whose value was copied doesn't change:

```

class Employee {
    int age;
    void modifyVal(int a) {
        a = a + 1;
        System.out.println(a);
    }
}

```



Method `modifyVal` accepts method argument of type `int`

```

        }
    }

class Office {
    public static void main(String args[]) {
        Employee e = new Employee();
        System.out.println(e.age);
        e.modifyVal(e.age);
        System.out.println(e.age);
    }
}

```

The code demonstrates the concept of method parameters and their scope. The variable `e` is an object of type `Employee`. In the `main` method, it is printed directly, resulting in `0`. Then, the `modifyVal` method is called with `e.age` as the argument. Inside `modifyVal`, the value of `age` is incremented by 1, but this change does not affect the original `age` field of the `e` object. When `e.age` is printed again, it still shows `0`.

The output of the previous code is as follows:

```

0
1
0

```

The method `modifyVal` ① accepts a method argument `a` of type `int`. In this method, the variable `a` is a method parameter and holds a copy of the value that is passed to it. The method increments the value of the method parameter `a` and prints its value.

When the class `Office` calls the method `modifyVal` ②, it passes a copy of the value of the object field `age` to it. The method `modifyVal` never accesses the object field `age`. Hence, after the execution of this method, the value of the method field `age` prints as `0` again.

What happens if the definition of the class `Employee` is modified as follows (modifications in bold):

```

class Employee {
    int age;
    void modifyVal(int age) {
        age = age + 1;
        System.out.println(age);
    }
}

```

The class `Office` will still print the same answer because the method `modifyVal` defines a method parameter with the name `age`. Note the following important points related to passing a method parameter to a method:

- It's okay to define a method parameter with the same name as an instance variable (or object field).
- Within a method, a method parameter takes precedence over an object field. When the method `modifyVal` refers to the variable `age`, it refers to the method parameter `age`, not the instance variable `age`. To access the instance variable `age` within the method `modifyVal`, the variable name `age` needs to be prefixed with the keyword `this` (`this` is a keyword that refers to the object itself).

The keyword `this` is discussed in detail in chapter 6.



EXAM TIP When you pass a primitive variable to a method, its value remains the same after the execution of the method. The value doesn't change, regardless of whether the method reassigns the primitive to another variable or modifies it.

3.8.2 Passing object references to methods

There are two main cases:

- When a method reassigns the object reference passed to it to another variable
- When a method modifies the state of the object reference passed to it

WHEN METHODS REASSIGN THE OBJECT REFERENCES PASSED TO THEM

When you pass an object reference to a method, the method can assign it to another variable. In this case, the state of the object, which was passed on to the method, remains intact.

The following code example explains this concept. Suppose you have the following definition of class Person:

```
class Person {
    private String name;
    Person(String newName) {
        name = newName;
    }
    public String getName() {
        return name;
    }
    public void setName(String val) {
        name = val;
    }
}9
```

What do you think is the output of the following code?

```
class Test {
    public static void swap(Person p1, Person p2) {
        Person temp = p1;
        p1 = p2;
        p2 = temp;
    }
    public static void main(String args[]) {
        Person person1 = new Person("John");
        Person person2 = new Person("Paul");
        System.out.println(person1.getName()
                           + ":" + person2.getName());
        swap(person1, person2);
        System.out.println(person1.getName()
                           + ":" + person2.getName());
    }
}
```

Executes
method
swap

Method to swap two
object references

① Creates
object

② Prints John:Paul
before passing
objects referred by
variable person1
and person2 to
method swap

③ Prints John:Paul
after method swap
completes execution

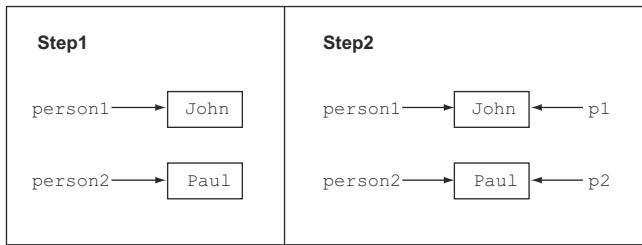


Figure 3.22 Objects of class Person, referred to by variables person1, person2, p1, and p2

In the previous code, ① creates two object references, person1 and person2, illustrated in step 1 of figure 3.22. The boxed values represent objects of class Person. ② prints John:Paul—the value of person1.name and person2.name.

The code then calls the method swap and passes to it the objects referred to by person1 and person2. When these objects are passed as arguments to the method swap, the method arguments p1 and p2 also refer to these objects. This behavior is illustrated in step 2 in figure 3.22.

The method swap defines three lines of code:

- Person temp = p1; makes temp refer to the object referred to by p1.
- p1 = p2; makes p1 refer to the object referred to by p2.
- p2 = temp; makes p2 refer to the object referred to by temp.

These three steps are represented in figure 3.23.

As you can see in figure 3.23, the reference variables person1 and person2 are still referring to the objects that they passed to the method swap. Because no change was made to the values of the objects referred to by variables person1 and person2, ③ prints John:Paul again.

The output of the previous code is:

```
John:Paul
John:Paul
```

WHEN METHODS MODIFY THE STATE OF THE OBJECT REFERENCES PASSED TO THEM

Let's see how a method can change the state of an object so that the modified state is accessible in the calling method. Assume the same definition of the class Person, listed again for your convenience:

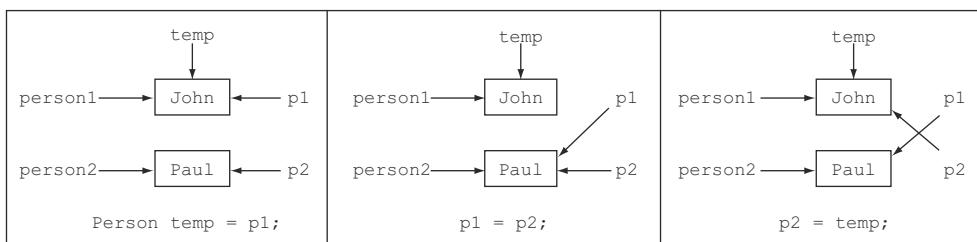


Figure 3.23 The change in the objects referred to by variables during the execution of the method swap

```

class Person {
    private String name;
    Person(String newName) {
        name = newName;
    }
    public String getName() {
        return name;
    }
    public void setName(String val) {
        name = val;
    }
}

```

What's the output of the following code?

```

class Test {
    public static void resetValueOfMemberVariable(Person p1) {
        p1.setName("Rodrigue");
    }
    public static void main(String args[]) {
        Person person1 = new Person("John");
        System.out.println(person1.getName());
        resetValueOfMemberVariable(person1);
        System.out.println(person1.getName());
    }
}

```

The output of the previous code is as follows:

```

John
Rodrigue

```

The method `resetValueOfMemberVariable` accepts the object referred to by `person1` and assigns it to the method parameter `p1`. Now both the variables `person1` and `p1` refer to the same object. `p1.setName("Rodrigue")` modifies the value of the object referred to by variable `p1`. Because the variable `person1` also refers to the same object, `person1.getName()` returns the new name, `Rodrigue`, in the method `main`. This sequence of actions is represented in figure 3.24.

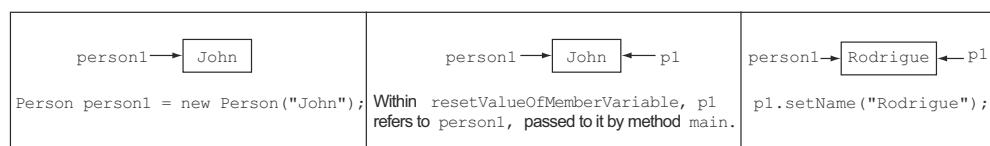


Figure 3.24 Modification of the state of an object passed to the method `resetValueOfMemberVariable`

3.9 Summary

I started this chapter by discussing the scope of these variables: local, method parameter, instance, and class. Often these variables' scopes overlap with each other. I also covered the constructors of a class: the user-defined and default constructors. Java inserts a default constructor in a class that doesn't define any constructor. You can modify the source code of such a class, add a constructor, and recompile the class. Upon recompilation, the Java compiler removes the automatically generated constructor.

I then covered the subobjective of reading from and writing to object fields. The terms *object fields* and *instance variables* have the same meaning and are used interchangeably. You can read from and write to object fields by directly accessing them or by using accessor methods. I also showed you how to apply encapsulation principles to a class and explained why doing so is useful.

Finally, I explained the effect upon references and primitives when they're passed into methods that change their values. When you pass a primitive value to a method, its value never changes for the calling method. When you pass an object reference variable to a method, a change in its value may be reflected in the calling method—if the called method modifies an object field of the object passed to it. If the called method assigns a new object reference to the method argument before modifying the value of its fields, these changes aren't visible in the calling method.

3.10 Review notes

This section lists the main points covered in this chapter.

Scope of variables:

- Variables can have multiple scopes: class, instance, local, and method parameters.
- Local variables are defined within a method. Loop variables are local to the loop within which they're defined.
- The scope of local variables is less than the scope of a method if they're declared in a sub-block (within braces, {}) in a method. This sub-block can be an `if` statement, a `switch` construct, a loop, or a `try-catch` block (discussed in chapter 7).
- Local variables can't be accessed outside the method in which they're defined.
- Instance variables are defined and accessible within an object. They're accessible to all the instance methods of a class.
- Class variables are shared by all of the objects of a class—they can be accessed even if there are no objects of the class.
- Method parameters are used to accept arguments in a method. Their scope is limited to the method where they're defined.
- A method parameter and a local variable can't be defined using the same name.
- Class and instance variables can't be defined using the same name.

- Local and instance variables can be defined using the same name. In a method, if a local variable exists with the same name as an instance variable, the local variable takes precedence.

Object's lifecycle:

- An object's lifecycle starts when it's initialized and lasts until it goes out of scope or is no longer referenced by a variable.
- When an object is alive, it can be referenced by a variable and other classes can use it by calling its methods and accessing its variables.
- Declaring a reference object variable isn't the same as creating an object.
- An object is created using the operator new. Strings have special shorthand built into the compiler. Strings can be created by using double quotes, as in "Hello".
- An object is marked as eligible for garbage collection when it can no longer be accessed.
- An object can become inaccessible if it can no longer be referenced by any variable, which happens when a reference variable is explicitly set to null or when it goes out of scope.
- You can be sure only about whether objects are marked for garbage collection. You can never be sure about whether an object has been garbage collected.

Create methods with arguments and return values:

- The return type of a method states the type of value that a method will return.
- You can define multiple method parameters for a method.
- The method parameter can be of a primitive type or objects of a class or interface.
- The method parameters are separated by commas.
- Each method parameter is preceded by the name of its type. You can't define the type of a method once, even when they're of the same type (the way you can when declaring multiple variables of same type).
- You can define only one variable argument in a parameter list, and it should be the final variable in the parameter list. If these two rules aren't followed, your code won't compile.
- For a method that returns a value, the return statement must be followed immediately by a value.
- For a method that doesn't return a value (return type is void), the return statement must not be followed by a return value.
- If there is code that can be executed only after a return statement, the class will fail to compile.
- A method can optionally accept method arguments.
- A method may optionally return a value.

- A method returns a value by using the keyword `return` followed by the name of a variable, whose value is passed back to the calling method.
- The returned value from a method may or may not be assigned to a variable. If the value is assigned to a variable, the variable type should be compatible with the type of the return value.
- A `return` statement should be the last statement in a method. Statements placed after the `return` statement aren't accessible and fail to compile.

Create an overloaded method:

- Overloaded methods accept different lists of arguments. The argument lists can differ by
 - Changes in the number of parameters that are accepted
 - Changes in the types of parameters that are accepted
 - Changes in the positions of parameters that are accepted
- Methods can't be defined as overloaded methods if they differ only in their return types or access modifiers.

Constructors of a class:

- Constructors are special methods defined in a class that create and return an object of the class in which they're defined.
- Constructors have the same name as the class, and they don't specify a return type—not even `void`.
- User-defined constructors are defined by the developer.
- Default constructors are defined by Java, but only if the developer doesn't define any constructor in a class.
- You can define a constructor using the four access modifiers: `public`, `protected`, `default`, and `private`.
- If you define a return type for a constructor, it'll no longer be treated like a constructor. It'll be treated like a regular method, even though it shares the same name as its class.
- An *initializer block* is defined within a class, not as a part of a method. It executes for every object that's created for a class.
- If you define both an initializer and a constructor for a class, both of these will execute. The initializer block will execute prior to the constructor.
- Unlike constructors, an initializer block can't accept method parameters.
- An initializer block can create local variables. It can access and assign values to instance and static variables. It can call methods and define loops, conditional statements, and `try-catch-finally` blocks.

Overloaded constructors:

- A class can also define overloaded constructors.
- Overloaded constructors should be defined using different argument lists.

- Overloaded constructors can't be defined by just a change in the access modifiers.
- Overloaded constructors may be defined using different access modifiers.
- A constructor can call another overloaded constructor by using the keyword `this`.
- A constructor can't invoke a constructor by using its class's name.
- If present, a call to another constructor should be the first statement in a constructor.

Accessing object fields:

- An object field is another name for an instance variable defined in a class.
- An object field can be read by either directly accessing the variable (if its access modifier permits) or by using a method that returns its value.
- An object field can be written by either directly accessing the variable (if its access modifier permits) or by using constructors and methods that accept a value and assign it to the instance variable.
- You can call methods defined in a class using an object reference variable.
- When calling a method, it must be passed the correct number and type of method arguments.

Applying encapsulation principles to a class:

- A well-encapsulated object doesn't expose the internal parts of an object outside it. It defines a set of well-defined interfaces (methods), which enables the users of the class to interact with it.
- A class that isn't well encapsulated is at risk of being assigned undesired values for its variables by the callers of the class, which can make the state of an object unstable.
- By exposing object functionality only through methods, you can prevent private variables from being assigned values that don't fit your requirements.
- The terms *encapsulation* and *information hiding* are also used interchangeably.
- One of the best ways to define a well-encapsulated class is to define its instance variables as private variables and allow access to these variables using methods.

Passing objects and primitives to methods:

- Objects and primitives behave in different manners when they're passed to a method, because of differences in the way these two data types are internally stored by Java.
- When you pass a primitive variable to a method, its value remains the same after the execution of the method. This doesn't change, regardless of whether the method reassigns the primitive to another variable or modifies it.
- When you pass an object to a method, the method can modify the object's state by executing its methods. In this case, the modified state of the object is reflected in the calling method.

3.11 Sample exam questions

Q3-1. How can you include encapsulation in your class design?

- a Define instance variables as private members.
- b Define public methods to access and modify the instance variables.
- c Define some of the instance variables as public members.
- d All of the above.

Q3-2. Examine the following code and select the correct option(s):

```
public class Person {
    public int height;
    public void setHeight(int newHeight) {
        if (newHeight <= 300)
            height = newHeight;
    }
}
```

- a The height of a Person can never be set to more than 300.
- b The previous code is an example of a well-encapsulated class.
- c The class would be better encapsulated if the height validation weren't set to 300.
- d Even though the class isn't well encapsulated, it can be inherited by other classes.

Q3-3. Which of the following methods correctly accepts three whole numbers as method arguments and returns their sum as a decimal number?

- a `public void addNumbers(byte arg1, int arg2, int arg3) {
 double sum = arg1 + arg2 + arg3;
}`
- b `public double subtractNumbers(byte arg1, int arg2, int arg3) {
 double sum = arg1 + arg2 + arg3;
 return sum;
}`
- c `public double numbers(long arg1, byte arg2, double arg3) {
 return arg1 + arg2 + arg3;
}`
- d `public float wakaWakaAfrica(long a1, long a2, short a977) {
 double sum = a1 + a2 + a977;
 return (float)sum;
}`

Q3-4. Which of the following statements are true?

- a If the return type of a method is `int`, the method can return a value of type `byte`.
 - b A method may or may not return a value.
 - c If the return type of a method is `void`, it can define a `return` statement without a value, as follows:
- ```
return;
```

- d** A method may or may not accept any method arguments.
- e** A method must accept at least one method argument or define its return type.
- f** A method whose return type is `String` can't return null.

**Q3-5.** Given the following definition of class `Person`,

```
class Person {
 public String name;
 public int height;
}
```

what is the output of the following code?

```
class EJavaGuruPassObjects1 {
 public static void main(String args[]) {
 Person p = new Person();
 p.name = "EJava";

 anotherMethod(p);
 System.out.println(p.name);

 someMethod(p);
 System.out.println(p.name);
 }

 static void someMethod(Person p) {
 p.name = "someMethod";
 System.out.println(p.name);
 }

 static void anotherMethod(Person p) {
 p = new Person();
 p.name = "anotherMethod";
 System.out.println(p.name);
 }
}
```

- a** anotherMethod  
anotherMethod  
someMethod  
someMethod
- b** anotherMethod  
EJava  
someMethod  
someMethod
- c** anotherMethod  
EJava  
someMethod  
EJava
- d** Compilation error.

**Q3-6.** What is the output of the following code?

```
class EJavaGuruPassPrim {
 public static void main(String args[]) {
 int ejg = 10;
 anotherMethod(ejg);
 System.out.println(ejg);
```

```

 someMethod(ejg);
 System.out.println(ejg);
 }
 static void someMethod(int val) {
 ++val;
 System.out.println(val);
 }
 static void anotherMethod(int val) {
 val = 20;
 System.out.println(val);
 }
}

a 20
10
11
11

b 20
20
11
10

c 20
10
11
10

d Compilation error

```

**Q3-7.** Given the following signature of method eJava, choose the options that correctly overload this method:

```

public String eJava(int age, String name, double duration)

a private String eJava(int val, String firstName, double dur)
b public void eJava(int val1, String val2, double val3)
c String eJava(String name, int age, double duration)
d float eJava(double name, String age, byte duration)
e ArrayList<String> eJava()
f char[] eJava(double numbers)
g String eJava()

```

**Q3-8.** Given the following code,

```

class Course {
 void enroll(long duration) {
 System.out.println("long");
 }
 void enroll(int duration) {
 System.out.println("int");
 }
 void enroll(String s) {
 System.out.println("String");
 }
}

```

```

 void enroll(Object o) {
 System.out.println("Object");
 }
}

```

what is the output of the following code?

```

class EJavaGuru {
 public static void main(String args[]) {
 Course course = new Course();
 char c = 10;
 course.enroll(c);
 course.enroll("Object");
 }
}

```

- a** Compilation error
- b** Runtime exception
- c** int  
String
- d** long  
Object

**Q3-9.** Examine the following code and select the correct options:

```

class EJava {
 public EJava() {
 this(7);
 System.out.println("public");
 }
 private EJava(int val) {
 this("Sunday");
 System.out.println("private");
 }
 protected EJava(String val) {
 System.out.println("protected");
 }
}

class TestEJava {
 public static void main(String[] args) {
 EJava eJava = new EJava();
 }
}

```

- a** The class EJava defines three overloaded constructors.
- b** The class EJava defines two overloaded constructors. The private constructor isn't counted as an overloaded constructor.
- c** Constructors with different access modifiers can't call each other.
- d** The code prints the following:

```

protected
private
public

```

- e The code prints the following:

```
public
private
protected
```

**Q3-10.** Select the incorrect options:

- a If a user defines a private constructor for a public class, Java creates a public default constructor for the class.
- b A class that gets a default constructor doesn't have overloaded constructors.
- c A user can overload the default constructor of a class.
- d The following class is eligible for a default constructor:

```
class EJava {}
```

- e The following class is also eligible for a default constructor:

```
class EJava {
 void EJava() {}
}
```

## 3.12 Answers to sample exam questions

**Q3-1.** How can you include encapsulation in your class design?

- a Define instance variables as private members.
- b Define public methods to access and modify the instance variables.
- c Define some of the instance variables as public members.
- d All of the previous.

Answer: a, b

Explanation: A well-encapsulated class should be like a capsule, hiding its instance variables from the outside world. The only way you should access and modify instance variables is through the public methods of a class to ensure that the outside world can access only the variables the class allows it to. By defining methods to assign values to its instance variables, a class can control the range of values that can be assigned to them.

**Q3-2.** Examine the following code and select the correct option(s):

```
public class Person {
 public int height;
 public void setHeight(int newHeight) {
 if (newHeight <= 300)
 height = newHeight;
 }
}
```

- a The height of a Person can never be set to more than 300.
- b The previous code is an example of a well-encapsulated class.

- c The class would be better encapsulated if the height validation weren't set to 300.
- d Even though the class isn't well encapsulated, it can be inherited by other classes.

Answer: d

Explanation: This class isn't well encapsulated because its instance variable `height` is defined as a public member. Because the instance variable can be directly accessed by other classes, the variable doesn't always use the method `setHeight` to set its height. The class `Person` can't control the values that can be assigned to its public variable `height`.

**Q3-3.** Which of the following methods correctly accepts three whole numbers as method arguments and returns their sum as a decimal number?

- a `public void addNumbers(byte arg1, int arg2, int arg3) {  
 double sum = arg1 + arg2 + arg3;  
}`
- b `public double subtractNumbers(byte arg1, int arg2, int arg3) {  
 double sum = arg1 + arg2 + arg3;  
 return sum;  
}`
- c `public double numbers(long arg1, byte arg2, double arg3) {  
 return arg1 + arg2 + arg3;  
}`
- d `public float wakaWakaAfrica(long a1, long a2, short a977) {  
 double sum = a1 + a2 + a977;  
 return (float)sum;  
}`

Answer: b, d

Explanation: Option (a) is incorrect. The question specifies the method should return a decimal number (type `double` or `float`), but this method doesn't return any value.

Option (b) is correct. This method accepts three integer values: `byte`, `int`, and `int`. It computes the sum of these integer values and returns it as a decimal number (data type `double`). Note that the name of the method is `subtractNumbers`, which doesn't make it an invalid option. Practically, one wouldn't name a method `subtractNumbers` if it's adding them. But syntactically and technically, this option meets the question's requirements and is a correct option.

Option (c) is incorrect. This method doesn't accept integers as the method arguments. The type of the method argument `arg3` is `double`, which isn't an integer.

Option (d) is correct. Even though the name of the method seems weird, it accepts the correct argument list (all integers) and returns the result in the correct data type (`float`).

**Q3-4.** Which of the following statements are true?

- a If the return type of a method is `int`, the method can return a value of type `byte`.
- b A method may or may not return a value.

- c If the return type of a method is void, it can define a return statement without a value, as follows:

```
return;
```

- d A method may or may not accept any method arguments.
- e A method should accept at least one method argument or define its return type.
- f A method whose return type is String can't return null.

Answer: a, b, c, d

Explanation: Option (e) is incorrect. There is no constraint on the number of arguments that can be passed on to a method, regardless of whether the method returns a value.

Option (f) is incorrect. You can't return the value null for methods that return primitive data types. You can return null for methods that return objects (String is a class and not a primitive data type).

**Q3-5.** Given the following definition of class Person,

```
class Person {
 public String name;
 public int height;
}
```

what is the output of the following code?

```
class EJavaGuruPassObjects1 {
 public static void main(String args[]) {
 Person p = new Person();
 p.name = "EJava";

 anotherMethod(p);
 System.out.println(p.name);

 someMethod(p);
 System.out.println(p.name);
 }

 static void someMethod(Person p) {
 p.name = "someMethod";
 System.out.println(p.name);
 }

 static void anotherMethod(Person p) {
 p = new Person();
 p.name = "anotherMethod";
 System.out.println(p.name);
 }
}

a anotherMethod
anotherMethod
someMethod
someMethod
```

- b** anotherMethod  
EJava  
someMethod  
someMethod
- c** anotherMethod  
EJava  
someMethod  
EJava
- d** Compilation error.

Answer: b

Explanation: The class EJavaGuruPassObject1 defines two methods, someMethod and anotherMethod. The method someMethod modifies the value of the object parameter passed to it. Hence, the changes are visible within this method and in the calling method (method main). But the method anotherMethod reassigns the reference variable passed to it. Changes to any of the values of this object are limited to this method. They aren't reflected in the calling method (the main method).

### Q3-6. What is the output of the following code?

```
class EJavaGuruPassPrim {
 public static void main(String args[]) {
 int ejg = 10;
 anotherMethod(ejg);
 System.out.println(ejg);
 someMethod(ejg);
 System.out.println(ejg);
 }
 static void someMethod(int val) {
 ++val;
 System.out.println(val);
 }
 static void anotherMethod(int val) {
 val = 20;
 System.out.println(val);
 }
}

a 20
10
11
11

b 20
20
11
10

c 20
10
11
10

d Compilation error
```

Answer: c

Explanation: When primitive data types are passed to a method, the values of the variables in the calling method remain the same. This behavior doesn't depend on whether the primitive values are reassigned other values or modified by addition, subtraction, or multiplication—or any other operation.

**Q3-7.** Given the following signature of method eJava, choose the options that correctly overload this method:

```
public String eJava(int age, String name, double duration)
a private String eJava(int val, String firstName, double dur)
b public void eJava(int vall, String val2, double val3)
c String eJava(String name, int age, double duration)
d float eJava(double name, String age, byte duration)
e ArrayList<String> eJava()
f char[] eJava(double numbers)
g String eJava()
```

Answer: c, d, e, f, g

Explanation: Option (a) is incorrect. Overloaded methods can change the access modifiers, but changing the access modifier alone won't make it an overloaded method. This option also changes the names of the method parameters, but that doesn't make any difference to a method signature.

Option (b) is incorrect. Overloaded methods can change the return type of the method, but changing the return type won't make it an overloaded method.

Option (c) is correct. Changing the placement of the types of the method parameters overloads it.

Option (d) is correct. Changing the return type of a method and the placement of the types of the method parameters overloads it.

Option (e) is correct. Changing the return type of a method and making a change in the parameter list overload it.

Option (f) is correct. Changing the return type of a method and making a change in the parameter list overload it.

Option (g) is correct. Changing the parameter list also overloads a method.

**Q3-8.** Given the following code,

```
class Course {
 void enroll(long duration) {
 System.out.println("long");
 }
 void enroll(int duration) {
 System.out.println("int");
 }
 void enroll(String s) {
 System.out.println("String");
```

```

 }
 void enroll(Object o) {
 System.out.println("Object");
 }
}

```

what is the output of the following code?

```

class EJavaGuru {
 public static void main(String args[]) {
 Course course = new Course();
 char c = 10;
 course.enroll(c);
 course.enroll("Object");
 }
}

```

- a** Compilation error
- b** Runtime exception
- c** int  
String
- d** long  
Object

Answer: c

Explanation: No compilation issues exist with the code. You can overload methods by changing the type of the method arguments in the list. Using method arguments with data types having a base-derived class relationship (Object and String classes) is acceptable. Using method arguments with data types for which one can be automatically converted to the other (int and long) is also acceptable.

When the code executes course.enroll(c), char can be passed to two overloaded enroll methods that accept int and long. The char gets expanded to its nearest type—int—so course.enroll(c) calls the overloaded method that accepts int, printing int. The code course.enroll("Object") is passed a String value. Although String is also an Object, this method calls the specific (not general) type of the argument passed to it. So course.enroll("Object") calls the overloaded method that accepts String, printing String.

**Q3-9.** Examine the following code and select the correct options:

```

class EJava {
 public EJava() {
 this(7);
 System.out.println("public");
 }
 private EJava(int val) {
 this("Sunday");
 System.out.println("private");
 }
}

```

```

 protected EJava(String val) {
 System.out.println("protected");
 }
 }

 class TestEJava {
 public static void main(String[] args) {
 EJava eJava = new EJava();
 }
 }
}

```

- a The class EJava defines three overloaded constructors.**
- b The class EJava defines two overloaded constructors. The private constructor isn't counted as an overloaded constructor.**
- c Constructors with different access modifiers can't call each other.**
- d The code prints the following:**

```

protected
private
public

```

- e The code prints the following:**

```

public
private
protected

```

Answer: a, d

Explanation: You can define overloaded constructors with different access modifiers in the same way that you define overloaded methods with different access modifiers. But a change in only the access modifier can't be used to define overloaded methods or constructors. `private` methods and constructors are also counted as overloaded methods.

The following line of code calls `EJava`'s constructor, which doesn't accept any method argument:

```
EJava eJava = new EJava();
```

The no-argument constructor of this class calls the constructor that accepts an `int` argument, which in turn calls the constructor with the `String` argument. Because the constructor with the `String` constructor doesn't call any other methods, it prints `protected` and returns control to the constructor that accepts an `int` argument. This constructor prints `private` and returns control back to the constructor that doesn't accept any method argument. This constructor prints `public` and returns control to the `main` method.

**Q 3-10.** Select the incorrect options:

- a If a user defines a `private` constructor for a `public` class, Java creates a `public` default constructor for the class.**
- b A class that gets a default constructor doesn't have overloaded constructors.**

- c A user can overload the default constructor of a class.

- d The following class is eligible for default constructor:

```
class EJava {}
```

- e The following class is also eligible for a default constructor:

```
class EJava {
 void EJava() {}
}
```

Answer: a, c

Explanation: Option (a) is incorrect. If a user defines a constructor for a class with any access modifier, it's no longer an eligible candidate to be provided with a default constructor.

Option (b) is correct. A class gets a default constructor only when it doesn't have any constructor. A default or an automatic constructor can't exist with other constructors.

Option (c) is incorrect. A default constructor can't coexist with other constructors. A default constructor is automatically created by the Java compiler if the user doesn't define any constructor in a class. If the user reopens the source code file and adds a constructor to the class, upon recompilation no default constructor will be created for the class.

Option (d) is correct. Because this class doesn't have a constructor, Java will create a default constructor for it.

Option (e) is also correct. This class also doesn't have a constructor, so it's eligible for the creation of a default constructor. The following isn't a constructor because the return type of a constructor isn't void:

```
void EJava() {}
```

It's a regular and valid method, with the name same as its class.

# *String, StringBuilder, Arrays, and ArrayList*

| Exam objectives covered in this chapter                                                                 | What you need to know                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|---------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [2.7] Create and manipulate strings.                                                                    | How to create <code>String</code> objects using the assignment and <code>new</code> operators. Use of the operators <code>=</code> , <code>+=</code> , <code>!=</code> , and <code>==</code> with <code>String</code> objects. Literal value for class <code>String</code> .<br>Use of methods from class <code>String</code> . Immutable <code>String</code> values. All of the <code>String</code> methods manipulate and return a new <code>String</code> object. |
| [3.3] Test equality between strings and other objects using <code>==</code> and <code>equals()</code> . | How to determine the equality of two <code>String</code> objects. Differences between using operator <code>==</code> and method <code>equals()</code> to determine equality of <code>String</code> objects.                                                                                                                                                                                                                                                          |
| [2.6] Manipulate data using the <code>StringBuilder</code> class and its methods.                       | How to create <code>StringBuilder</code> classes and how to use their commonly used methods.<br>Difference between <code>StringBuilder</code> and <code>String</code> classes. Difference between methods with similar names defined in both of these classes.                                                                                                                                                                                                       |
| [4.1] Declare, instantiate, initialize, and use a one-dimensional array.                                | How to declare, instantiate, and initialize one-dimensional arrays using single and multiple steps.<br>The do's and don'ts of each of these steps.                                                                                                                                                                                                                                                                                                                   |
| [4.2] Declare, instantiate, initialize, and use a multidimensional array.                               | How to declare, instantiate, and initialize multidimensional arrays using single and multiple steps, with do's and don'ts for each of these steps.<br>Accessing elements in asymmetric multidimensional arrays.                                                                                                                                                                                                                                                      |

| Exam objectives covered in this chapter | What you need to know                                                                                                                                             |
|-----------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [4.3] Declare and use an ArrayList.     | How to declare, create, and use an ArrayList. Advantages of using an ArrayList over arrays. Use of methods that add, modify, and delete elements of an ArrayList. |

In the OCA Java SE 7 Programmer I exam, you'll be asked many questions about how to create, modify, and delete String objects, StringBuilder objects, arrays, and ArrayList objects. To prepare you for such questions, in this chapter I'll provide insight into the variables you'll use to store these objects' values, along with definitions for some of their methods. This information should help you apply all of the methods correctly.

In this chapter, we'll cover the following:

- Creating and manipulating String and StringBuilder objects
- Using common methods from class String and StringBuilder
- Creating and using one-dimensional and multidimensional arrays in single and multiple steps
- Accessing elements in asymmetric multidimensional arrays
- Declaring, creating, and using an ArrayList and understanding the advantages of an ArrayList over arrays
- Using methods that add, modify, and delete elements of an ArrayList

## 4.1 Welcome to the world of the String class



[2.7] Create and manipulate strings



[3.3] Test equality between strings and other objects using == and equals()

In this section, we'll cover the class `String` defined in the Java API in the `java.lang` package. The `String` class represents character strings. We'll create objects of the class `String` and work with its commonly used methods, including `indexOf()`, `substring()`, `replace()`, `charAt()`, and others. You'll also learn how to determine the equality of two `String` objects.

The `String` class is perhaps the most used class in the Java API. You'll find instances of this class being used by every other class in the Java API. How many times do you think you've used the class `String`? Don't answer that question—it's like trying to count your hair.

Although many developers find the `String` class to be one of the simplest to work with, this perception can be deceptive. For example, in the `String` value "Shreya", at which position do you think is `r` stored—second or third? The correct answer is second because the first letter of a `String` is stored at position 0 and not position 1. You'll learn many other facts about the `String` class in this section.

Let's start by creating new objects of this class.

### 4.1.1 Creating String objects

You can create objects of the class `String` by using the `new` operator, by using the assignment operator (`=`), or by enclosing a value within double quotes (`"`). But you may have noticed a *big* difference in how these objects are created, stored, and referred by Java.

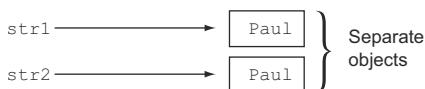
Let's create two `String` objects with the value "Paul" using the operator `new`:

```
String str1 = new String("Paul");
String str2 = new String("Paul");
System.out.println(str1 == str2);
```

**Create two String objects by using the operator new**

**When comparing the objects referred to by the variables str1 and str2, it prints false.**

Figure 4.1 illustrates the previous code.



**Figure 4.1 String objects created using the operator new always refer to separate objects, even if they store the same sequence of characters.**

In the previous code, a comparison of the `String` reference variables `str1` and `str2` prints `false`. The operator `==` compares the addresses of the objects referred to by the variables `str1` and `str2`. Even though these `String` objects store the same sequence of characters, they refer to separate objects that are stored at separate locations.

Let's create two `String` objects with the value "Harry" using the assignment operator (`=`). Figure 4.2 illustrates the variables `str3` and `str4` and the objects referred to by these variables.

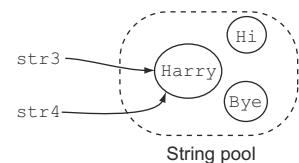
```
String str3 = "Harry";
String str4 = "Harry";
System.out.println(str3 == str4);
```

**Create two String objects by using assignment operator =**

**Prints true because str3 and str4 refer to the same object**

In the previous example, the variables `str1` and `str2` referred to different `String` objects, even if they were created using the same sequence of characters. In the case of variables `str3` and `str4`, the objects are created and stored in a *pool* of `String` objects. Before creating a new object in the pool, Java first searches for an object with similar contents. When the following line of code executes, no `String` object with the value "Harry" is found in the pool of `String` objects:

```
String str3 = "Harry";
```

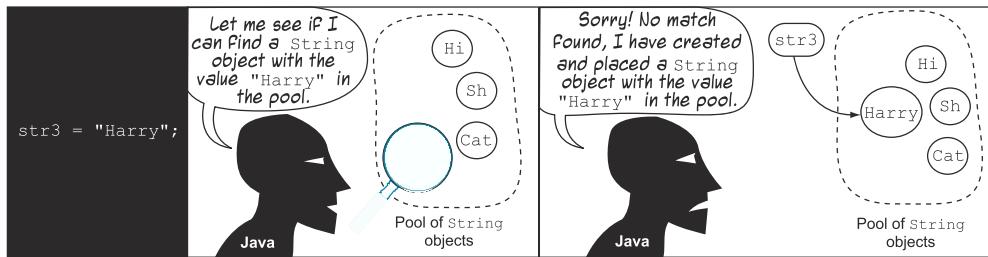


**Figure 4.2 String objects created using the assignment operator (=) may refer to the same object if they store the same sequence of characters.**

As a result, Java creates a `String` object with the value "Harry" in the pool of `String` objects referred to by variable `str3`. This action is depicted in figure 4.3.

When the following line of code executes, Java is able to find a `String` object with the value "Harry" in the pool of `String` objects:

```
String str4 = "Harry";
```



**Figure 4.3** The sequence of steps that executes when Java is unable to locate a String in a pool of String objects

Java doesn't create a new String object in this case, and the variable str4 refers to the existing String object "Harry". As shown in figure 4.4, both variables str3 and str4 refer to the same String object in the pool of String objects.

You can also create a String object by enclosing a value within double quotes (""):

`System.out.println("Morning");` Creates a new String object with value Morning in the String constant pool

These values are reused from the String constant pool if a matching value is found. If a matching value isn't found, the JVM creates a String object with the specified value and places it in the String constant pool:

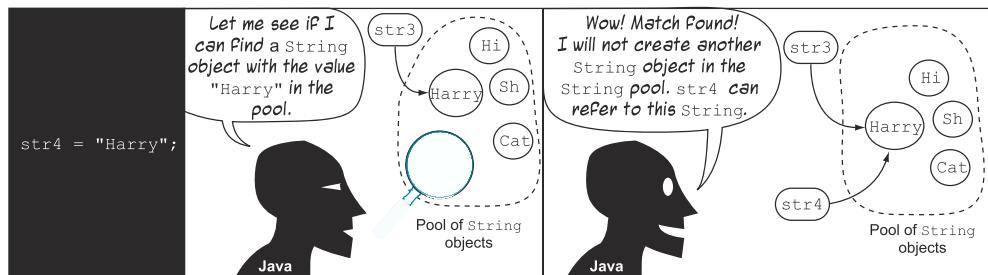
```
String morning1 = "Morning";
System.out.println("Morning" == morning1);
```

Compare the preceding example with the following example, which creates a String object using the operator new and (only) double quotes and then compares their references:

```
String morning2 = new String("Morning");
System.out.println("Morning" == morning2);
```

This String object is not placed in the String constant pool

The preceding code shows that object references of String objects that exist in the String constant pool and object references of String objects that don't exist in



**Figure 4.4** The sequence of actions that executes when Java locates a String in the pool of String objects

the String constant pool don't refer to the same String object, even if they define the same String value.



**NOTE** The terms “String constant pool” and “String pool” are used interchangeably and refer to the same pool of String objects. Because String objects are immutable, the pool of String objects is also called the “String *constant* pool.” You may see either of these terms on the exam.

You can also invoke other overloaded constructors of class String to create its objects by using the operator new:

```
String girl = new String("Shreya");
char[] name = new char[] {'P', 'a', 'u', 'l'};
String boy = new String(name);
```

String constructor  
that accepts a String

String constructor that  
accepts a char array

You can also create objects of String using the classes StringBuilder and StringBuffer:

```
StringBuilder sd1 = new StringBuilder("String Builder");
String str5 = new String(sd1);
StringBuffer sb2 = new StringBuffer("String Buffer");
String str6 = new String(sb2);
```

String constructor  
that accepts object  
of StringBuilder

String constructor that  
accepts object of StringBuffer

Because String is a class, you can assign null to it, as shown in the next example:

```
String empName = null;
```

null is a literal  
value for objects



**EXAM TIP** The literal value for String is null.

#### COUNTING STRING OBJECTS

To test your understanding on the various ways in which a String object can be created, the exam may question you on the total number of String objects created in a given piece of code. Count the total number of String objects created in the following code, assuming that the String constant pool doesn't define any matching String values:

```
class ContString {
 public static void main(String... args) {
 String summer = new String("Summer"); ←①
 String summer2 = "Summer"; ←②
 System.out.println("Summer");
 System.out.println("autumn"); ←③
 System.out.println("autumn" == "summer"); ←④
 String autumn = new String("Summer"); ←⑤
 } ←⑥
}
```

I'll walk through the code with you step by step to calculate the total number of String objects created:

- The code at ① creates a new String object with the value "Summer". This object is not placed in the String constant pool.

- The code at ② creates a new String object with the value "Summer" and places it in the String constant pool.
- The code at ③ doesn't need to create any new String object. It reuses the String object with the value "Summer" that already existed in the String constant pool.
- The code at ④ creates a new String object with the value "autumn" and places it in the String constant pool.
- The code at ⑤ reuses the String value "autumn" from the String constant pool. It creates a String object with the value "summer" in the String constant pool (note the difference in the case of letters—Java is case sEnSITVe and "Summer" is not same as "summer").
- The code at ⑥ creates a new String object with the value "Summer".
- The previous code creates a total of five String objects.



**EXAM TIP** If a String object is created using the keyword new, it always results in the creation of a new String object. A new String object gets created using the assignment operator (=) or double quotes only if a matching String object with the same value isn't found in the String constant pool.

#### 4.1.2 *The class String is immutable*

The concept that the class String is immutable is an important point to remember. Once created, the contents of an object of the class String can never be modified. The immutability of String objects helps the JVM reuse String objects, reducing memory overhead and increasing performance.

As shown previously in figure 4.4, the JVM creates a pool of String objects that can be referenced by multiple variables across the JVM. The JVM can make this optimization only because String is immutable. String objects can be shared across multiple reference variables without any fear of changes in their values. If the reference variables str1 and str2 refer to the same String object value "Java", str1 need not worry for its lifetime that the value "Java" might be changed by variable str2.

Let's take a quick look at how the immutability of class String is implemented by the authors of this class:

- The class String stores its values in a private variable of the type char array (char value[]). Arrays are fixed in size and don't grow once initialized.
- This value variable is marked as final in the class String. Note that final is a nonaccess modifier, and a final variable can be initialized only once.
- None of the methods defined in the class String manipulate the individual elements of the array value.

I'll discuss each of these points in detail in the following sections.

### Code from Java API classes

To get a better understanding of how classes `String`, `StringBuilder`, and `ArrayList` work, I'll explain the variables used to store these objects' values, along with definitions for some of their methods. My purpose is not to overwhelm you, but to prepare you. The exam won't question you on this subject, but these details will help you retain relevant information for the exam and implement similar requirements in code for practical projects.

The source code of the classes defined in the Java API is shipped with the Java Development Kit (JDK). You can access it by unzipping the folder `src` from your JDK's installation folder.

The rest of this section discusses how the authors of the Java API have implemented immutability in the class `String`.

#### STRING USES A CHAR ARRAY TO STORE ITS VALUE

Here's a partial definition of the class `String` from the Java source code file (`String.java`) that includes the array used to store the characters of a `String` value (the relevant code is in bold):

```
public final class String
 implements java.io.Serializable, Comparable<String>, CharSequence
{
 private final char value[];
 | The rest of the code
 | of the class String
 |
 |
}
```

The value array is used  
for character storage

The arrays are fixed in size—they can't grow once they're initialized.

Let's create a variable name of type `String` and see how it's stored internally:

```
String name = "Selvan";
```

Figure 4.5 shows a UML representation (class diagram on the left and object diagram on the right) of the class `String` and its object name, with only one relevant variable, `value`, which is an array of the type `char` and is used to store the sequence of characters assigned to a `String`.

As you can see in figure 4.5, the `String` value `Selvan` is stored in an array of type `char`. In this chapter, I'll cover arrays in detail, as well as how an array stores its first value at position 0.

|                               |                                                     |
|-------------------------------|-----------------------------------------------------|
| <code>String</code>           | <code>name : String</code>                          |
| <code>- value : char[]</code> | <code>value = {'S', 'e', 'l', 'v', 'a', 'n'}</code> |
| <code>:</code>                | <code>:</code>                                      |

**Figure 4.5 UML presentations of the class `String` and a `String` object with only one variable**



**Figure 4.6 Mapping characters stored by a String with the positions at which they're stored**

Figure 4.6 shows how Selvan is stored as a char array.

What do you think you'll get when you request that this String return the character at position 4? If you said a and not v, you got the right answer (as in figure 4.6).

#### STRING USES FINAL VARIABLE TO STORE ITS VALUE

The variable value, which is used to store the value of a String object, is marked as final. Review the following code snippet from the class `String.java`:

```
private final char value[]; ← | value is used for
 | character storage
```

The basic characteristic of a final variable is that it can initialize a value only once. By marking the variable `value` as final, the class `String` makes sure that it can't be reassigned a value.

#### METHODS OF STRING DON'T MODIFY THE CHAR ARRAY

Although we can't reassign a value to a final char array (as mentioned in the previous section), we can reassign its individual characters. Wow—does this mean that the statement “Strings are immutable” isn't completely true?

No, that statement is still true. The char array used by the class `String` is marked private, which means that it isn't accessible outside the class for modification. The class `String` itself doesn't modify the value of this variable, either.

All the methods defined in the class `String`, such as `substring`, `concat`, `toLowerCase`, `toUpperCase`, `trim`, and so on, which seem to modify the contents of the `String` object on which they're called, create and return a new `String` object, rather than modifying the existing value. Figure 4.7 illustrates the partial definition of `String`'s `replace` method.

I'll reiterate that the previous code from the class `String` will help you relate the theory to the code and understand how and why a particular concept works. If you understand a particular concept well in terms of how and why it works, you'll be able to retain that information longer.

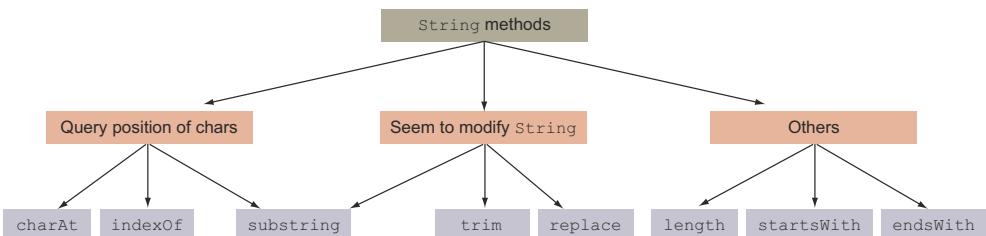
```
public String replace(char oldChar, char newChar) {
 if (oldChar != newChar) {
 // code to create a new char array and
 // replace the desired char with the new char

 return new String(0, len, buf);
 }
 return this;
}
```

↑

replace creates and returns a new String object. It doesn't modify the existing array value.

**Figure 4.7 The partial definition of the method replace from the class String shows that this method creates and returns a new String object rather than modifying the value of the String object on which it's called.**

**Figure 4.8 Categorization of the String methods**

**EXAM TIP** Strings are immutable. Once initialized, a String value can't be modified. All the String methods that return a modified String value return a new String object with the modified value. The original String value always remains the same.

#### 4.1.3 Methods of the class String

Figure 4.8 categorizes the methods that are on the exam into groups: ones that query positions of characters, ones that seem to modify String, and others.

Categorizing the methods in this way will help you better understand these methods. For example, the methods `charAt()`, `indexOf()`, and `substring()` query the position of individual characters in a String. The methods `substring()`, `trim()`, and `replace()` seem to be modifying the value of a String.

##### CHARAT()

You can use the method `charAt(int index)` to retrieve a character at a specified index of a String:

```
String name = new String("Paul");
System.out.println(name.charAt(0));
System.out.println(name.charAt(2));
```

Prints P  
Prints u

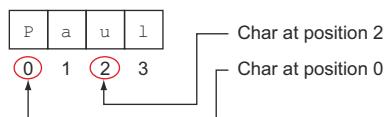
Figure 4.9 illustrates the previous string, Paul.

Because the last character is placed at index 3, the following code will throw an exception at runtime:

```
System.out.println(name.charAt(4));
```



**NOTE** As a quick introduction, a *runtime exception* is a programming error determined by the Java Runtime Environment (JRE) during the execution of code. These errors occur because of the inappropriate use of another piece of code (exceptions are covered in detail in chapter 7). The previous code tries to access a nonexistent index position, so it causes an exception.

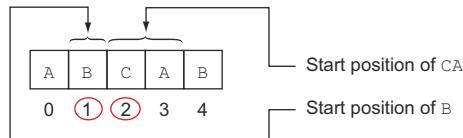
**Figure 4.9 The sequence of characters of "Paul" stored by String and the corresponding array index positions**

**INDEXOF()**

You can search a String for the occurrence of a char or a String. If the specified char or String is found in the target String, this method returns the first matching position; otherwise, it returns -1:

```
String letters = "ABCAB";
System.out.println(letters.indexOf('B'));
System.out.println(letters.indexOf("S"));
System.out.println(letters.indexOf("CA"));
```

Figure 4.10 illustrates the previous string ABCAB.



**Figure 4.10** The characters "ABCAB" stored by String

By default, the `indexOf()` method starts its search from the first char of the target String. If you wish, you can also set the starting position, as in the following example:

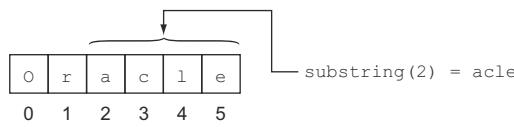
```
String letters = "ABCAB";
System.out.println(letters.indexOf('B', 2));
```

**SUBSTRING()**

The `substring()` method is shipped in two flavors. The first returns a substring of a String from the position you specify to the end of the String, as in the following example:

```
String exam = "Oracle";
String sub = exam.substring(2);
System.out.println(sub);
```

Figure 4.11 illustrates the previous example.



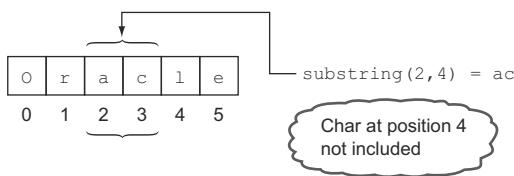
**Figure 4.11** The String "Oracle"

You can also specify the end position with this method:

```
String exam = "Oracle";
String result = exam.substring(2, 4);
System.out.println(result);
```

Figure 4.12 illustrates the String value "Oracle", including both a start and end point for the method `substring`.

An interesting point is that the `substring` method doesn't include the character at the end position. In the previous example, `result` is assigned the value `ac` (characters at positions 2 and 3), not the value `acl` (characters at positions 2, 3, and 4).



**Figure 4.12** How the method `substring` looks for the specified characters from the start until the end position



**EXAM TIP** The `substring` method doesn't include the character at the end position in its return value.

### **TRIM()**

The `trim()` method returns a new `String` by removing all the leading and trailing *white space* in a `String`. White spaces are blanks (new lines, spaces, or tabs).

Let's define and print a `String` with leading and trailing white space. (The colons printed before and after the `String` determine the start and end of the `String`.)

```
String varWithSpaces = " AB CB ";
System.out.print(":");
System.out.print(varWithSpaces);
System.out.print(":");
```

← String with white space  
← Prints :AB CB : ← Prints :AB CB :

Here's another example that trims the leading and trailing white space:

```
System.out.print(":");
System.out.print(varWithSpaces.trim());
System.out.print(":");
```

← Prints :AB CB: ← Prints :AB CB:

Note that this method doesn't remove the space *within* a `String`.

### **REPLACE()**

This method will return a new `String` by replacing all the occurrences of a `char` with another `char`. Instead of specifying a `char` to be replaced by another `char`, you can also specify a sequence of characters—a `String` to be replaced by another `String`:

```
String letters = "ABCAB";
System.out.println(letters.replace('B', 'b'));
System.out.println(letters.replace("CA", "12"));
```

← Prints AbCAb ← Prints ABI2B

Notice the type of the method parameters passed on this method: either `char` or `String`. You can't mix these parameter types, as the following code shows:

```
String letters = "ABCAB";
System.out.println(letters.replace('B', "b"));
System.out.println(letters.replace("B", 'b'));
```

← Won't compile

Again, notice that this method doesn't—or can't—change the value of the variable `letters`. Examine the following line of code and its output:

```
System.out.println(letters);
```

← Prints ABCAB because previous replace() method calls don't affect the char[] array within letters

**LENGTH()**

You can use the `length()` method to retrieve the length of a String. Here's an example showing its use:

```
System.out.println("Shreya".length());
```

Prints 6



**EXAM TIP** The length of a String is one number greater than the position that stores its last character. The length of String "Shreya" is 6, but its last character, a, is stored at position 5 because the positions start at 0, not 1.

**STARTSWITH() AND ENDSWITH()**

The method `startsWith()` determines whether a String starts with a specified prefix, specified as a String. You can also specify whether you wish to search from the start of a String or from a particular position. This method returns `true` if a match is found and `false` otherwise:

```
String letters = "ABCAB";
System.out.println(letters.startsWith("AB"));
System.out.println(letters.startsWith("a"));
System.out.println(letters.startsWith("A", 3));
```

Prints true  
Prints false  
Prints true

The method `endsWith()` tests whether a String ends with a particular suffix. It returns `true` for a matching value and `false` otherwise:

```
System.out.println(letters.endsWith("CAB"));
System.out.println(letters.endsWith("B"));
System.out.println(letters.endsWith("b"));
```

Prints true  
Prints true  
Prints false

**METHOD CHAINING**

It's common practice to use multiple String methods in a single line of code, as follows:

```
String result = "Sunday ".replace(' ', 'Z').trim().concat("M n");
System.out.println(result);
```

Prints SundayZZM n

The methods are evaluated from left to right. The first method to execute in this example is `replace`, not `concat`.

Method chaining is one of the favorite topics of the exam authors. You're sure to encounter a question on method chaining in the OCA Java SE 7 Programmer I exam.



**EXAM TIP** When chained, the methods are evaluated from left to right.

Note that there's a difference between calling a chain of methods on a String object versus doing the same and then reassigning the return value to the same variable:

```
String day = "SunDday";
day.replace('D', 'Z').substring(3);
System.out.println(day);
```

Calls methods replace and substring on day.

String is immutable—no change in the value variable day. Prints SunDday.

```
day = day.replace('D', 'Z').substring(3);
System.out.println(day);
```

Calls methods replace and substring on day, and assigns the result back to variable day.

Prints ZDay.

Because `String` objects are immutable, their values won't change if you execute methods on them. You can, of course, reassign a value to a reference variable of type `String`. Watch out for related questions in the exam.

Although the next Twist in the Tale exercise may seem simple, with only two lines of code, appearances can be deceptive (answers in the appendix).

#### Twist in the Tale 4.1

Let's modify some of the code used in the previous section. Execute this code on your system. Which answer correctly shows its output?

```
String letters = "ABCAB";
System.out.println(letters.substring(0, 2).startsWith('A'));

a true
b false
c AB
d ABC
e Compilation error
```

---

#### 4.1.4 *String objects and operators*

Of all the operators that are on this exam, you can use just a handful with the `String` objects:

- Concatenation: `+` and `+=`
- Equality: `==` and `!=`

In this section, we'll cover the concatenation operators. We'll cover the equality operators in the next section (4.1.5).

Concatenation operators (`+` and `+=`) have a special meaning for `Strings`. The Java language has additional functionality defined for these operators for `String`. You can use the operators `+` and `+=` to concatenate two `String` values. Behind the scenes, string concatenation is implemented by using the `StringBuilder` (covered in the next section) or `StringBuffer` (similar to `StringBuilder`) classes.

But remember that a `String` is immutable. You can't modify the value of any existing object of `String`. The `+` operator enables you to create a new object of class `String` with a value equal to the concatenated values of multiple `Strings`. Examine the following code:

```
String aString = "OCJA" + "Cert" + "Exam";
```

← aString contains  
OCJACertExam

Here's another example:

```
int num = 10;
int val = 12;
String aStr = "OCJA";
```

```
String anotherStr = num + val + aStr;
System.out.println(anotherStr);
```

The code above concatenates the values of variables num, val, and aStr. The variable num is 22, val is OCJA, and aStr is not explicitly defined but is implied to be "". The resulting string is 22OCJA. An annotation 'Prints 22OCJA' with an arrow points to the final output.

Why do you think the value of the variable anotherStr is 22OCJA and not 1012OCJA? The + operator can be used with the primitive values, and the expression num + val + aStr is evaluated from left to right. Here's the sequence of steps executed by Java to evaluate the expression:

- Adds operands num and val to get 22.
- Concatenates 22 with OCJA to get 22OCJA.

If you wish to treat the numbers stored in variables num and val as String values, modify the expression as follows:

```
anotherStr = "" + num + val + aStr;
```

The code above uses the + operator between the empty string "" and the integer num (1012). This forces the addition of strings. The resulting string is 1012OCJA. An annotation 'Evaluates to 1012OCJA' with an arrow points to the final output.

### A practical tip on String concatenation

During my preparation for my Java Programmer certification, I learned how the output changes in String concatenation when the order of values being concatenated is changed. At work, it helped me to quickly debug a Java application that was logging incorrect values to a log file. It didn't take me long to discover that the offending line of code was `logToFile("Shipped:" + numReceived() + inTransit());`. The methods were returning correct values individually, but the return values of these methods were not being added. They were being concatenated as String values, resulting in the unexpected output.

One solution is to enclose the int addition within parentheses, as in `logToFile("Shipped:" + (numReceived() + inTransit()));`. This code will log the text "Shipped" with the sum of the numeric values returned by the methods numReceived() and inTransit().

When you use += to concatenate String values, ensure that the variable you're using has been initialized (and doesn't contain null). Look at the following code:

```
String lang = "Java";
lang += " is everywhere!";
String initializedToNull = null;
initializedToNull += "Java";
System.out.println(initializedToNull);
```

The code above shows a common mistake. The variable lang is initialized to "Java" and then concatenated with " is everywhere!". The resulting string is "java is everywhere". However, the variable initializedToNull is initialized to null and then concatenated with "Java". Since initializedToNull is null, the resulting string is nullJava. Annotations indicate that lang is assigned "java is everywhere" and the final output is Prints nullJava.

#### 4.1.5 Determining equality of Strings

The correct way to compare two String values for equality is to use the equals method defined in the String class. This method returns a true value if the object being compared to it isn't null, is a String object, and represents the same sequence of characters as the object to which it's being compared.

The following listing shows the method definitions of the equals method defined in class String in the Java API.

**Listing 4.1 Method definition of the equals method from the class String**

```

public boolean equals(Object anObject) {
 if (this == anObject) {
 return true;
 }
 if (anObject instanceof String) {
 String anotherString = (String)anObject;
 int n = count;
 if (n == anotherString.count) {
 char v1[] = value;
 char v2[] = anotherString.value;
 int i = offset;
 int j = anotherString.offset;
 while (n-- != 0) {
 if (v1[i++] != v2[j++])
 return false;
 }
 return true;
 }
 }
 return false;
}

```

The diagram illustrates the logic of the `equals` method with numbered annotations:

- 1** Returns true if the object being compared is the same object.
- 2** Executes statements in if construct if `anObject` is of type `String`.
- 3** Continues comparison if the length of `String` values being compared is equal.
- 4** Compares individual `String` characters; returns false if there's a mismatch with any individual `String` character.
- 5** Returns true if all characters of `String` `anObject` successfully matched with this object.
- 6** Returns false if the object being compared to is not of type `String` or the lengths of the comparing `Strings` don't match.

In listing 4.1, the `equals` method accepts a method parameter of type `Object` and returns a boolean value. Let's walk through the `equals` method defined by class `String`:

- **1** compares the object reference variables. If the reference variables are the same, they refer to the same equal object.
- **2** compares the type of the method parameter to this object. If the method parameter passed to this method is not of type `String`, **6** returns false.
- **3** checks whether the lengths of the `String` values being compared are equal.
- **4** compares the individual characters of the `String` values. It returns false if a mismatch is found at any position. If no mismatch is found, **5** returns true.

Examine the following code:

```

String var1 = new String("Java");
String var2 = new String("Java");
System.out.println(var1.equals(var2)); ← Prints true
System.out.println(var1 == var2); ← Prints false

```

The operator `==` compares the reference variables, that is, whether the variables refer to the same object. Hence, `var1 == var2` in the previous code prints false. Now examine the following code:

```

String var3 = "code";
String var4 = "code";
System.out.println(var3.equals(var4)); ← Prints true
System.out.println(var3 == var4); ← Prints true

```

Even though comparing `var3` and `var4` using the operator `==` prints true, you should *never* use this operator for comparing `String` values. The variables `var3` and `var4` refer

to the same `String` object created and shared in the pool of `String` objects. (We discussed the pool of `String` objects in section 4.1.1 earlier in this chapter). This operator won't always return the value `true`, even if the two objects store the same `String` values.



**EXAM TIP** The operator `==` compares whether the reference variables refer to the same objects, and the method `equals` compares the `String` values for equality. Always use the `equals` method to compare two `String`s for equality. Never use the `==` operator for this purpose.

You can use the operator `!=` to compare the inequality of objects referred to by the `String` variables. It's the inverse of the operator `==`. Let's compare the usage of the operator `!=` with the operator `==` and the method `equals()`:

```
String var1 = new String("Java");
String var2 = new String("Java");
System.out.println(var1.equals(var2));
System.out.println(var1 == var2);
System.out.println(var1 != var2);
```

The following example uses the operators `!=` and `==` and the method `equals` to compare `String` variables that refer to the same object in the `String` constant pool:

```
String var3 = "code";
String var4 = "code";
System.out.println(var3.equals(var4));
System.out.println(var3 == var4);
System.out.println(var3 != var4);
```

As you can see, in both of the previous examples the operator `!=` returns the inverse of the value returned by the operator `==`.

Because `Strings` are immutable, we also need a mutable sequence of characters that can be manipulated. Let's take a look at the other type of `String` on the OCA Java SE Programmer I exam: `StringBuilder`.

## 4.2 **Mutable strings: *StringBuilder***



[2.6] Manipulate data using the `StringBuilder` class and its methods

The class `StringBuilder` is defined in the package `java.lang` and it has a mutable sequence of characters. You must use class `StringBuilder` when you're dealing with larger strings or modifying the contents of a string often. Doing so will improve the performance of your code. Unlike `StringBuilder`, the `String` class has an immutable sequence of characters. Every time you modify a string that's represented by the `String` class, your code actually creates new `String` objects instead of modifying the existing one.



**EXAM TIP** You can expect questions on the need for the `StringBuilder` class and its comparison with the `String` class.

Let's work with the methods of the class `StringBuilder`. Because `StringBuilder` represents a mutable sequence of characters, the main operations on `StringBuilder` are related to the modification of its value by adding another value at the end or at a particular position, deletion of characters, or changing characters at a particular position.

#### 4.2.1 ***The `StringBuilder` class is mutable***

In contrast to the class `String`, the class `StringBuilder` uses a non-final char array to store its value. Following is a partial definition of the class `AbstractStringBuilder` (the base class of class `StringBuilder`). It includes the declaration of the variables `value` and `count`, which are used to store the value of `StringBuilder` and its length respectively (the relevant code is in bold):

```
abstract class AbstractStringBuilder implements Appendable, CharSequence {
 /**
 * The value is used for character storage.
 */
 char value[];

 /**
 * The count is the number of characters used.
 */
 int count;
 //... rest of the code
}
```

This information will come in handy when we discuss the methods of class `StringBuilder` in the following sections.

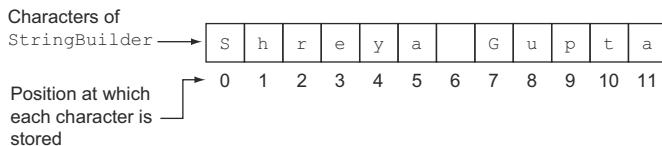
#### 4.2.2 ***Creating `StringBuilder` objects***

You can create objects of class `StringBuilder` using multiple overloaded constructors, as follows:

```
class CreateStringBuilderObjects {
 public static void main(String args[]) {
 StringBuilder sb1 = new StringBuilder(); ← ① No-argument constructor
 StringBuilder sb2 = new StringBuilder(sb1); ← ② Constructor that accepts a StringBuilder object
 StringBuilder sb3 = new StringBuilder(50); ← ③ Constructor that accepts an int value specifying initial capacity of StringBuilder object
 StringBuilder sb4 = new StringBuilder("Shreya Gupta"); ← ④ Constructor that accepts a String
 }
}
```

**Constructor that accepts a String**

- ➊ constructs a `StringBuilder` object with no characters in it and an initial capacity of 16 characters.
- ➋ constructs a `StringBuilder` object that contains the same set of characters as contained by the `StringBuilder` object passed to it.
- ➌ constructs a `StringBuilder` object with no characters and an initial capacity of 50 characters.
- ➍ constructs a `StringBuilder` object with an initial value as contained by the `String` object. Figure 4.13 illustrates `StringBuilder` object `sb4` with the value `Shreya Gupta`.



**Figure 4.13** The *StringBuilder* object with character values and their corresponding storage positions

When you create a *StringBuilder* object using its default constructor, the following code executes behind the scenes to initialize the array value defined in the class *StringBuilder* itself:

```
StringBuilder() {
 value = new char[16];
}
```

Creates an array  
of length 16

When you create a *StringBuilder* object by passing it a *String*, the following code executes behind the scenes to initialize the array value:

```
public StringBuilder(String str) {
 value = new char[str.length() + 16];
 append(str);
}
```

Creates an array of  
length 16 + str.length

The creation of objects for the class *StringBuilder* is the basis for the next Twist in the Tale exercise. Your task in this exercise is to look up the Java API documentation or the Java source code to answer the question. You can access the Java API documentation in a couple of ways:

- View it online at <http://docs.oracle.com/javase/7/docs/api/>.
- Download it to your system from [www.oracle.com/technetwork/java/javase/documentation/java-se-7-doc-download-435117.html](http://www.oracle.com/technetwork/java/javase/documentation/java-se-7-doc-download-435117.html). Accept the license agreement and click on the link for *jdk-7u6-apidocs.zip* to download it. (These links may change eventually as Oracle updates its website.)

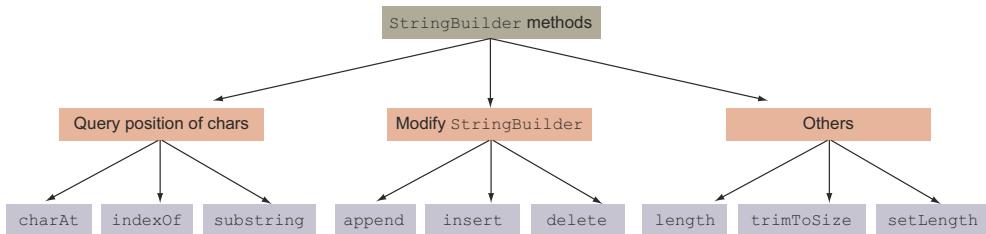
The answer to the following Twist in the Tale exercise is given in the appendix.

#### Twist in the Tale 4.2

Take a look at the Java API documentation or the Java source code files and answer the following question:

Which of the following options (there's just one correct answer) correctly creates an object of the class *StringBuilder* with a default capacity of 16 characters?

- StringBuilder name = *StringBuilder*.getInstance();
- StringBuilder name = *StringBuilder*.createInstance();
- StringBuilder name = *StringBuilder*.buildInstance();
- None of the above



**Figure 4.14 Categorization of `StringBuilder` methods**

### 4.2.3 Methods of class `StringBuilder`

You'll be pleased to learn that a lot of the methods defined in the class `StringBuilder` work exactly like the versions in the class `String`—for example, methods such as `charAt`, `indexOf`, `substring`, and `length`. We won't discuss these again for the class `StringBuilder`. In this section, we'll discuss the other main methods of the class `StringBuilder`: `append`, `insert`, and `delete`.

Figure 4.14 shows the categorization of this class's methods.

#### APPEND()

The `append` method adds the specified value at the end of the existing value of a `StringBuilder` object. Because you may want to add data from multiple data types to a `StringBuilder` object, this method has been overloaded so that it can accept data of any type.

This method accepts all the primitives—`String`, `char` array, and `Object`—as method parameters, as shown in the following example:

```

class AppendStringBuilder {
 public static void main(String args[]) {
 StringBuilder sb1 = new StringBuilder();
 sb1.append(true);
 sb1.append(10);
 sb1.append('a');
 sb1.append(20.99);
 sb1.append("Hi");
 System.out.println(sb1);
 }
}

```

**Appends boolean**  
**Appends int**  
**Appends char**  
**Appends double**  
**Appends String**  
**Prints true10a20.99Hi**

You can append a complete `char` array, `StringBuffer`, or `String` or its subset as follows:

```

StringBuilder sb1 = new StringBuilder();
char[] name = {'J', 'a', 'v', 'a', '7'};
sb1.append(name, 1, 3);
System.out.println(sb1);

```

**Starting with position 1**  
**append 3 characters,**  
**position 1 inclusive**  
**Prints ava**

Because the method `append` also accepts a method parameter of type `Object`, you can pass it any object from the Java API or your own user-defined object:

```

class AppendStringBuilder2 {
 public static void main(String args[]) {
 StringBuilder sb1 = new StringBuilder();
 sb1.append("Java");
 sb1.append(new Person("Oracle"));
 System.out.println(sb1);
 }
}
class Person {
 String name;
 Person(String str) { name = str; }
}

```

The output of the previous code is:

```
JavaPerson@126b249
```

In this output, the hex value (126b249) that follows the @ sign may differ on your system.

When you append an object's value to a *StringBuilder*, the method `append` calls the target class's `toString` method to retrieve the object's String representation. If the `toString` method has been overridden by the class, then the method `append` adds the String value returned by it to the target *StringBuilder* object. In the absence of the overridden `toString` method, the `toString` method defined in the class `Object` executes. The default implementation of the method `toString` in the class `Object` returns the name of the class followed by the @ char and unsigned hexadecimal representation of the hash code of the object (the value returned by the object's `hashCode` method).



**EXAM TIP** For classes that haven't overridden the `toString` method, the `append` method appends the output from the default implementation of method `toString` defined in class `Object`.

It's interesting to take a quick look at how the `append` method works for the class `StringBuilder`. Following is a partial code listing of the method `append` that accepts a boolean parameter (as explained in the comments):

```

public AbstractStringBuilder append(boolean b) {
 if (b) {
 int newCount = count + 4;
 if (newCount > value.length)
 expandCapacity(newCount);
 value[count++] = 't';
 value[count++] = 'r';
 value[count++] = 'u';
 value[count++] = 'e';
 } else {
 ...
 }
 return this;
}

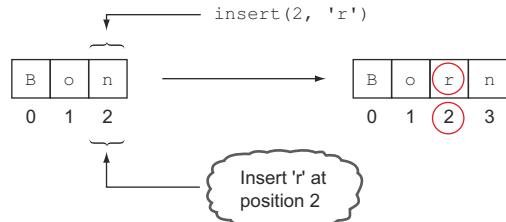
```

① and ② determine whether the array value can accommodate four additional characters corresponding to the boolean literal value true. It increases the capacity of the array value (used to store the characters of a `StringBuilder` object) if it isn't big enough. ③ adds individual characters of the boolean value true to the array value.

### INSERT()

The `insert` method is as powerful as the `append` method. It also exists in multiple flavors (read: overloaded methods) that accept any data type. The main difference between the `append` and `insert` methods is that the `insert` method enables you to insert the requested data at a particular position, but the `append` method only allows you to add the requested data at the end of the `StringBuilder` object:

```
class InsertStringBuilder {
 public static void main(String args[]) {
 StringBuilder sb1 = new StringBuilder("Bon");
 sb1.insert(2, 'r');
 System.out.println(sb1);
 }
}
```



**Figure 4.15** Inserting a char using the method `insert` in `StringBuilder`

Figure 4.15 illustrates the previous code.

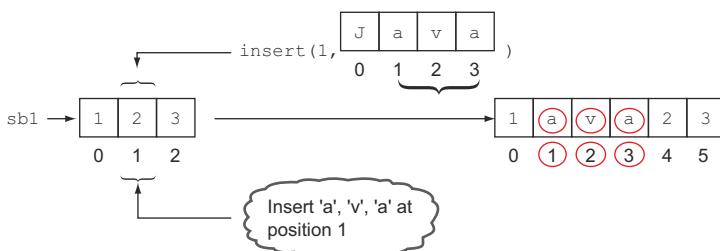
As with `String` objects, the first character of `StringBuilder` is stored at position 0. Hence, the previous code inserts the letter `r` at position 2, which is occupied by the letter `n`. You can also insert a complete `char` array, `StringBuffer`, or `String` or its subset, as follows:

```
StringBuilder sb1 = new StringBuilder("123");
char[] name = {'J', 'a', 'v', 'a'};
sb1.insert(1, name, 1, 3);
```

← **Prints 1ava23**

← **Insert at sb1 position 1,  
values ava from String name**

Figure 4.16 illustrates the previous code.



**Figure 4.16** Inserting a substring of `String` in `StringBuilder`



**EXAM TIP** Take note of the start and end positions when inserting a value in a *StringBuilder*. Multiple flavors of the *insert* method defined in *StringBuilder* may confuse you because they can be used to insert either single or multiple characters.

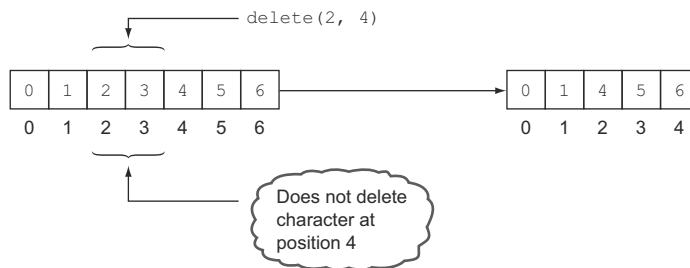
#### **DELETE() AND DELETECHARAT()**

The method *delete* removes the characters in a substring of the specified *StringBuilder*. The method *deleteCharAt* removes the char at the specified position. Here's an example showing the method *delete*:

```
class DeleteStringBuilder {
 public static void main(String args[]) {
 StringBuilder sb1 = new StringBuilder("0123456");
 sb1.delete(2, 4);
 System.out.println(sb1);
 }
}
```

① Removes characters at positions starting from 2 to 4, excluding 4  
Prints 01456

① removes characters at positions 2 and 3. The *delete* method doesn't remove the letter at position 4. Figure 4.17 illustrates the previous code.



**Figure 4.17** The method *delete(2, 4)* doesn't delete the character at position 4.

The method *deleteCharAt* is simple. It removes a single character, as follows:

```
class DeleteStringBuilder {
 public static void main(String args[]) {
 StringBuilder sb1 = new StringBuilder("0123456");
 sb1.deleteCharAt(2);
 System.out.println(sb1);
 }
}
```

Prints 013456



**EXAM TIP** Combinations of the *deleteCharAt* and *insert* methods can be quite confusing.

#### **TRIM()**

Unlike the class *String*, the class *StringBuilder* doesn't define the method *trim*. An attempt to use it with this class will prevent your code from compiling. The only reason I'm describing a nonexistent method here is to ward off any confusion.

#### **REVERSE()**

As the name suggests, the *reverse* method reverses the sequence of characters of a *StringBuilder*:

```
class ReverseStringBuilder {
 public static void main(String args[]) {
 StringBuilder sb1 = new StringBuilder("0123456");
 sb1.reverse();
 System.out.println(sb1);
 }
}
```

Prints  
6543210



**EXAM TIP** You can't use the method `reverse` to reverse a substring of `StringBuilder`.

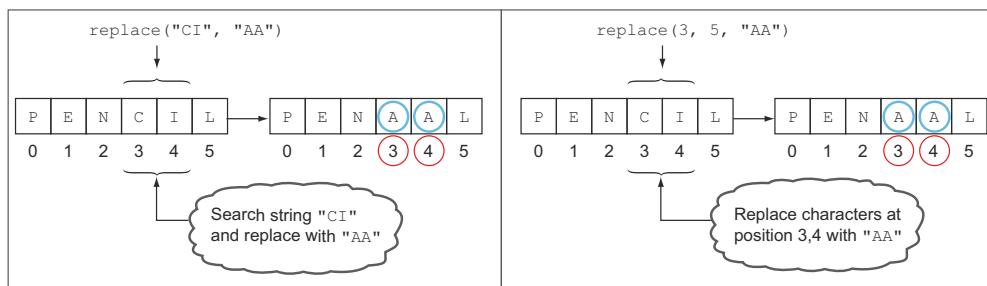
#### REPLACE()

Unlike the `replace` method defined in the class `String`, the `replace` method in the class `StringBuilder` replaces a sequence of characters, identified by their positions, with another `String`, as in the following example:

```
class ReplaceStringBuilder {
 public static void main(String args[]) {
 StringBuilder sb1 = new StringBuilder("0123456");
 sb1.replace(2, 4, "ABCD");
 System.out.println(sb1);
 }
}
```

Prints  
0IABCD456

Figure 4.18 shows a comparison of the `replace` methods defined in the classes `String` and `StringBuilder`.



**Figure 4.18 Comparing the `replace` methods in `String` (left) and `StringBuilder` (right).** The `method replace in String accepts the characters to be replaced. The method replace in StringBuilder accepts a position to be replaced.`

#### SUBSEQUENCE()

Apart from using the method `substring`, you can also use the method `subSequence` to retrieve a subsequence of a `StringBuilder` object. This method returns objects of type `CharSequence`:

```
class SubSequenceStringBuilder {
 public static void main(String args[]) {
 StringBuilder sb1 = new StringBuilder("0123456");
 System.out.println(sb1.subSequence(2, 4));
 System.out.println(sb1);
 }
}
```

Prints 23  
Prints 0123456

The method `subsequence` doesn't modify the existing value of a `StringBuilder` object.

#### 4.2.4 A quick note on the class `StringBuffer`

Though the OCA Java SE 7 Programmer I exam objectives don't mention the class `StringBuffer`, you may see it in the list of (incorrect) answers in the OCA exam.

The classes `StringBuffer` and `StringBuilder` offer the same functionality, with one difference: the methods of the class `StringBuffer` are synchronized where necessary, whereas the methods of the class `StringBuilder` aren't. What does this mean? When you work with the class `StringBuffer`, only one thread out of multiple threads can execute your method. This arrangement prevents any inconsistencies in the values of the instance variables that are modified by these (synchronized) methods. But it introduces additional overhead, so working with synchronized methods and the `StringBuffer` class affects the performance of your code.

The class `StringBuilder` offers the same functionality as offered by `StringBuffer`, minus the additional feature of synchronized methods. Often your code won't be accessed by multiple threads, so it won't need the overhead of thread synchronization. If you need to access your code from multiple threads, use `StringBuffer`; otherwise use `StringBuilder`.

### 4.3 Arrays



[4.1] Declare, instantiate, initialize, and use a one-dimensional array



[4.2] Declare, instantiate, initialize, and use a multidimensional array

In this section, I'll cover declaration, allocation, and initialization of one-dimensional and multidimensional arrays. You'll learn about the differences between arrays of primitive data types and arrays of objects.

#### 4.3.1 What is an array?

An array is an object that stores a collection of values. The fact that an array itself is an object is often overlooked. I'll reiterate: an array is an object itself, which implies that it stores references to the data it stores. Arrays can store two types of data:

- A collection of primitive data types
- A collection of objects

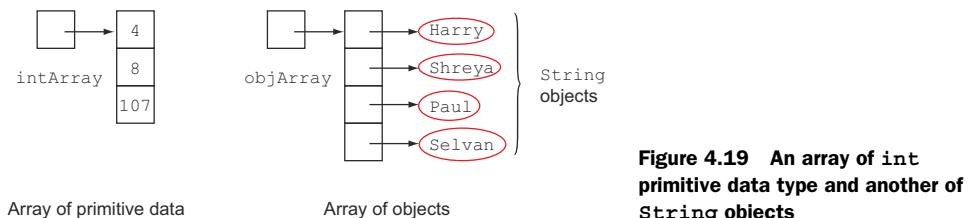
An array of primitives stores a collection of values that constitute the primitive values themselves. (With primitives, there are no objects to reference.) An array of objects stores a collection of values, which are in fact heap-memory addresses or pointers. The addresses point to (reference) the object instances that your array is said to store, which means that object arrays store references (to objects) and primitive arrays store primitive values.

The members of an array are defined in contiguous (continuous) memory locations and hence offer improved access speed. (You should be able to quickly access all the students of a class if they all can be found next to each other.)

The following code creates an array of primitive data and an array of objects:

```
class CreateArray {
 public static void main(String args[]) {
 int intArray[] = new int[] {4, 8, 107};
 String objArray[] = new String[] {"Harry", "Shreya",
 "Paul", "Selvan"};
 }
}
```

I'll discuss the details of creating arrays shortly. The previous example shows one of the ways to create arrays. Figure 4.19 illustrates the arrays `intArray` and `objArray`. Unlike `intArray`, `objArray` stores references to `String` objects.



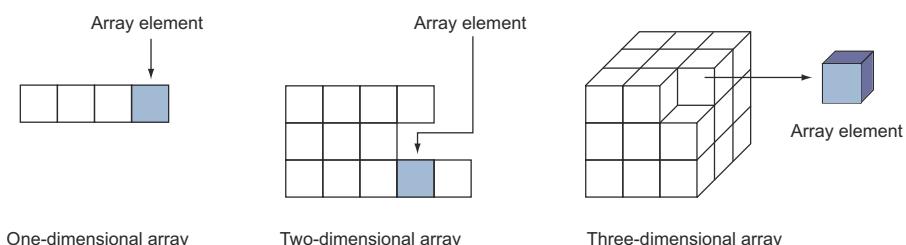
**NOTE** Arrays are objects and refer to a collection of primitive data types or other objects.

In Java, you can define one-dimensional and multidimensional arrays. A *one-dimensional array* is an object that refers to a collection of scalar values. A two-dimensional (or more) array is referred to as a *multidimensional array*. A two-dimensional array refers to a collection of objects in which each of the objects is a one-dimensional array. Similarly, a three-dimensional array refers to a collection of two-dimensional arrays, and so on. Figure 4.20 depicts a one-dimensional array and multidimensional arrays (two-dimensional and three-dimensional).

Note that multidimensional arrays may or may not contain the same number of elements in each row or column, as shown in the two-dimensional array in figure 4.20.

Creating an array involves three steps, as follows:

- Declaring the array
- Allocating the array
- Initializing the array elements



**Figure 4.20 One-dimensional and multidimensional (two- and three-dimensional) arrays**

You can create an array by executing the previous steps using separate lines of code or you can combine these steps on the same line of code. Let's start with the first approach: completing each step on a separate line of code.

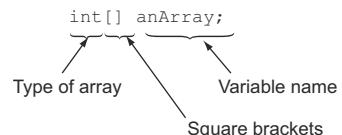
### 4.3.2 Array declaration

An array declaration includes the array *type* and array *variable*, as shown in figure 4.21. The type of objects that an array can store depends on its type. An array type is followed by empty pairs of square brackets [ ].

To declare an array, specify its type, followed by the name of the array variable. Here's an example of declaring arrays of int and String values:

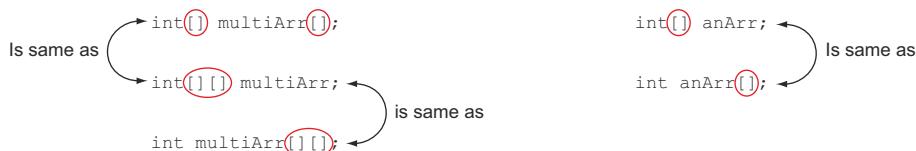
```
int intArray[];
String[] strArray;
int[] multiArray;
```

One-dimensional  
array                          Multidimensional  
array



**Figure 4.21** Array declaration includes the array type and array variable

The number of bracket pairs indicates the depth of array nesting. Java doesn't impose any theoretical limit on the level of array nesting. The square brackets can follow the array type or its name, as shown in figure 4.22.



**Figure 4.22** Square brackets can follow either the variable name or its type. In the case of multidimensional arrays, it can follow both of them.

The array declaration only creates a variable that refers to null, as shown in figure 4.23.

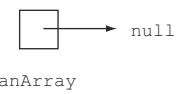
Because no elements of an array are created when it's declared, it's invalid to define the size of an array with its declaration. The following code won't compile:

```
int intArray[2];
String[5] strArray;
int[2] multiArray[3];
```

Array size can't be defined with the array declaration. This code won't compile.

An array type can be any of the following:

- Primitive data type
- Interface
- Abstract class
- Concrete class



**Figure 4.23** Array declaration creates a variable that refers to null.



**NOTE** Arrays can be of any data type other than null.

### 4.3.3 Array allocation

As the name suggests, array allocation will allocate memory for the elements of an array. When you allocate memory for an array, you should specify its dimensions, such as the number of elements the array should store. Note that the size of an array can't expand or reduce once it is allocated. Here are a few examples:

```
int intArray[];
String[] strArray;
int[] multiArr[];

intArray = new int[2];
strArray = new String[4];
multiArr = new int[2][3];
```

**Array declaration**

**Note use of keyword new to allocate an array**

Because an array is an object, it's allocated using the keyword new, followed by the type of value that it stores, and then its size. The code won't compile if you don't specify the size of the array or if you place the array size on the left of the = sign, as follows:

```
intArray = new int[];
intArray[2] = new int;
```

**Won't compile. Array size missing.**

**Won't compile. Array size placed incorrectly.**

The size of the array should evaluate to an int value. You can't create an array with its size specified as a floating-point number. The following line of code won't compile:

```
intArray = new int[2.4];
```

**Won't compile. Can't define size of an array as a floating-point number**

Java accepts an expression to specify the size of an array, as long as it evaluates to an int value. The following are valid array allocations:

```
strArray = new String[2*5];
int x = 10, y = 4;
strArray = new String[x*y];
strArray = new String[Math.max(2, 3)];
```

**2\*5 evaluates to an integer value.**

**This is acceptable. Expression x\*y evaluates to an integer value.**

**This is acceptable. Math.max(2,3) returns an int value.**

Let's allocate the multidimensional array multiArr, as follows:

```
int[] multiArr[];
multiArr = new int[2][3];
```

**Array declaration**

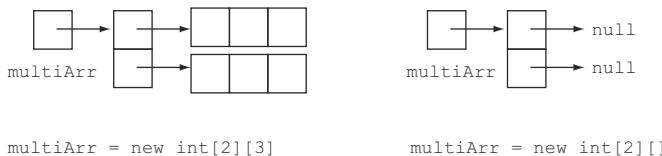
**OK to define size in both the square brackets**

You can also allocate the multidimensional array multiArr by defining size in only the first square bracket:

```
multiArr = new int[2][];
```

**OK to define the size in only the first square brackets**

It's interesting to note what happens when the multidimensional array multiArr is allocated by defining sizes for a single dimension and for both its dimensions. This difference is shown in figure 4.24.



**Figure 4.24** The difference in array allocation of a two-dimensional array when it's allocated using values for only one of its dimensions and for both its dimensions.

You can't allocate a multidimensional array as follows:

```

int[] multiArr[];
multiArr = new int[];
multiArr = new int[] [3];

```

② Size in first square bracket missing  
① Nonmatching square brackets

Multidimensional array declaration

- ① won't compile because there's a mismatch in the number of square brackets on both sides of the assignment operator (=). The compiler required [] [] on the right side of the assignment operator, but it finds only []. ② won't compile because you can't allocate a multidimensional array without including a size in the first square brackets and defining a size in the second square brackets.

Once allocated, the array elements store their default values. For arrays that store objects, all the allocated array's elements store null. For arrays that store primitive values, the default values depend on the exact data types stored by them.



**EXAM TIP** Once allocated, all the array elements store their default values. Elements in an array that store objects default to null. Elements of an array that store primitive data types store 0 for integer types (byte, short, int, long), 0.0 for decimal types (float and double), false for boolean, or \u0000 for char data.

#### 4.3.4 Array initialization

You can initialize an array as follows:

```

int intArray[];
intArray = new int[2];
for (int i=0; i<intArray.length; i++) {
 intArray[i] = i + 5;
}
intArray[0] = 10;
intArray[1] = 1870;

```

Array declaration

Array allocation

① Initializes array using a for loop

② Reinitializes individual array elements

- ① Uses a for loop to initialize the array intArray with the required values. ② initializes the individual array elements without using a for loop. Note that all array objects can access the instance variable length, which stores the array size.

Similarly, a String array can be declared, allocated, and initialized as follows:

```

String[] strArray;
strArray = new String[4];
for (int i=0; i<strArray.length; i++) {
 strArray[i] = new String("Hello" + i);
}

```

Array declaration

Array allocation

Initializes array using a for loop

```
strArray[1] = "Summer";
strArray[3] = "Winter";
strArray[0] = "Autumn";
strArray[2] = "Spring";
```

**Initializes array without using a for loop**

When you initialize a two-dimensional array, you can use nested for loops to initialize its array elements. Also notice that to access an element in a two-dimensional array, you should use two array position values, as follows:

```
int[] multiArr[];
multiArr = new int[2][3];

for (int i=0; i<multiArr.length; i++) {
 for (int j=0; j<multiArr[i].length; j++) {
 multiArr[i][j] = i + j;
 }
}

multiArr[0][0] = 10;
multiArr[1][2] = 1210;
multiArr[0][1] = 110;
multiArr[0][2] = 1087;
```

**Array declaration**  
←  
**Array allocation**

**Initializes array using a for loop**

**Initializes array without using a for loop**

What happens when you try to access a nonexistent array index position? The following code creates an array of size 2 but tries to access its array element at index 3:

```
int intArray[] = new int[2];
System.out.println(intArray[3]);
```

**Length of intArray is 2**  
←  
**3 isn't a valid index position for intArray**

The previous code will throw a runtime exception, `ArrayIndexOutOfBoundsException`. For an array of size 2, the only valid index positions are 0 and 1. All the rest of the array index positions will throw the exception `ArrayIndexOutOfBoundsException` at runtime.



**NOTE** Don't worry if you can't immediately absorb all of the information related to exceptions here. Exceptions are covered in detail in chapter 7.

The Java compiler doesn't check the range of the index positions at which you try to access an array element. You may be surprised to learn that the following line of code will compile successfully even though it uses a negative array index value:

```
int intArray[] = new int[2];
System.out.println(intArray[-10]);
```

**Length of intArray is 2**  
←  
**Will compile successfully even though it tries to access array element at negative index**

Though the previous code compiles successfully, it will throw the exception `ArrayIndexOutOfBoundsException` at runtime. Code to access an array element will fail to compile if you don't pass it a `char`, `byte`, `short`, or `int` data type (wrapper classes are not on this exam, and I don't include them in this discussion):

```
int intArray[] = new int[2];
System.out.println(intArray[1.2]);
```

**Won't compile—can't specify array index using floating-point number**



**EXAM TIP** Code to access an array index will throw a runtime exception if you pass it an invalid array index value. Code to access an array index will fail to compile if you don't use a char, byte, short, or int.

Also, you can't remove array positions. For an array of objects, you can set a position to value null, but it doesn't remove the array position:

```
String[] strArray = new String[] {"Autumn", "Summer",
 "Spring", "Winter"};
strArray[2] = null;
for (String val : strArray)
 System.out.println(val);
```

1 Define an array of String objects  
2 Can you remove an array position like this?  
3 Outputs four values

① creates an array of String and initializes it with four String values. ② sets the value at array index 2 to null. ③ iterates over all the array elements. As shown in the following output, four (not three) values are printed:

```
Autumn
Summer
null
Winter
```

#### 4.3.5 Combining array declaration, allocation, and initialization

You can combine all the previously mentioned steps of array declaration, allocation, and initialization into one step, as follows:

```
int intArray[] = {0, 1};
String[] strArray = {"Summer", "Winter"};
int multiArray[][] = {{0, 1}, {3, 4, 5}};
```

Notice that the previous code

- Doesn't use the keyword new to initialize an array
- Doesn't specify the size of the array
- Uses a single pair of braces to define values for a one-dimensional array and multiple pairs of braces to define a multidimensional array

All the previous steps of array declaration, allocation, and initialization can be combined in the following way, as well:

```
int intArray2[] = new int[]{0, 1};
String[] strArray2 = new String[]{"Summer", "Winter"};
int multiArray2[][] = new int[][]{{0, 1}, {3, 4, 5}};
```

Unlike the first approach, the preceding code uses the keyword new to initialize an array.

If you try to specify the size of an array with the preceding approach, the code won't compile. Here are a few examples:

```
int intArray2[] = new int[2]{0, 1};
String[] strArray2 = new String[2>{"Summer", "Winter"};
int multiArray2[][] = new int[2][]{{0, 1}, {3, 4, 5}};
```



**EXAM TIP** When you combine an array declaration, allocation, and initialization in a single step, you can't specify the size of the array. The size of the array is calculated by the number of values that are assigned to the array.

Another important point to note is that if you declare and initialize an array using two separate lines of code, you'll use the keyword new to initialize the values. The following lines of code are correct:

```
int intArray[];
intArray = new int[] {0, 1};
```

But you can't miss the keyword new and initialize your array as follows:

```
int intArray[];
intArray = {0, 1};
```

#### 4.3.6 Asymmetrical multidimensional arrays

At the beginning of this section, I mentioned that a multidimensional array can be asymmetrical. Arrays can define a different number of columns for each of its rows.

The following example is an asymmetrical two-dimensional array:

```
String multiStrArr[][] = new String[][] {
 {"A", "B"},
 null,
 {"Jan", "Feb", "Mar"},
};
```

Figure 4.25 shows this asymmetrical array.

As you might have noticed, `multiStrArr[1]` refers to a null value. An attempt to access any element of this array, such as `multiStrArr[1][0]`, will throw an exception. This brings us to the next Twist in the Tale exercise (answers are in the appendix).

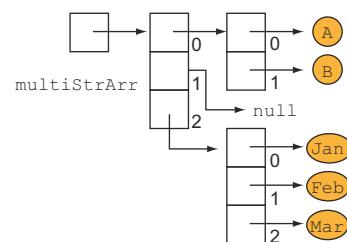


Figure 4.25 An asymmetrical array

#### Twist in the Tale 4.3

Modify some of the code used in the previous example as follows:

```
Line1> String multiStrArr[][] = new String[][] {
Line2> {"A", "B"},
Line3> null,
Line4> {"Jan", "Feb", null},
Line5> };
```

Which of the following individual options are true for the previous code?

- a Code on line 4 is the same as `{"Jan", "Feb", null, null}`,
- b No value is stored at `multiStrArr[2][2]`
- c No value is stored at `multiStrArr[1][1]`
- d Array `multiStrArr` is asymmetric.

### 4.3.7 Arrays of type interface, abstract class, and class Object

In the section on array declaration, I mentioned that the type of an array can also be an interface or an abstract class. What values do elements of these arrays store? Let's take a look at some examples.

#### INTERFACE TYPE

If the type of an array is an interface, its elements are either null or objects that implement the relevant interface type. For example, for the interface `MyInterface`, the array `interfaceArray` can store references to objects of either the class `MyClass1` or `MyClass2`:

```
interface MyInterface {}
class MyClass1 implements MyInterface {}
class MyClass2 implements MyInterface {}

class Test {
 MyInterface[] interfaceArray = new MyInterface[]
 {
 new MyClass1(),
 null,
 new MyClass2()
 };
}
```

#### ABSTRACT CLASS TYPE

If the type of an array is an abstract class, its elements are either null or objects of concrete classes that extend the relevant abstract class:

```
abstract class Vehicle{}
class Car extends Vehicle {}
class Bus extends Vehicle {}

class Test {
 Vehicle[] vehicleArray = { new Car(),
 new Bus(),
 null};
```



**null is a valid element**

Next, I'll discuss a special case in which the type of an array is `Object`.

#### OBJECT

Because all classes extend the class `java.lang.Object`, elements of an array whose type is `java.lang.Object` can refer to any object. Here's an example:

```
interface MyInterface {}
class MyClass1 implements MyInterface {}
abstract class Vehicle{}
class Car extends Vehicle {}
class Test {
 Object[] objArray = new Object[] {
 new MyClass1(),
 null,
 new Car(),
 new java.util.Date(),
```



**null is a valid element**

```

 new String("name"),
 new Integer [7]
 };
}

```

① Array element of type Object  
can refer to another array

① is valid code. Because an array is an object, the element of the array of `java.lang.Object` can refer to another array. Figure 4.26 illustrates the previously created array, `objArray`.

### 4.3.8 Members of an array

Array objects have the following public members:

- `length`—The variable `length` contains the number of components of the array.
- `clone()`—This method overrides the method `clone` defined in class `Object` but doesn't throw checked exceptions. The return type of this method is the same as the array's type. For example, for an array of type `Type[]`, this method returns `Type[]`.
- *Inherited methods*—Methods inherited from the class `Object`, except the method `clone`.

As mentioned in the earlier section on the `String` class, a `String` uses method `length()` to retrieve its length. With an array, you can use the array's variable `length` to determine the number of the array's elements. In the exam, you may be tricked by code that tries to access the `length` of a `String` using variable `length`. Note the correct combination of class and member used to access its length:

- `string`—Retrieve length using the method `length()`
- `Array`—Determine element count using the variable `length`

I have an interesting way to remember this rule. As opposed to an array, you'll invoke a *lot* of methods on `String` objects. So you use *method* `length()` to retrieve the length of `String` and *variable* `length` to retrieve the length of an array.

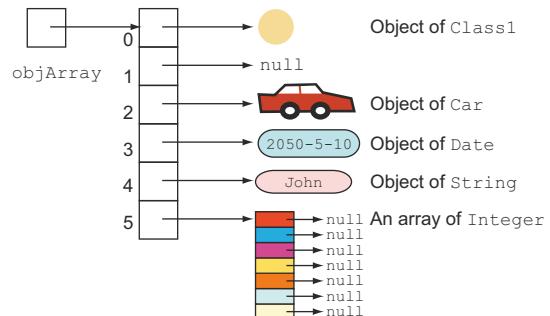
## 4.4 ArrayList



[4.3] Declare and use an `ArrayList`

In this section, I'll cover how to use `ArrayList`, its commonly used methods, and the advantages it offers over an array.

The OCA Java SE 7 Programmer I exam covers only one class from the Java Collection API: `ArrayList`. The rest of the classes from the Java Collection API are covered in the OCP Java SE 7 Programmer II exam (exam number 1Z0-804). One of the reasons



**Figure 4.26 An array of class Object**

to include this class in the Java Associate exam could be how frequently this class is used by all Java programmers.

`ArrayList` is one of the most widely used classes from the Collections framework. It offers the best combination of features offered by an *array* and the *List* data structure. The most commonly used operations with a list are: add items to a list, modify items in a list, delete items from a list, and iterate over the items.

One frequently asked question by Java developers is: “Why should I bother with an `ArrayList` when I can already store objects of the same type in an array?” The answer lies in the ease of use of an `ArrayList`. This is an important question, and the OCA Java SE 7 Programmer I exam contains explicit questions on the practical reasons for using an `ArrayList`.

You can compare an `ArrayList` with a resizable array. As you know, once it’s created, you can’t increase or decrease the size of an array. On the other hand, an `ArrayList` automatically increases and decreases in size as elements are added to or removed from it. Also, unlike arrays, you don’t need to specify an initial size to create an `ArrayList`.

Let’s compare an `ArrayList` and an array with real-world objects. Just as a balloon can increase and decrease in size when it’s inflated or deflated, an `ArrayList` can increase or decrease in size as values are added to it or removed from it. One comparison is a cricket ball, as it has a predefined size. Once created, like an array, it can’t increase or decrease in size.

Here are a few more important properties of an `ArrayList`:

- It implements the interface `List`.
- It allows null values to be added to it.
- It implements all list operations (`add`, `modify`, and `delete` values).
- It allows duplicate values to be added to it.
- It maintains its insertion order.
- You can use either `Iterator` or `ListIterator` (an implementation of the `Iterator` interface) to iterate over the items of an `ArrayList`.
- It supports generics, making it type safe. (You have to declare the type of the elements that should be added to an `ArrayList` with its declaration.)

#### 4.4.1 Creating an `ArrayList`

The following example shows you how to create an `ArrayList`:

```
import java.util.ArrayList;
public class CreateArrayList {
 public static void main(String args[]) {
 ArrayList<String> myArrList = new ArrayList<String>();
 }
}
```

Annotations:

- 1 Import `java.util.ArrayList`
- 2 Declare an `ArrayList` object

Package `java.util` isn't implicitly imported into your class, which means that ① imports the class `ArrayList` in the class `CreateArrayList` defined previously. To create an `ArrayList`, you need to inform Java about the type of the objects that you want to store in this collection of objects. ② declares an `ArrayList` called `myArrList`, which can store `String` objects specified by the name of the class `String` between the angle brackets (`<>`). Note that the name `String` appears twice in the code at ②, once on the left side of the equal sign and the other on the right. Do you think the second one seems redundant? Congratulations, Oracle agrees with you. Starting with Java version 7, you can omit the object type on the right side of the equal sign and create an `ArrayList` as follows:

```
ArrayList<String> myArrList = new ArrayList<>();
```

**Missing object type on  
right of = works in Java  
version 7 and above**

Many developers still work with Java SE versions prior to version 7, so you're likely to see some developers still using the older way of creating an `ArrayList`.

Take a look at what happens behind the scenes (in the Java source code) when you execute the previous statement to create an `ArrayList`. Because you didn't pass any arguments to the constructor of class `ArrayList`, its no-argument constructor will execute. Examine the definition of the following no-argument constructor defined in class `ArrayList.java`:

```
/**
 * Constructs an empty list with an initial capacity of ten.
 */
public ArrayList() {
 this(10);
}
```

Because you can use an `ArrayList` to store any type of `Object`, `ArrayList` defines an instance variable `elementData` of type `Object` to store all its individual elements. Following is a partial code listing from class `ArrayList`:

```
/**
 * The array buffer into which the elements of the ArrayList are stored.
 * The capacity of the ArrayList is the length of this array buffer.
 */
private transient Object[] elementData;
```

Figure 4.27 illustrates the variable `elementData` shown within an object of `ArrayList`.



**Figure 4.27 Variable `elementData` shown within an object of `ArrayList`**

Here is the definition of the constructor from the class ArrayList (ArrayList.java), which initializes the previously defined instance variable, elementData:

```
/**
 * Constructs an empty list with the specified initial capacity.
 *
 * @param initialCapacity the initial capacity of the list
 * @exception IllegalArgumentException if the specified initial capacity
 * is negative
 */
public ArrayList(int initialCapacity) {
 super();
 if (initialCapacity < 0)
 throw new IllegalArgumentException("Illegal Capacity: " +
 initialCapacity);
 this.elementData = new Object[initialCapacity];
}
```

Wait a minute. Did you notice that an ArrayList uses an array to store its individual elements? Does that make you wonder why on earth you would need another class if it uses a type (array, to be precise) that you already know how to work with? The simple answer is that you wouldn't want to reinvent the wheel.

For an example, answer this question: to decode an image, which of the following options would you prefer:

- Creating your own class using characters to decode the image
- Using an existing class that offers the same functionality

Obviously, it makes sense to go with the second option. If you use an existing class that offers the same functionality, you get more benefits with less work. The same logic applies to ArrayList. It offers you all of the benefits of using an array, with none of the disadvantages. It offers an expandable array that is modifiable.



**NOTE** An ArrayList uses an array to store its elements. It provides you with the functionality of a dynamic array.

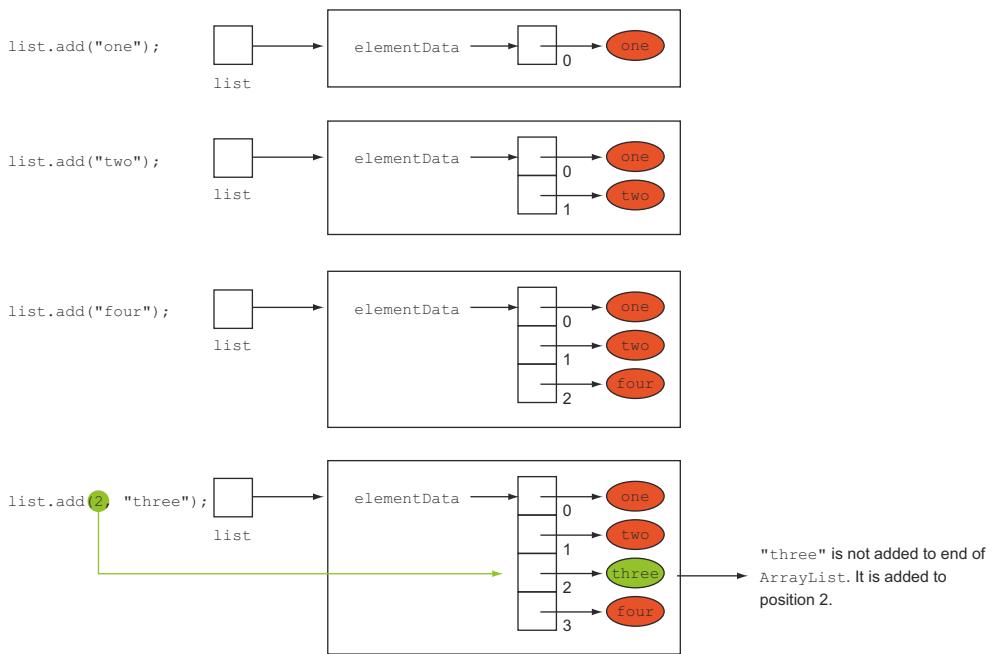
I'll cover how to add, modify, delete, and access the elements of an ArrayList in the following sections. Let's start with adding elements to an ArrayList.

#### 4.4.2 Adding elements to an ArrayList

Let's start with adding elements to an ArrayList, as follows:

```
import java.util.ArrayList;
public class AddToArrayList {
 public static void main(String args[]) {
 ArrayList<String> list = new ArrayList<>();
 list.add("one");
 list.add("two");
 list.add("four");
 list.add(2, "three");
 }
}
```

1
**Add element at the end**
  
2
**Add element at specified position**



**Figure 4.28** Code that adds elements to the end of an ArrayList and at a specified position

You can add a value to an ArrayList either at its end or at a specified position. ① adds elements at the end of list. ② adds an element to list at position 2. Please note that the first element of an ArrayList is stored at position 0. Hence, at ② the String literal value "three" will be inserted at position 2, which was occupied by the literal value "four". When a value is added to a place that is already occupied by another element, the values shift by a place to accommodate the newly added value. In this case, the literal value "four" shifted to position 3 to make way for the literal value "three" (see figure 4.28).

Let's see what happens behind the scenes in an ArrayList when you add an element to it. Here's the definition of the method add from the class ArrayList:

```
/**
 * Appends the specified element to the end of this list.
 *
 * @param e element to be appended to this list
 * @return <tt>true</tt> (as specified by {@link Collection#add})
 */
public boolean add(E e) {
 ensureCapacity(size + 1); // Create another array with
 // the increased capacity
 // and copy existing elements to it.
 elementData[size++] = e; // Store the newly added variable
 // reference at the
 // end of the list.
```

```

 return true;
 }
}

```

When you add an element to the end of the list, the `ArrayList` first checks whether its instance variable `elementData` has an empty slot at the end. If there's an empty slot at its end, it stores the element at the first available empty slot. If no empty slots exist, the method `ensureCapacity` creates another array with a higher capacity and copies the existing values to this newly created array. It then copies the newly added value at the first available empty slot in the array.

When you add an element at a particular position, an `ArrayList` creates a new array and inserts all its elements at positions other than the position you specified. If there are any subsequent elements to the right of the position that you specified, it shifts them by one position. Then it adds the new element at the requested position.

**PRACTICAL TIP** Understanding how and why a class works in a particular manner will take you a long way, in regard to both the certification exam and your career. This understanding should help you retain the information for a longer time and help you answer questions in the certification exam that are looking to verify your practical knowledge of using this class. Last, but not least, the internal workings of a class will enable you to make informed decisions on using a particular class at your workplace and writing efficient code.

#### 4.4.3 Accessing elements of an `ArrayList`

Before we modify or delete the elements of an `ArrayList`, let's see how to access them. To access the elements of an `ArrayList`, you can either use Java's enhanced for loop, `Iterator`, or `ListIterator`.

The following code accesses and prints all the elements of an `ArrayList` using the enhanced for loop (code to access elements is in bold):

```

import java.util.ArrayList;

public class AccessArrayList {
 public static void main(String args[]) {
 ArrayList<String> myArrList = new ArrayList<>();
 myArrList.add("One");
 myArrList.add("Two");
 myArrList.add("Four");
 myArrList.add(2, "Three");

 for (String element : myArrList) {
 System.out.println(element);
 }
 }
}

```

1 Code to access  
ArrayList elements

The output of the previous code is as follows:

```

One
Two
Three
Four

```

- ➊ defines the enhanced for loop to access all the elements of the myArrayList.

Let's take a look at how to use a ListIterator to loop through all the values of an ArrayList:

```
import java.util.ArrayList;
import java.util.ListIterator;

public class AccessArrayListUsingListIterator {
 public static void main(String args[]) {
 ArrayList<String> myArrayList = new ArrayList<String>();
 myArrayList.add("One");
 myArrayList.add("Two");
 myArrayList.add("Four");
 myArrayList.add(2, "Three");
 ListIterator<String> iterator = myArrayList.listIterator();
 while (iterator.hasNext()) {
 System.out.println(iterator.next());
 }
 }
}
```

- ➊ gets the iterator associated with ArrayList myArrayList. ➋ calls the method hasNext on iterator to check whether more elements of myArrayList exist. The method hasNext returns a boolean true value if more of its elements exist, and false otherwise. ➌ calls the method next on iterator to get the next item from myArrayList.

The previous code prints out the same results as the code that preceded it, the code that used an enhanced for loop to access ArrayList's elements. A ListIterator doesn't contain any reference to the *current* element of an ArrayList. ListIterator provides you with a method (hasNext) to check whether more elements exist for an ArrayList. If true, you can extract its *next* element using method next().

Note that an ArrayList preserves the insertion order of its elements. ListIterator and the enhanced for loop will return to you the elements in the order in which you added them.



**EXAM TIP** An ArrayList preserves the order of insertion of its elements. Iterator, ListIterator, and the enhanced for loop will return the elements in the order in which they were added to the ArrayList. An iterator (Iterator or ListIterator) lets you remove elements as you iterate an ArrayList. It's not possible to remove elements from an ArrayList while iterating it using a for loop.

#### 4.4.4 **Modifying the elements of an ArrayList**

You can modify an ArrayList by either replacing an existing element in ArrayList or modifying all of its existing values. The following code uses the set method to replace an element in an ArrayList:

```
import java.util.ArrayList;

public class ReplaceElementInArrayList {
 public static void main(String args[]) {
 ArrayList<String> myArrayList = new ArrayList<String>();
```

```

myArrList.add("One");
myArrList.add("Two");
myArrList.add("Three");
myArrList.set(1, "One and Half");
for (String element:myArrList)
 System.out.println(element);
}
}

```

**Replace ArrayList element at position 1 ("Two") with "One and Half"**

The output of the previous code is as follows:

```

One
One and Half
Three

```

You can also modify the existing values of an ArrayList by accessing its individual elements. Because Strings are immutable, let's try this with StringBuilder. Here's the code:

```

import java.util.ArrayList;
public class ModifyArrayListWithStringBuilder {
 public static void main(String args[]) {
 ArrayList<StringBuilder> myArrList =
 new ArrayList<StringBuilder>();
 myArrList.add(new StringBuilder("One"));
 myArrList.add(new StringBuilder("Two"));
 myArrList.add(new StringBuilder("Three"));

 for (StringBuilder element : myArrList)
 element.append(element.length());

 for (StringBuilder element : myArrList)
 System.out.println(element);
 }
}

```

**1 Access ArrayList elements and modify them**

The output of this code is as follows:

```

One3
Two3
Three5

```

**1** accesses all the elements of myArrList and modifies the element value by appending its length to it. The modified value is printed by accessing myArrList elements again.

#### 4.4.5 Deleting the elements of an ArrayList

ArrayList defines two methods to remove its elements, as follows:

- `remove(int index)`—This method removes the element at the specified position in this list.
- `remove(Object o)`—This method removes the first occurrence of the specified element from this list, if it's present.

Let's take a look at some code that uses these removal methods:

```

import java.util.ArrayList;
public class DeleteElementsFromArrayList {
 public static void main(String args[]) {
 ArrayList<StringBuilder> myArrList = new ArrayList<>();

 StringBuilder sb1 = new StringBuilder("One");
 StringBuilder sb2 = new StringBuilder("Two");
 StringBuilder sb3 = new StringBuilder("Three");
 StringBuilder sb4 = new StringBuilder("Four");

 myArrList.add(sb1);
 myArrList.add(sb2);
 myArrList.add(sb3);
 myArrList.add(sb4);

 myArrList.remove(1);
 for (StringBuilder element : myArrList)
 System.out.println(element);

 myArrList.remove(sb3);
 myArrList.remove(new StringBuilder("Four"));

 System.out.println();
 for (StringBuilder element : myArrList)
 System.out.println(element);
 }
}

```

**Doesn't remove Four**

**1**

**Remove element at position 1**

**Prints One, Three, and Four**

**1**

**Removes Three from list**

**Prints One and Four**

The output of the previous code is as follows:

```

One
Three
Four

One
Four

```

① tries to remove the `StringBuilder` with the value "Four" from `myArrList`. The removal of the specified element fails because of the manner in which the object references are compared for equality. Two objects are equal if their object references (the variables that store them) point to the same object.

You can always override the `equals` method in your own class to change this default behavior. The following is an example using the class `MyPerson`:

```

import java.util.ArrayList;
class MyPerson {
 String name;
 MyPerson(String name) { this.name = name; }

 @Override
 public boolean equals(Object obj) {
 if (obj instanceof MyPerson) {
 MyPerson p = (MyPerson) obj;
 boolean isEqual = p.name.equals(this.name);
 return isEqual;
 }
 else
 }
}

```

**Cast obj to MyPerson**

**1**

**Method equals**

**1**

**null and objects of type other than MyPerson can't be equal to this object**

**Compare name of method parameter to that of this object's name**

```

 return false;
 }
}
public class DeleteElementsFromArrayList2 {
 public static void main(String args[]) {
 ArrayList<MyPerson> myArrList = new ArrayList<MyPerson>();

 MyPerson p1 = new MyPerson("Shreya");
 MyPerson p2 = new MyPerson("Paul");
 MyPerson p3 = new MyPerson("Harry");

 myArrList.add(p1);
 myArrList.add(p2);
 myArrList.add(p3);

 myArrList.remove(new MyPerson("Paul"));

 for (MyPerson element:myArrList)
 System.out.println(element.name);
 }
}

```

At ①, the method `equals` in class `MyPerson` overrides method `equals` in class `Object`. It returns `false` if a `null` value is passed to this method. It returns `true` if an object of `MyPerson` is passed to it with a matching value for its instance variable `name`.

At ②, the method `remove` removes the element with the name `Paul` from `myArrList`. As mentioned earlier, the method `remove` compares the objects for equality before removing it from `ArrayList` by calling method `equals`.

When elements of an `ArrayList` are removed, the remaining elements are rearranged at their correct positions. This change is required to retrieve all the remaining elements at their correct new positions.

#### 4.4.6 Other methods of `ArrayList`

Let's briefly discuss the other important methods defined in `ArrayList`.

##### ADDING MULTIPLE ELEMENTS TO AN `ARRAYLIST`

You can add multiple elements to an `ArrayList` from another `ArrayList` or any other class that is a subclass of `Collection` by using the following overloaded versions of method `addAll`:

- `addAll(Collection<? extends E> c)`
- `addAll(int index, Collection<? extends E> c)`

Method `addAll(Collection<? extends E> c)` appends all of the elements in the specified collection to the end of this list in the order in which they're returned by the specified collection's `Iterator`. If you aren't familiar with generics, and the parameters of this method look scary to you, don't worry—other classes from the `Collection API` are not on this exam.

Method `addAll(int index, Collection<? extends E> c)` inserts all of the elements in the specified collection into this list, starting at the specified position.

In the following code example, all elements of `ArrayList` `yourArrList` are inserted into `ArrayList` `myArrList`, starting at position 1:

```
ArrayList<String> myArrList = new ArrayList<String>();
myArrList.add("One");
myArrList.add("Two");

ArrayList<String> yourArrList = new ArrayList<String>();
yourArrList.add("Three");
yourArrList.add("Four");
myArrList.addAll(1, yourArrList);
for (String val : myArrList)
 System.out.println(val);
```

← **Add elements of yourArrList to myArrList**

The output of the previous code is as follows:

```
One
Three
Four
Two
```

The elements of `yourArrList` aren't removed from it. The objects that are stored in `yourArrList` can now be referred to from `myArrList`.

What happens if you modify the *common* object references in these lists, `myArrList` and `yourArrList`? We have two cases here: In the first one, you *reassign* the object reference using either of the lists. In this case, the value in the second list will remain unchanged. In the second case, you *modify* the internals of any of the common list elements—in this case, the change will be reflected in both of the lists.



**EXAM TIP** This is also one of the favorite topics of the exam authors. In the exam, you're likely to encounter a question that adds the same object reference to multiple lists and then tests you on your understanding of the state of the same object and reference variable in all the lists. If you have any questions on this issue, please refer to the section on reference variables (section 2.3).

Time for our next Twist in the Tale exercise. Let's modify some of the code that we've used in our previous examples and see how it affects the output (answers in the appendix).

#### Twist in the Tale 4.4

What is the output of the following code?

```
ArrayList<String> myArrList = new ArrayList<String>();
String one = "One";
String two = new String("Two");
myArrList.add(one);
myArrList.add(two);
ArrayList<String> yourArrList = myArrList;
one.replace("O", "B");
```

```
for (String val : myArrList)
 System.out.print(val + ":");

for (String val : yourArrList)
 System.out.print(val + ":");

a One:Two:One:Two:
b Bne:Two:Bne:Two:
c One:Two:Bne:Two:
d Bne:Two:One:Two:
```

---

### CLEARING ARRAYLIST ELEMENTS

You can remove all the ArrayList elements by calling clear on it. Here's an example:

```
ArrayList<String> myArrList = new ArrayList<String>();
myArrList.add("One");
myArrList.add("Two");

myArrList.clear();

for (String val:myArrList)
 System.out.println(val);
```

The previous code won't print out anything because there are no more elements in myArrList.

### ACCESSING INDIVIDUAL ARRAYLIST ELEMENTS

In this section, we'll cover the following methods for accessing elements of an ArrayList:

- `get(int index)`—This method returns the element at the specified position in this list.
- `size()`—This method returns the number of elements in this list.
- `contains(Object o)`—This method returns true if this list contains the specified element.
- `indexOf(Object o)`—This method returns the index of the first occurrence of the specified element in this list, or -1 if this list doesn't contain the element.
- `lastIndexOf(Object o)`—This method returns the index of the last occurrence of the specified element in this list, or -1 if this list doesn't contain the element.

You can retrieve an object at a particular position in ArrayList and determine its size as follows:

```
ArrayList<String> myArrList = new ArrayList<String>();
myArrList.add("One");
myArrList.add("Two");
String valFromList = myArrList.get(1);
System.out.println(valFromList);
```

↳ Prints Two—element  
at position 1

```
System.out.println(myArrList.size());
```

↳ Prints 2

Behind the scenes, the method `get` will check whether the requested position exists in the `ArrayList` by comparing it with the array's size. If the requested element isn't within the range, the `get` method throws a `java.lang.IndexOutOfBoundsException` error at runtime.

All of the remaining three methods—`contains`, `indexOf`, and `lastIndexOf`—require you to have an unambiguous and strong understanding of how to determine the equality of objects. `ArrayList` stores objects, and these three methods will compare the values that you pass to these methods with all the elements of the `ArrayList`.

By default, objects are considered equal if they are referred to by the same variable (the `String` class is an exception with its pool of `String` objects). If you want to compare objects by their state (values of the instance variable), override the `equals` method in that class. I've already demonstrated the difference in how equality of objects of a class is determined, when the class overrides its `equals` method and when it doesn't, in section 4.4.5 with an overridden `equals` method in the class `MyPerson`.

Let's see the usage of all these methods:

```
public class MiscMethodsArrayList3 {
 public static void main(String args[]) {
 ArrayList<StringBuilder> myArrList =
 new ArrayList<StringBuilder>();
 StringBuilder sb1 = new StringBuilder("Jan");
 StringBuilder sb2 = new StringBuilder("Feb");
 myArrList.add(sb1);
 Adds sb2 to the ArrayList again myArrList.add(sb2);
 myArrList.add(sb2);
Adds sb1 to the ArrayList System.out.println(myArrList.contains(new StringBuilder("Jan")));
Adds sb2 to the ArrayList System.out.println(myArrList.contains(sb1));
Prints true
Prints false System.out.println(myArrList.indexOf(new StringBuilder("Feb")));
Prints -1 System.out.println(myArrList.indexOf(sb2));
Prints 1 System.out.println(myArrList.lastIndexOf(
 new StringBuilder("Feb")));
Prints 2 System.out.println(myArrList.lastIndexOf(sb2));
 }
}
```

The output of the previous code is as follows:

```
false
true
-1
1
-1
2
```

Take a look at the output of the same code using a list of `MyPerson` objects that has overridden the `equals` method. First, here's the definition of the class `MyPerson`:

```

class MyPerson {
 String name;
 MyPerson(String name) { this.name = name; }
 @Override
 public boolean equals(Object obj) {
 if (obj instanceof MyPerson) {
 MyPerson p = (MyPerson) obj;
 boolean isEqual = p.name.equals(this.name);
 return isEqual;
 }
 else
 return false;
 }
}

```

**Overridden equals method in class MyPerson. It returns true for same String values for instance variable name.**

The definition of the class MiscMethodsArrayList4 follows:

```

public class MiscMethodsArrayList4 {
 public static void main(String args[]) {
 ArrayList<MyPerson> myArrList = new ArrayList<MyPerson>();

 MyPerson p1 = new MyPerson("Shreya");
 MyPerson p2 = new MyPerson("Paul");
 myArrList.add(p1); ← Adds p1 to ArrayList
 myArrList.add(p2); ← Adds p2 to ArrayList
 myArrList.add(p2); ← Adds p2 to ArrayList again
 }

 Prints true
 System.out.println(myArrList.contains(new MyPerson("Shreya")));
 System.out.println(myArrList.contains(p1));
 Prints true

 Prints 1
 System.out.println(myArrList.indexOf(new MyPerson("Paul")));
 System.out.println(myArrList.indexOf(p2));
 Prints 1

 Prints 2
 System.out.println(myArrList.lastIndexOf(new MyPerson("Paul")));
 System.out.println(myArrList.lastIndexOf(p2));
 Prints 2
}

```

As you can see from the output of the preceding code, equality of the objects of class MyPerson is determined by the rules defined in its equals method. Two objects of class MyPerson with the same value for its instance variable name are considered to be equal. myArrList stores objects of class MyPerson. To find a target object, myArrList will rely on the output given by the equals method of class MyPerson; it won't compare the object references of the stored and target objects.



**EXAM TIP** An ArrayList can accept duplicate object values.

#### CLONING AN ARRAYLIST

The method clone defined in the class ArrayList returns a *shallow copy* of this ArrayList instance. “Shallow copy” means that this method creates a new instance of the ArrayList object to be cloned. Its element references are copied, but the objects themselves are not.

Here's an example:

```

public class MiscMethodsArrayList5 {
 public static void main(String args[]) {
 ArrayList<StringBuilder> myArrList = new ArrayList<StringBuilder>();
 StringBuilder sb1 = new StringBuilder("Jan");
 StringBuilder sb2 = new StringBuilder("Feb");

 myArrList.add(sb1);
 myArrList.add(sb2);
 myArrList.add(sb2);

 ArrayList<StringBuilder> assignedArrList = myArrList; 1 Assigns object referred to by myArrList to assignedArrList

 Prints true 3 ↗ System.out.println(myArrList == assignedArrList); 2 Clones myArrList and assigns it to clonedArrList

 Prints false 4 ↗ System.out.println(myArrList == clonedArrList);

 Prints true 5 ↗ String Builder myArrVal = myArrList.get(0);
 Prints true 6 ↗ String Builder assignedArrVal = assignedArrList.get(0);
 Prints true 7 ↗ String Builder clonedArrVal = clonedArrList.get(0);
 Prints true 8 ↗ System.out.println(myArrVal == assignedArrVal);
 Prints true 9 ↗ System.out.println(myArrVal == clonedArrVal);
 }
}

```

Let's go through the previous code:

- ① assigns the object referred to by `myArrList` to `assignedArrList`. The variables `myArrList` and `assignedArrList` now refer to the same object.
- ② assigns a *copy* of the object referred to by `myArrList` to `clonedArrList`. The variables `myArrList` and `clonedArrList` refer to different objects. Because method `clone` returns a value of the type `Object`, it is cast to `ArrayList<StringBuilder>` to assign it to `clonedArrList` (don't worry if you can't follow this line—casting is covered in chapter 6).
- ③ prints `true` because `myArrList` and `assignedArrList` refer to the same object.
- ④ prints `false` because `myArrList` and `clonedArrList` refer to separate objects, because the method `clone` creates and returns a new object of `ArrayList` (but with the same list members).
- ⑤ proves that the method `clone` didn't copy the elements of `myArrList`. All the variable references `myArrVal`, `AssignedArrVal`, and `clonedArrVal` refer to the same objects.
- Hence, both ⑥ and ⑦ print `true`.

#### CREATING AN ARRAY FROM AN `ArrayList`

You can use the method `toArray` to return an array containing all of the elements in an `ArrayList` in sequence from the first to the last element. As mentioned earlier in this chapter (refer to figure 4.27 in section 4.4.1), an `ArrayList` uses a private variable, '`elementData`' (an array), to store its own values. Method `toArray` doesn't return a reference to this array. It creates a new array, copies the elements of the `ArrayList` to it and then returns it.

Now comes the tricky part. No references to the returned array, which is itself an object, are maintained by the `ArrayList`. But the references to the individual `ArrayList` elements are copied to the returned array and are still referred to by the `ArrayList`.

This implies that if you modify the returned array by, say, swapping the position of its elements or by assigning new objects to its elements, the elements of `ArrayList` won't be affected. But, if you modify the state of (mutable) elements of the returned array, then the modified state of elements will be reflected in the `ArrayList`.

## 4.5 Comparing objects for equality



[3.3] Test equality between strings and other objects using `==` and `equals()`

In section 4.1, you saw how the class `String` defined a set of rules to determine whether two `String` values are equal, and how these rules were coded in the method `equals`. Similarly, any Java class can define a set of rules to determine whether its two objects should be considered equal. This comparison is accomplished using the method `equals`, which is described in the next section.

### 4.5.1 The method `equals` in the class `java.lang.Object`

The method `equals` is defined in class `java.lang.Object`. All of the Java classes directly or indirectly inherit from this class. Listing 4.2 contains the default implementation of the method `equals` from class `java.lang.Object`.

#### Listing 4.2 Implementation of `equals` method from the class `java.lang.Object`

```
public boolean equals(Object obj) {
 return (this == obj);
}
```

As you can see, the default implementation of the `equals` method only compares whether two object variables refer to the same object. Because instance variables are used to store the state of an object, it's common to compare the values of the instance variables to determine whether two objects should be considered equal.

### 4.5.2 Comparing objects of a user-defined class

Let's work with an example of class `BankAccount`, which defines two instance variables: `acctNumber`, of type `String`, and `acctType`, of type `int`. The `equals` method compares the values of these instance variables to determine the equality of two objects of class `BankAccount`.

Here's the relevant code:

```
class BankAccount {
 String acctNumber;
 int acctType;

 public boolean equals(Object anObject) {
 if (anObject instanceof BankAccount) {
```

Check whether we are comparing the same type of objects

```

 BankAccount b = (BankAccount)anObject;
 return (acctNumber.equals(b.acctNumber) && ←
 acctType == b.acctType);
 }
 else
 return false;
}
}

```

**Two bank objects are considered equal if they have the same values, for instance variables acctNumber and acctType**

Let's verify the working of this equals method in the following code:

```

class Test {
 public static void main(String args[]) {
 BankAccount b1 = new BankAccount();
 b1.acctNumber = "0023490";
 b1.acctType = 4;

 BankAccount b2 = new BankAccount();
 b2.acctNumber = "11223344";
 b2.acctType = 3;

 BankAccount b3 = new BankAccount();
 b3.acctNumber = "11223344";
 b3.acctType = 3;

 System.out.println(b1.equals(b2));
 System.out.println(b2.equals(b3));
 System.out.println(b1.equals(new String("abc")));
 }
}

```

- ➊ prints false because the value of the reference variables b1 and b2 do not match.
- ➋ prints true because the values of the reference variables b2 and b3 match each other.
- ➌ passes an object of type String to the method equals defined in the class BankAccount. This method returns false if the method parameter passed to it is not of type BankAccount. Hence ➌ prints false.

Even though the following implementation is unacceptable for classes used in the real world, it's still correct syntactically:

```

class BankAccount {
 String acctNumber;
 int acctType;

 public boolean equals(Object anObject) {
 return true;
 }
}

```

The previous definition of the equals method will return true for any object that's compared to an object of class BankAccount because it doesn't compare any values. Let's see what happens when you compare an object of class String with an object of class BankAccount and vice versa using equals():

```

class TestBank {
 public static void main(String args[]) {

```

```

BankAccount acct = new BankAccount();
String str = "Bank";
System.out.println(acct.equals(str));
System.out.println(str.equals(acct));
}
}

```

In the preceding code, ① prints true, but ② prints false. The equals method in the class String returns true only if the object that's being compared to is a String with the same sequence of characters.



**EXAM TIP** In the exam, watch out for questions about the correct implementation of the equals method to compare two objects versus questions about the equals methods that simply compile correctly. If you'd been asked whether equals() in the previous example code would compile correctly, the correct answer is yes.

#### 4.5.3 Incorrect method signature of the equals method

It's a very common mistake to write an equals method that accepts a member of the class itself. In the following code, the only change is in the type of method parameter:

```

class BankAccount {
 String acctNumber;
 int acctType;

 public boolean equals(BankAccount anObject) {
 if (anObject instanceof BankAccount) {
 BankAccount b = (BankAccount)anObject;
 return (acctNumber.equals(b.acctNumber) &&
 acctType == b.acctType);
 }
 else
 return false;
 }
}

```

Though the previous definition of equals() may seem to be flawless, what happens when you try to add and retrieve an object of class BankAccount (as shown in the preceding code) from an ArrayList? The method contains defined in the class ArrayList compares two objects by calling the object's equals method. It does not compare object references.

In the following code, see what happens when you add an object of the class BankAccount to an ArrayList and then try to verify whether the list contains a BankAccount object with the same instance variables values for acctNumber and acctType as the object being searched for:

```

class TestMethodEquals {
 public static void main(String args[]) {
 BankAccount b1 = new BankAccount();
 b1.acctNumber = "0023490"; b1.acctType = 4;
}

```

```

ArrayList <BankAccount> list = new ArrayList<BankAccount>();
list.add(b1);

BankAccount b2 = new BankAccount();
b2.acctNumber = "0023490"; b2.acctType = 4;

System.out.println(list.contains(b2));
}
}

① Adds object b1 to list → ②
③ Creates b2 with same state as b1 ← ④ Prints false

```

① and ③ define objects b1 and b2 of the class BankAccount with the same state. ② adds b1 to the list. ④ compares the object b2 with the objects added to the list.

An ArrayList uses the method equals to compare two objects. Because the class BankAccount didn't follow the rules for correctly defining (overriding) the method equals, ArrayList uses the method equals from the base class Object, which compares object references. Because the code didn't add b2 to list, it prints false.

What do you think will be the output of the previous code if you change the definition of the method equals in the class BankAccount so that it accepts a method parameter of type Object? Try it for yourself!



**EXAM TIP** The method equals defines a method parameter of type Object, and its return type is boolean. Don't change the name of the method, its return type, or the type of method parameter when you define (*override*) this method in your class to compare two objects.

#### 4.5.4 Contract of the equals method

The Java API defines a *contract* for the equals method, which should be taken care of when you implement it in any of your classes. I've pulled the following contract explanation directly from the Java API documentation:<sup>1</sup>

The equals method implements an equivalence relation on non-null object references:

- It is reflexive: for any non-null reference value x, x.equals(x) should return true.
- It is symmetric: for any non-null reference values x and y, x.equals(y) should return true if and only if y.equals(x) returns true.
- It is transitive: for any non-null reference values x, y, and z, if x.equals(y) returns true and y.equals(z) returns true, then x.equals(z) should return true.
- It is consistent: for any non-null reference values x and y, multiple invocations of x.equals(y) consistently return true or consistently return false, provided no information used in equals() comparisons on the objects is modified.
- For any non-null reference value x, x.equals(null) should return false.

<sup>1</sup> The Java API documentation for equals can be found on the Oracle site: [http://docs.oracle.com/javase/7/docs/api/java/lang/Object.html#equals\(java.lang.Object\)](http://docs.oracle.com/javase/7/docs/api/java/lang/Object.html#equals(java.lang.Object)).

As per the contract, the definition of the `equals` method that we defined for the class `BankAccount` in an earlier example violates the contract for the `equals` method. Take a look at the definition again:

```
public boolean equals(Object anObject) {
 return true;
}
```

This code returns `true`, even for `null` values passed to this method. According to the contract of the method `equals`, if a `null` value is passed to the `equals` method, the method should return `false`.



**EXAM TIP** You may get to answer explicit questions on the contract of the `equals` method. An `equals` method that returns `true` for a `null` object passed to it will violate the contract. Also, if the `equals` method modifies the value of any of the instance variables of the method parameter passed to it, or of the object on which it is called, it will violate the `equals` contract.

### The `hashCode()` method

A lot of programmers are confused about the role of the method `hashCode` in determining the equality of objects. The method `hashCode` is *not* called by the `equals` method to determine the equality of two objects. Because the `hashCode` method is not on the exam, I'll discuss it quickly here to ward off any confusion about this method.

The method `hashCode` is used by the collection classes (such as `TreeMap` and `HashMap`) that store *key-value* pairs, where a *key* is an object. These collection classes use the `hashCode` of a *key* to search efficiently for the corresponding *value*. The `hashCode` of the *key* (an object) is used to specify a *bucket* number, which should store its corresponding *value*. The `hashCode` values of two objects can be the same. When these collection classes find the right bucket, they call the `equals` method to select the correct *value* object (that shares the same *key* values). The `equals` method is called even if a *bucket* contains only one object. After all, it might be the same hash but a different `equals`, and there is no match to get!

According to the Java documentation, when you override the `equals` method in your class, you should also override the `hashCode` method. If you don't, objects of your classes won't behave as required if they're used as *keys* by collection classes that store *key-value* pairs. This method is not discussed in detail in this chapter because it isn't on the exam. But don't forget to override it with the method `equals` in your real-world projects.

## 4.6 Summary

In this chapter, you learned about the `String` class, its properties, and its methods. Because this is one of the most frequently used classes in Java, I'll reiterate that a good understanding of this class in terms of why its methods behave in a particular manner will go a long way to helping you successfully complete the OCA Java SE 7 Programmer I exam.

You also learned how to create objects of the class `String` using the operator `new` and the assignment operator (`=`). You also learned the differences between how `String` objects are stored using these two approaches. If you use the assignment operator to create your `String` objects, they're stored in a common pool of `String` objects (also known as the `String` constant pool) that can be used by others. This storage is possible because `String` objects are immutable—that is, their values can't be changed.

You also learned how a `char` array is used to store the value of a `String` object. This knowledge helps explain why the methods `charAt()`, `indexOf()`, and `substring()` search for the first character of a `String` at position 0, not position 1. We also reviewed the methods `replace()`, `trim()`, and `substring()`, which seem to modify the value of a `String` but will never be able to do it because `String` objects are immutable. You also learned the methods `length()`, `startsWith()`, and `endsWith()`.

Because all operators can't be used with `Strings`, you learned about the ones that can be used with `String`: `+`, `+=`, `==`, and `!=`. You also learned that the equality of `Strings` can be determined using the method `equals`. By using the operator `==`, you can only determine whether both the variables are referring to the same object; it doesn't compare the values stored by `Strings`. As with all the other object types, the only literal value that can be assigned to a `String` is `null`.

We worked with the class `StringBuilder`, which is defined in the package `java.lang` and is used to store a mutable sequence of characters. The class `StringBuilder` is usually used to store a sequence of characters that needs to be modified often—like when you're building a query for database applications. Like the `String` class, `StringBuilder` also uses a `char` array to store its characters. A lot of the methods defined in class `StringBuilder` work exactly as defined by the class `String`, such as the methods `charAt`, `indexOf`, `substring`, and `length`. The `append` method is used to add characters to the end of a `StringBuilder` object. The `insert` method is another important `StringBuilder` method that's used to insert either single or multiple characters at a specified position in a `StringBuilder` object. The class `StringBuilder` offers the same functionality offered by the class `StringBuffer`, minus the additional feature of methods that are synchronized where needed.

An array is an object that stores a collection of values. An array can store a collection of primitive data types or a collection of objects. You can define one-dimensional and multidimensional arrays. A one-dimensional array is an object that refers to a collection of scalar values. A two-dimensional (or more) array is referred to as a multidimensional array. A two-dimensional array refers to a collection of objects, where each of the objects is a one-dimensional array. Similarly, a three-dimensional array refers to a collection of two-dimension arrays, and so on. Arrays can be declared, allocated, and initialized in a single step or in multiple steps. A two-dimensional array does not need to be symmetrical, and each of its rows can define different numbers of members. You can define arrays of primitives, interfaces, abstract classes, and concrete classes. All arrays are objects and can access the variable `length` and methods inherited from the class `java.lang.Object`.

`ArrayList` is a resizable array that offers the best combination of features offered by an array and the `List` data structure. You can add objects to an `ArrayList` using the method `add`. You can access the objects of an `ArrayList` by using an enhanced for loop. An `ArrayList` preserves the order of insertion of its elements. `ListIterator` and the enhanced for loop will return the elements in the order in which they were added to the `ArrayList`. You can modify the elements of an `ArrayList` using the method `set`. You can remove the elements of an `ArrayList` by using the method `remove`, which accepts the element position or an object. You can also add multiple elements to an `ArrayList` by using the method `addAll`. The method `clone` defined in the class `ArrayList` returns a *shallow copy* of this `ArrayList` instance. “Shallow copy” means that the method creates a new instance of the `ArrayList` to be cloned, but the `ArrayList` elements aren’t copied.

You can compare the objects of your class by overriding the `equals` method. The `equals` method is defined in the class `java.lang.Object`, which is the base class of all classes in Java. The default implementation of the method `equals` only compares the object references for equality. Because instance variables are used to store the state of an object, it’s common to compare the values of these variables to determine whether two objects should be considered equal in the `equals` method. The Java API documentation defines a contract for the `equals` method. In the exam, for a given definition of the method `equals`, it is important to note the differences between an `equals` method that compiles successfully, one that fails compilation, and one that doesn’t follow the contract.

## 4.7 Review notes

This section lists the main points covered in this chapter.

The class `String`:

- The class `String` represents an immutable sequence of characters.
- A `String` object can be created by using the operator `new`, by using the assignment operator (`=`), or by using double quotes (as in `System.out.println("Four")`).
- `String` objects created using the assignment operator are placed in a *pool* of `String` objects. Whenever the JRE receives a new request to create a `String` object using the assignment operator, it checks whether a `String` object with the same value already exists in the pool. If found, it returns the object reference for the existing `String` object from the pool.
- `String` objects created using the operator `new` are never placed in the pool of `String` objects.
- The comparison operator (`==`) compares `String` references, whereas the `equals` method compares the `String` values.
- None of the methods defined in the class `String` can modify its value.
- The method `charAt(int index)` retrieves a character at a specified index of a `String`.

- The method `indexOf` can be used to search a `String` for the occurrence of a `char` or a `String`, starting from the first position or a specified position.
- The method `substring` can be used to retrieve a portion of a `String` object. The `substring` method doesn't include the character at the end position.
- The `trim` method will return a new `String` by removing all the leading and trailing white spaces in a `String`. This method doesn't remove any white space *within* a `String`.
- You can use the method `length` to retrieve the length of a `String`.
- The method `startsWith` determines whether a `String` starts with a specified `String`.
- The method `endsWith` determines whether a `String` ends with a specified `String`.
- It's a common practice to use multiple `String` methods in a single line of code. When chained, the methods are evaluated from left to right.
- You can use the concatenation operators `+` and `+=` and comparison operators `!=` and `==` with `String` objects.
- The Java language provides special support for concatenating `String` objects by using the operators `+` and `+=`.
- The right technique for comparing two `String` values for equality is to use the method `equals` defined in the `String` class. This method returns a `true` value if the object being compared isn't `null` and is a `String` object that represents the same sequence of characters as the object to which it's being compared.
- The comparison operator `==` determines whether both the reference variables are referring to the same `String` objects. Hence, it's not the right operator for comparing `String` values.

The class `StringBuilder`:

- The class `StringBuilder` is defined in the package `java.lang` and represents a mutable sequence of characters.
- The `StringBuilder` class is very efficient when a user needs to modify a sequence of characters often. Because it's mutable, the value of a `StringBuilder` object can be modified without the need to create a new `StringBuilder` object.
- A `StringBuilder` object can be created using its constructors, which can accept either a `String` object, another `StringBuilder` object, an `int` value to specify the capacity of `StringBuilder`, or nothing.
- The methods `charAt`, `indexOf`, `substring`, and `length` defined in the class `StringBuilder` work in the same way as methods with the same names defined in the class `String`.
- The `append` method adds the specified value at the end of the existing value of a `StringBuilder` object.
- The `insert` method enables you to insert characters at a specified position in a `StringBuilder` object. The main difference between the `append` and `insert`

methods is that the `insert` method enables you to insert the requested data at a particular position, whereas the `append` method only allows you to add the requested data at the end of the `StringBuilder` object.

- The method `delete` removes the characters in a substring of the specified `StringBuilder`. The method `deleteCharAt` removes the `char` at the specified position.
- Unlike the class `String`, the class `StringBuilder` doesn't define the method `trim`.
- The method `reverse` reverses the sequence of characters of a `StringBuilder`.
- The `replace` method in the class `StringBuilder` replaces a sequence of characters, identified by their position, with another `String`.
- In addition to using the method `substring`, you can also use the method `subSequence` to retrieve a subsequence of a `StringBuilder` object.

#### Arrays:

- An array is an object that stores a collection of values.
- An array itself is an object.
- An array can store two types of data—a collection of primitive data types and a collection of objects.
- You can define one-dimensional and multidimensional arrays.
- A one-dimensional array is an object that refers to a collection of scalar values.
- A two-dimensional (or more) array is referred to as a multidimensional array.
- A two-dimensional array refers to a collection of objects, in which each of the objects is a one-dimensional array.
- Similarly, a three-dimensional array refers to a collection of two-dimensional arrays, and so on.
- Multidimensional arrays may or may not contain the same number of elements in each row or column.
- The creation of an array involves three steps: declaration of an array, allocation of an array, and initialization of array elements.
- An array declaration is composed of an array type, a variable name, and one or more occurrences of `[]`.
- Square brackets can follow either the variable name or its type. In the case of multidimensional arrays, it can follow both of them.
- An array declaration creates a variable that refers to `null`.
- Because no elements of an array are created when it's declared, it's invalid to define the size of an array with its declaration.
- *Array allocation* allocates memory for the elements of an array. When you allocate memory for an array, you must specify its dimensions, such as the number of elements the array should store.
- Because an array is an object, it's allocated using the keyword `new`, followed by the type of value that it stores, and then its size.

- Once allocated, all the array elements store their default values. Elements of an array that store objects refer to null. Elements of an array that store primitive data types store 0 for integer types (byte, short, int, long), 0.0 for decimal types (float and double), false for boolean, or \u0000 for char data.
- To access an element in a two-dimensional array, use two array position values.
- You can combine all the steps of array declaration, allocation, and initialization into one single step.
- When you combine array declaration, allocation, and initialization in a single step, you can't specify the size of the array. The size of the array is calculated by the number of values that are assigned to the array.
- You can declare and allocate an array but choose not to initialize it (for example, `int [] a = new int [5];`).
- The Java compiler doesn't check the range of the index positions at which you try to access an array element. The code throws an `ArrayIndexOutOfBoundsException` exception if the requested index position doesn't fall in the valid range at runtime.
- A multidimensional array can be asymmetrical; it may not define the same number of columns for each of its rows.
- The type of an array can also be an interface or abstract class. Such an array can be used to store objects of classes that inherit from the interface type or the abstract class type.
- The type of an array can also be `java.lang.Object`. Because all classes extend the class `java.lang.Object` class, elements of this array can refer to any object.
- All the arrays are objects and can access the variable `length`, which specifies the number of components stored by the array.
- Because all arrays are objects, they inherit and can access all methods from the class `Object`.

#### ArrayList:

- `ArrayList` is one of the most widely used classes from the Collections framework. It offers the best combination of features offered by an array and the `List` data structure.
- An `ArrayList` is like a resizable array.
- Unlike arrays, you may not specify an initial size to create an `ArrayList`.
- `ArrayList` implements the interface `List` and allows null values to be added to it.
- `ArrayList` implements all list operations (add, modify, and delete values).
- `ArrayList` allows duplicate values to be added to it and maintains its insertion order.
- You can use either `Iterator` or `ListIterator` to iterate over the items of an `ArrayList`.

- `ArrayList` supports generics, making it type safe.
- Internally, an array of type `java.lang.Object` is used to store the data in an `ArrayList`.
- You can add a value to an `ArrayList` either at its end or at a specified position by using the method `add`.
- To access the elements of an `ArrayList`, you can use either the enhanced for loop, `Iterator`, or `ListIterator`.
- An iterator (`Iterator` or `ListIterator`) lets you remove elements as you iterate through an `ArrayList`. It's not possible to remove elements from an `ArrayList` while iterating through it using a for loop.
- An `ArrayList` preserves the order of insertion of its elements. `ListIterator` and the enhanced for loop will return the elements in the order in which they were added to the `ArrayList`.
- You can use the method `set` to modify an `ArrayList` by either replacing an existing element in `ArrayList` or modifying its existing values.
- `remove(int)` removes the element at the specified position in the list.
- `remove(Object o)` removes the first occurrence of the specified element from the list, if it's present.
- You can add multiple elements to an `ArrayList` from another `ArrayList` or any other class that's a subclass of `Collection` by using the method `addAll`.
- You can remove all the `ArrayList` elements by calling the method `clear` on it.
- `get(int index)` returns the element at the specified position in the list.
- `size()` returns the number of elements in the list.
- `contains(Object o)` returns true if the list contains the specified element.
- `indexOf(Object o)` returns the index of the first occurrence of the specified element in the list, or -1 if the list doesn't contain the element.
- `lastIndexOf(Object o)` returns the index of the last occurrence of the specified element in the list, or -1 if the list doesn't contain the element.
- The method `clone` defined in the class `ArrayList` returns a *shallow copy* of this `ArrayList` instance. "Shallow copy" means that the method creates a new instance of the `ArrayList` to be cloned, but the `ArrayList` elements aren't copied.
- You can use the method `toArray` to return an array containing all of the elements in `ArrayList` in sequence from the first to the last element.

Comparing objects for equality:

- Any Java class can define a set of rules to determine whether two objects should be considered equal.
- The method `equals` is defined in the class `java.lang.Object`. All the Java classes directly or indirectly inherit this class.
- The default implementation of the `equals` method only compares whether two object variables refer to the same object.

- Because instance variables are used to store the state of an object, it's common to compare the values of the instance variables to determine whether two objects should be considered equal.
- When you override the `equals` method in your class, make sure that you use the correct method signature for the `equals` method.
- The Java API defines a contract for the `equals` method, which should be taken care of when you implement the method in any of your classes.
- According to the contract of the method `equals`, if a `null` value is passed to it, the method `equals` should return `false`.
- If the `equals` method modifies the value of any of the instance variables of the method parameter passed to it, or of the object on which it is called, it will violate the contract.

## 4.8 Sample exam questions

**Q4-1.** What is the output of the following code?

```
class EJavaGuruArray {
 public static void main(String args[]) {
 int[] arr = new int[5];
 byte b = 4; char c = 'c'; long longVar = 10;
 arr[0] = b;
 arr[1] = c;
 arr[3] = longVar;
 System.out.println(arr[0] + arr[1] + arr[2] + arr[3]);
 }
}

a 4c010
b 4c10
c 113
d 103
e Compilation error
```

**Q4-2.** What is the output of the following code?

```
class EJavaGuruArray2 {
 public static void main(String args[]) {
 int[] arr1;
 int[] arr2 = new int[3];
 char[] arr3 = {'a', 'b'};
 arr1 = arr2;
 arr1 = arr3;
 System.out.println(arr1[0] + ":" + arr1[1]);
 }
}

a 0:0
b a:b
c 0:b
```

- d** a:0
- e** Compilation error

**Q4-3.** Which of the following are valid lines of code to define a multidimensional int array?

- a** int [] [] array1 = {{1, 2, 3}, {}, {1, 2, 3, 4, 5}};
- b** int [] [] array2 = new array() {{1, 2, 3}, {}, {1, 2, 3, 4, 5}};
- c** int [] [] array3 = {1, 2, 3}, {0}, {1, 2, 3, 4, 5};
- d** int [] [] array5 = new int [2] [] ;

**Q4-4.** Which of the following statements are correct?

- a** By default, an ArrayList creates an array with an initial size of 16 to store its elements.
- b** Because ArrayList stores only objects, you can't pass an element of an ArrayList to a switch construct.
- c** Calling clear() and remove() on an ArrayList will remove all its elements.
- d** If you frequently add elements to an ArrayList, specifying a larger capacity will improve the code efficiency.
- e** Calling the method clone() on an ArrayList creates its shallow copy; that is, it doesn't clone the individual list elements.

**Q4-5.** Which of the following statements are correct?

- a** An ArrayList offers a resizable array, which is easily managed using the methods it provides. You can add and remove elements from an ArrayList.
- b** Values stored by an ArrayList can be modified.
- c** You can iterate through elements of an ArrayList using a for loop, Iterator, or ListIterator.
- d** An ArrayList requires you to specify the total number of elements before you can store any elements in it.
- e** An ArrayList can store any type of object.

**Q4-6.** What is the output of the following code?

```

import java.util.*; // line 1
class EJavaGuruArrayList { // line 2
 public static void main(String args[]) { // line 3
 ArrayList<String> ejg = new ArrayList<>(); // line 4
 ejg.add("One"); // line 5
 ejg.add("Two"); // line 6
 System.out.println(ejg.contains(new String("One"))); // line 7
 System.out.println(ejg.indexOf("Two")); // line 8
 ejg.clear(); // line 9
 System.out.println(ejg); // line 10
 System.out.println(ejg.get(1)); // line 11
 } // line 12
} // line 13

```

- a Line 7 prints true
- b Line 7 prints false
- c Line 8 prints -1
- d Line 8 prints 1
- e Line 9 removes all elements of the list ejg
- f Line 9 sets the list ejg to null
- g Line 10 prints null
- h Line 10 prints []
- i Line 10 prints a value similar to ArrayList@16356
- k Line 11 throws an exception
- l Line 11 prints null

**Q4-7.** What is the output of the following code?

```
class EJavaGuruString {
 public static void main(String args[]) {
 String ejg1 = new String("E Java");
 String ejg2 = new String("E Java");
 String ejg3 = "E Java";
 String ejg4 = "E Java";
 do
 System.out.println(ejg1.equals(ejg2));
 while (ejg3 == ejg4);
 }
}
```

- a true printed once
- b false printed once
- c true printed in an infinite loop
- d false printed in an infinite loop

**Q4-8.** What is the output of the following code?

```
class EJavaGuruString2 {
 public static void main(String args[]) {
 String ejg = "game".replace('a', 'Z').trim().concat("Aa");
 ejg.substring(0, 2);
 System.out.println(ejg);
 }
}

a gZmeAZ
b gZmeAa
c gZm
d gZ
e game
```

**Q4-9.** What is the output of the following code?

```
class EJavaGuruString2 {
 public static void main(String args[]) {
 String ejg = "game";
 ejg.replace('a', 'Z').trim().concat("Aa");
 ejg.substring(0, 2);
 System.out.println(ejg);
 }
}

a gZmeAZ
b gZmeAa
c gZm
d gZ
e game
```

**Q4-10.** What is the output of the following code?

```
class EJavaGuruStringBuilder {
 public static void main(String args[]) {
 StringBuilder ejg = new StringBuilder(10 + 2 + "SUN" + 4 + 5);
 ejg.append(ejg.delete(3, 6));
 System.out.println(ejg);
 }
}

a 12S512S5
b 12S12S
c 1025102S
d Runtime exception
```

**Q4-11.** What is the output of the following code?

```
class EJavaGuruStringBuilder2 {
 public static void main(String args[]) {
 StringBuilder sb1 = new StringBuilder("123456");
 sb1.subSequence(2, 4);
 sb1.deleteCharAt(3);
 sb1.reverse();
 System.out.println(sb1);
 }
}

a 521
b Runtime exception
c 65321
d 65431
```

## 4.9 Answers to sample exam questions

**Q4-1.** What is the output of the following code?

```
class EJavaGuruArray {
 public static void main(String args[]) {
 int[] arr = new int[5];
 byte b = 4; char c = 'c'; long longVar = 10;
 arr[0] = b;
 arr[1] = c;
 arr[3] = longVar;
 System.out.println(arr[0] + arr[1] + arr[2] + arr[3]);
 }
}

a 4c010
b 4c10
c 113
d 103
e Compilation error
```

Answer: e

Explanation: The previous code won't compile due to the following line of code:

```
arr[3] = longVar;
```

This line of code tries to assign a value of type `long` to a variable of type `int`. Because Java does support implicit widening conversions for variables, the previous code fails to compile. Also, the previous code tries to trick you regarding your understanding of the following:

- Assigning a `char` value to an `int` array element (`arr[1] = c`)
- Adding a `byte` value to an `int` array element (`arr[0] = b`)
- Whether an unassigned `int` array element is assigned a default value (`arr[2]`)
- Whether `arr[0] + arr[1] + arr[2] + arr[3]` prints the sum of all these values, or a concatenated value

When answering questions in the OCA Java SE 7 Java Programmer I exam, be careful about such tactics. If any of the answers list a compilation error or a runtime exception as an option, look for obvious lines of code that could result in it. In this example, `arr[3] = longVar` will result in compilation error.

**Q4-2.** What is the output of the following code?

```
class EJavaGuruArray2 {
 public static void main(String args[]) {
 int[] arr1;
 int[] arr2 = new int[3];
 char[] arr3 = {'a', 'b'};
 arr1 = arr2;
 arr1 = arr3;
```

```

 System.out.println(arr1[0] + ":" + arr1[1]);
 }
}

a 0:0
b a:b
c 0:b
d a:0
e Compilation error

```

Answer: e

Explanation: Because a char value can be assigned to an int value, you might assume that a char array can be assigned to an int array. But we're talking about arrays of int and char primitives, which aren't the same as a primitive int or char. Arrays themselves are reference variables, which refer to a collection of objects of similar type.

**Q4-3.** Which of the following are valid lines of code to define a multidimensional int array?

- a `int[][] array1 = {{1, 2, 3}, {}, {1, 2, 3, 4, 5}};`
- b `int[][] array2 = new array() {{1, 2, 3}, {}, {1, 2, 3, 4, 5}};`
- c `int[][] array3 = {1, 2, 3}, {0}, {1, 2, 3, 4, 5};`
- d `int[][] array5 = new int[2][];`

Answer: a, d

Explanation: Option (b) is incorrect. This line of code won't compile because `new array()` isn't valid code. Unlike objects of other classes, an array isn't initialized using the keyword `new` followed by the word `array`. When the keyword `new` is used to initialize an array, it's followed by the type of the array, not the word `array`.

Option (c) is incorrect. To initialize a two-dimensional array, all of these values must be enclosed within another pair of curly braces, as shown in option (a).

**Q4-4.** Which of the following statements are correct?

- a By default, an `ArrayList` creates an array with an initial size of 16 to store its elements.
- b Because `ArrayList` stores only objects, you can't pass element of an `ArrayList` to a `switch` construct.
- c Calling `clear()` or `remove()` on an `ArrayList`, will remove all its elements.
- d If you frequently add elements to an `ArrayList`, specifying a larger capacity will improve the code efficiency.
- e Calling the method `clone()` on an `ArrayList` creates its shallow copy; that is, it doesn't clone the individual list elements.

Answer: d, e

Explanation: Option (a) is incorrect. By default, an `ArrayList` creates an array with an initial size of 10 to store its elements.

Option (b) is incorrect. Starting with Java 7, switch also accepts variables of type String. Because a String can be stored in an ArrayList, you can use elements of an ArrayList in a switch construct.

Option (c) is incorrect. Only remove() will remove all elements of an ArrayList.

Option (d) is correct. An ArrayList internally uses an array to store all its elements. Whenever you add an element to an ArrayList, it checks whether the array can accommodate the new value. If it can't, ArrayList creates a larger array, copies all the existing values to the new array, and then adds the new value at the end of the array. If you frequently add elements to an ArrayList, it makes sense to create an ArrayList with a bigger capacity because the previous process isn't repeated for each ArrayList insertion.

Option (e) is correct. Calling clone() on an ArrayList will create a separate reference variable that stores the same number of elements as the ArrayList to be cloned. But each individual ArrayList element will refer to the same object; that is, the individual ArrayList elements aren't cloned.

**Q4-5.** Which of the following statements are correct?

- a **An ArrayList offers a resizable array, which is easily managed using the methods it provides. You can add and remove elements from an ArrayList.**
- b **Values stored by an ArrayList can be modified.**
- c **You can iterate through elements of an ArrayList using a for loop, Iterator, or ListIterator.**
- d An ArrayList requires you to specify the total elements before you can store any elements in it.
- e **An ArrayList can store any type of object.**

Answer: a, b, c, e

Explanation: Option (a) is correct. A developer may prefer using an ArrayList over an array because it offers all the benefits of an array and a list. For example, you can easily add or remove elements from an ArrayList.

Option (b) is correct.

Option (c) is correct. An ArrayList can be easily searched, sorted, and have its values compared using the methods provided by the Collection framework classes.

Option (d) is incorrect. An array requires you to specify the total number of elements before you can add any element to it. But you don't need to specify the total number of elements that you may add to an ArrayList at any time in your code.

Option (e) is correct.

**Q4-6.** What is the output of the following code?

```
import java.util.*; // line 1
class EJavaGuruArrayList { // line 2
 public static void main(String args[]) { // line 3
 ArrayList<String> ejg = new ArrayList<>(); // line 4
```

```

ejg.add("One"); // line 5
ejg.add("Two"); // line 6

System.out.println(ejg.contains(new String("One"))); // line 7
System.out.println(ejg.indexOf("Two")); // line 8
ejg.clear(); // line 9
System.out.println(ejg); // line 10
System.out.println(ejg.get(1)); // line 11

}
} // line 12
// line 13

```

- a Line 7 prints true**
- b Line 7 prints false**
- c Line 8 prints -1**
- d Line 8 prints 1**
- e Line 9 removes all elements of the list ejg**
- f Line 9 sets ejg to null**
- g Line 10 prints null**
- h Line 10 prints []**
- i Line 10 prints a value similar to ArrayList@16356**
- k Line 11 throws an exception**
- l Line 11 prints null**

Answer: a, d, e, h, k

Explanation: Line 7: The method `contains` accepts an object and compares it with the values stored in the list. It returns `true` if the method finds a match and `false` otherwise. This method uses the `equals` method defined by the object stored in the list. In the example, the `ArrayList` stores objects of class `String`, which has overridden the `equals` method. The `equals` method of the `String` class compares the values stored by it. This is why line 7 returns the value `true`.

Line 8: `indexOf` returns the index position of an element if a match is found; otherwise, it returns `-1`. This method also uses the `equals` method behind the scenes to compare the values in an `ArrayList`. Because the `equals` method in class `String` compares its values and not the reference variables, the `indexOf` method finds a match in position 1.

Line 9: The `clear` method removes all the individual elements of an `ArrayList` such that an attempt to access any of the earlier `ArrayList` elements will throw a runtime exception. It doesn't set the `ArrayList` reference variable to `null`.

Line 10: `ArrayList` has overridden the `toString` method such that it returns a list of all its elements enclosed within square brackets. To print each element, the `toString` method is called to retrieve its `String` representation.

Line 11: The `get` method removes all the elements of an `ArrayList`. An attempt to access the (nonexistent) `ArrayList` element throws a runtime `IndexOutOfBoundsException` exception.

This question tests your understanding of `ArrayList` and determining the equality of `String` objects.

**Q4-7.** What is the output of the following code?

```
class EJavaGuruString {
 public static void main(String args[]) {
 String ejg1 = new String("E Java");
 String ejg2 = new String("E Java");
 String ejg3 = "E Java";
 String ejg4 = "E Java";
 do
 System.out.println(ejg1.equals(ejg2));
 while (ejg3 == ejg4);
 }
}
```

- a true printed once
- b false printed once
- c **true printed in an infinite loop**
- d false printed in an infinite loop

Answer: c

Explanation: `String` objects that are created without using the `new` operator are placed in a pool of `Strings`. Hence, the `String` object referred to by the variable `ejg3` is placed in a pool of `Strings`. The variable `ejg4` is also defined without using the `new` operator. Before Java creates another `String` object in the `String` pool for the variable `ejg4`, it looks for a `String` object with the same value in the pool. Because this value already exists in the pool, it makes the variable `ejg4` refer to the same `String` object. This, in turn, makes the variables `ejg3` and `ejg4` refer to the same `String` objects. Hence, both of the following comparisons will return `true`:

- `ejg3 == ejg4` (compare the object references)
- `ejg3.equals(ejg4)` (compare the object values)

Even though the variables `ejg1` and `ejg2` refer to different `String` objects, they define the same values. So `ejg1.equals(ejg2)` also returns `true`. Because the loop condition (`ejg3==ejg4`) always returns `true`, the code prints `true` in an infinite loop.

**Q4-8.** What is the output of the following code?

```
class EJavaGuruString2 {
 public static void main(String args[]) {
 String ejg = "game".replace('a', 'Z').trim().concat("Aa");
 ejg.substring(0, 2);
 System.out.println(ejg);
 }
}
```

- a `gZmeAZ`
- b `gZmeAa`

- c** gZm
- d** gZ
- e** game

Answer: b

Explanation: When chained, methods are evaluated from left to right. The first method to execute is replace, not concat. Strings are immutable. Calling the method substring on the reference variable ejg doesn't change the contents of the variable ejg. It returns a String object that isn't referred to by any other variable in the code. In fact, none of the methods defined in the String class modifies the object's own value. They all create and return new String objects.

**Q4-9.** What is the output of the following code?

```
class EJavaGuruString2 {
 public static void main(String args[]) {
 String ejg = "game";
 ejg.replace('a', 'Z').trim().concat("Aa");
 ejg.substring(0, 2);
 System.out.println(ejg);
 }
}

a gZmeAZ
b gZmeAa
c gZm
d gZ
e game
```

Answer: e

Explanation: String objects are immutable. It doesn't matter how many methods you execute on a String object; its value won't change. Variable ejg is initialized with the String value "game". This value won't change, and the code prints game.

**Q4-10.** What is the output of the following code?

```
class EJavaGuruStringBuilder {
 public static void main(String args[]) {
 StringBuilder ejg = new StringBuilder(10 + 2 + "SUN" + 4 + 5);
 ejg.append(ejg.delete(3, 6));
 System.out.println(ejg);
 }
}

a 12S512S5
b 12S12S
c 1025102S
d dRuntime exception
```

Answer: a

Explanation: This question tests you on your understanding of operators, `String`, and `StringBuilder`. The following line of code returns `12SUN45`:

```
10 + 2 + "SUN" + 4 + 5
```

The `+` operator adds two numbers but concatenates the last two numbers. When the `+` operator encounters a `String` object, it treats all the remaining operands as `String` objects.

Unlike the `String` objects, `StringBuilder` objects are mutable. The `append` and `delete` methods defined in this class change its value. `eJg.delete(3, 6)` modifies the existing value of the `StringBuilder` to `12S5`. It then appends the same value to itself when calling `eJg.append()`, resulting in the value `12S512S5`.

**Q4-11.** What is the output of the following code?

```
class EJavaGuruStringBuilder2 {
 public static void main(String args[]) {
 StringBuilder sb1 = new StringBuilder("123456");
 sb1.subSequence(2, 4);
 sb1.deleteCharAt(3);
 sb1.reverse();
 System.out.println(sb1);
 }
}

a 521
b Runtime exception
c 65321
d 65431
```

Answer: c

Explanation: Like the method `substring`, the method `subSequence` doesn't modify the contents of a `StringBuilder`. Hence, the value of the variable `sb1` remains `123456`, even after the execution of the following line of code:

```
sb1.subSequence(2, 4);
```

The method `deleteCharAt` deletes a `char` value at position 3. Because the positions are zero-based, the digit 4 is deleted from the value `123456`, resulting in `12356`. The method `reverse` modifies the value of a `StringBuilder` by assigning to it the reverse representation of its value. The reverse of `12356` is `65321`.



# Flow control

| Exam objectives covered in this chapter                                                    | What you need to know                                                                                                                                                                                                                                                                          |
|--------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [3.4] Create if and if-else constructs.                                                    | How to use <code>if</code> , <code>if-else</code> , <code>if-else-if-else</code> , and nested <code>if</code> constructs.<br>The differences between using these <code>if</code> constructs with and without curly braces <code>{ }</code> .                                                   |
| [3.5] Use a <code>switch</code> statement.                                                 | How to use a <code>switch</code> statement by passing the correct type of arguments to the <code>switch</code> statement and case and default labels.<br>The change in the code flow when <code>break</code> and <code>return</code> statements are used in the <code>switch</code> statement. |
| [5.1] Create and use <code>while</code> loops.                                             | How to use the <code>while</code> loop, including determining when to apply the <code>while</code> loop.                                                                                                                                                                                       |
| [5.2] Create and use <code>for</code> loops, including the enhanced <code>for</code> loop. | How to use <code>for</code> and enhanced <code>for</code> loops. The advantages and disadvantages of the <code>for</code> loop and enhanced <code>for</code> loop. Scenarios when you may not be able to use the enhanced <code>for</code> loop.                                               |
| [5.3] Create and use <code>do-while</code> loops.                                          | Creation and use of <code>do-while</code> loops. Every <code>do-while</code> loop executes at least once, even if its condition evaluates to <code>false</code> for the first iteration.                                                                                                       |
| [5.4] Compare loop constructs.                                                             | The differences and similarities between <code>for</code> , enhanced <code>for</code> , <code>do-while</code> , and <code>while</code> loops. Given a scenario or a code snippet, knowing which is the most appropriate loop.                                                                  |

| Exam objectives covered in this chapter         | What you need to know                                                                                                                                                                                                                                                                                                                                                                                                                        |
|-------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>[5.5] Use break and continue statements.</p> | <p>The use of <code>break</code> and <code>continue</code> statements. A <code>break</code> statement can be used within loops and <code>switch</code> statement. A <code>continue</code> statement can be used only within loops. The difference in the code flow when a <code>break</code> or <code>continue</code> statement is used. Identify the right scenarios for using <code>break</code> and <code>continue</code> statements.</p> |

We all make multiple decisions on a daily basis, and we often have to choose from a number of available options to make each decision. These decisions range from the complex, such as selecting what subjects to study in school or which profession to choose, to the simple, such as what food to eat or what clothes to wear. The option you choose that leads to a decision can potentially change the course of your life, in a small or big way. For example, if you choose to study medicine at a university, you have the option to become a research scientist; if you choose fine arts, you have the option to become a painter. But deciding whether to eat pasta or pizza for dinner isn't likely to have a huge impact on your life.

You may also repeat particular sets of actions. These actions can range from eating an ice cream cone every day to phoning a friend until you connect, or passing exams at school or university in order to achieve a desired degree. These repetitions can also change the course of your life: you might relish having ice cream everyday, or enjoy the benefits that come from earning a higher degree.

In Java, the selection statements (`if` and `switch`) and looping statements (`for`, enhanced `for`, `while`, and `do-while`) are used to define and choose among different courses of action, as well as to repeat lines of code. You use these types of statements to define the flow of control in code.

In the OCA Java SE 7 Programmer I exam, you'll be asked how to define and control the flow in your code. To prepare you, I'll cover the following topics in this chapter:

- Creating and using `if`, `if-else`, and `switch` constructs to execute statements selectively
- Creating and using loops—`while`, `do-while`, `for`, and enhanced `for`
- Creating nested constructs for selection and iteration statements
- Comparing the `do-while`, `while`, `for`, and enhanced `for` loop constructs
- Using `break` and `continue` statements

In Java, you can execute your code conditionally by using either the `if` or `switch` constructs. Let's start with the `if` construct.

## 5.1 The if and if-else constructs



[3.4] Create if and if-else constructs

In this section, we'll cover `if` and `if-else` constructs. We'll examine what happens when these constructs are used with and without curly braces `{}`. We'll also cover nested `if` and `if-else` constructs.

### 5.1.1 The if construct and its flavors

An `if` construct enables you to execute a set of statements in your code based on the result of a condition. This condition must always evaluate to a boolean or a Boolean value. (The Boolean wrapper class isn't covered in the OCA Java SE 7 Programmer I exam, so you won't see it being used in the coding examples in this book.) You can specify a set of statements to execute when this condition evaluates to `true` or `false`. (In many Java books, the terms *constructs* and *statements* are used interchangeably.)

Multiple flavors of the `if` statement are illustrated in figure 5.1:

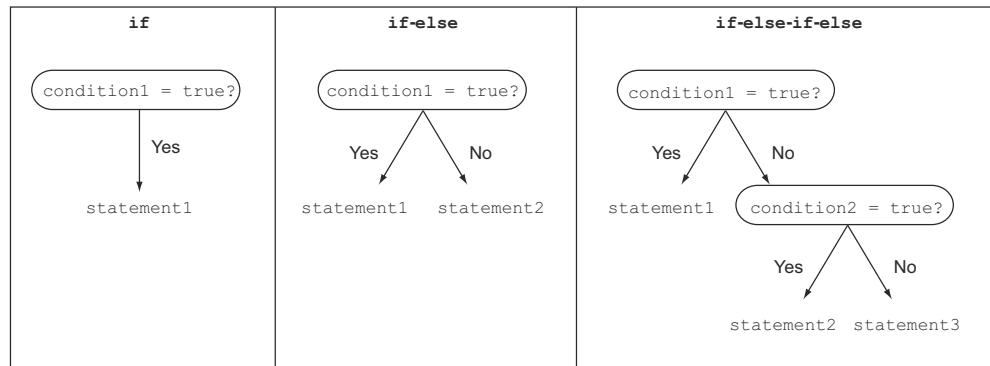
- `if`
- `if-else`
- `if-else-if-else`

In figure 5.1, `condition1` and `condition2` refer to a variable or an expression that must evaluate to a boolean or Boolean value. In the figure, `statement1`, `statement2`, and `statement3` refer to either a single line of code or a code block.

Because the Boolean wrapper class isn't covered in the OCA Java SE 7 Programmer I exam, I won't cover it in the coding examples in this book. We'll work with only the `boolean` data type.



**EXAM TIP** In Java, `then` isn't a keyword, so it shouldn't be used with the `if` statement.



**Figure 5.1** Multiple flavors of the `if` statement: `if`, `if-else`, and `if-else-if-else`

Let's look at the use of the previously mentioned `if` statement flavors by first defining a set of variables: `score`, `result`, `name`, and `file`, as follows:

```
int score = 100;
String result = "";
String name = "Lion";
java.io.File file = new java.io.File("F");
```

Figure 5.2 shows the use of `if`, `if-else`, and `if-else-if-else` constructs and compares them by showing the code side by side.

Let's quickly go through the code used in figure 5.2's `if`, `if-else`, and `if-else-if-else` statements. In the following example code, if the condition `name.equals("Lion")` evaluates to true, a value of 200 is assigned to the variable `score`:

```
if (name.equals("Lion"))
 score = 200;
```

#### Example of if construct

In the following example, if the condition `name.equals("Lion")` evaluates to true, a value of 200 is assigned to the variable `score`. If this condition were to evaluate to false, a value of 300 would be assigned to the variable `score`:

```
if (name.equals("Lion"))
 score = 200;
else
 score = 300;
```

#### Example of if-else construct

In the following example, if `score` is equal to 100, the variable `result` is assigned a value of A. If `score` is equal to 50, the variable `result` is assigned a value of B. If `score` is equal to 10, the variable `result` is assigned a value of C. If `score` doesn't match any of 100, 50, or 10, a value of F is assigned to the variable `result`. An `if-else-if-else` construct can use different conditions for all its `if` constructs:

| <code>if</code>                                      | <code>if-else</code>                                                       | <code>if-else-if-else</code>                                                                                                                          |
|------------------------------------------------------|----------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|
| <pre>if (name.equals("Lion"))     score = 200;</pre> | <pre>if (name.equals("Lion"))     score = 200; else     score = 300;</pre> | <pre>if (score == 100)     result = "A"; else if (score == 50)     result = "B"; else if (score == 10)     result = "C"; else     result = "F";</pre> |

**Figure 5.2** Multiple flavors of `if` statements implemented in code

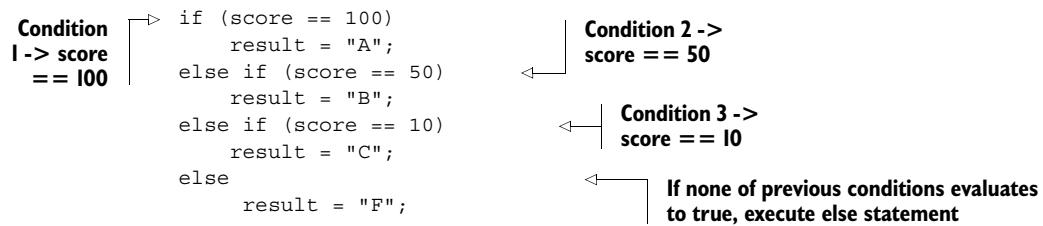


Figure 5.3 illustrates the previous code and makes several points clear:

- The last else statement is part of the last if construct, not any of the if constructs before it.
- The if-else-if-else is an if-else construct in which the else part defines another if construct. A few other programming languages, such as VB and C#, use if-elsif and if-elseif (without a space) constructs to define if-else-if constructs. If you've programmed with any of these languages, note the difference in Java. The following code is equal to the previous code:

```

if (score == 100)
 result = "A";
else
 if (score == 50)
 result = "B";
 else
 if (score == 10)
 result = "C";
 else
 result = "F";

```

Again, note that none of the previous if constructs use *then* to define the code to execute if a condition evaluates to true. Unlike other programming languages, *then* isn't a keyword in Java and isn't used with the if construct.



**EXAM TIP** The if-else-if-else is an if-else construct in which the else part defines another if construct.

The boolean expression used as a condition for the if construct can also include assignment operation. The following Twist in the Tale exercise throws in a twist by modifying the value of a variable that the if statement is comparing. Let's see if you can answer it correctly (answer in the appendix).

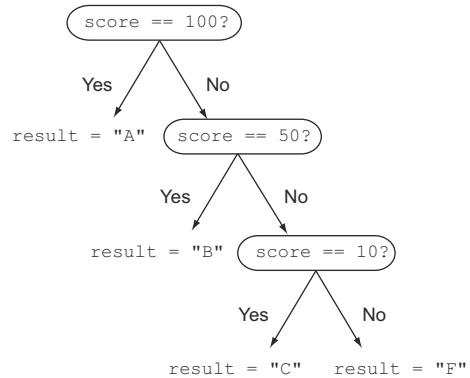


Figure 5.3 Execution of the if-else-if-else code

### Twist in the Tale 5.1

Let's modify the code used in the previous example as follows. What is the output of this code?

```
String result = "1";
int score = 10;
if ((score = score+10) == 100)
 result = "A";
else if ((score = score+29) == 50)
 result = "B";
else if ((score = score+200) == 10)
 result = "C";
else
 result = "F";
System.out.println(result + ":" + score);

a A:10
b C:10
c A:20
d B:29
e C:249
f F:249
```

---

### 5.1.2 Missing else blocks

What happens if you don't define the `else` statement for an `if` construct? It's acceptable to define one course of action for an `if` construct as follows (omitting the `else` part):

```
boolean testValue = false;
if (testValue == true)
 System.out.println("value is true");
```

But you can't define the `else` part for an `if` construct, skipping the `if` code block. The following code won't compile:

```
boolean testValue = false;
if (testValue == true)
else
 System.out.println("value is false");
```

↓ Won't compile

Here is another interesting and bizarre piece of code:

```
int score = 100;
if((score=score+10) > 110);
```

↓ ① Missing then or else part

① is a valid line of code, even if it doesn't define either the `then` or `else` part of the `if` statement. In this case, the `if` condition evaluates and that's it. The `if` construct doesn't define any code that should execute based on the result of this condition.



**NOTE** Using `if(testValue==true)` is the same as using `if(testValue)`. Similarly, `if(testValue==false)` is the same as using `if(!testValue)`. This book includes examples of both these approaches. A lot of beginners in Java programming find the latter approach (without the explicit ==) confusing.

### 5.1.3 Implications of the presence and absence of {} in if-else constructs

You can execute a single statement or a block of statements when an `if` condition evaluates to true or false. An `if` block is marked by enclosing one or more statements within a pair of curly braces, `{}`. An `if` block will execute a single line of code if there are no braces, but will execute an unlimited number of lines if they're contained within a block (defined using braces). The braces are optional if there's only one line in the `if` statement.

The following code executes only one statement of assigning value 200 to variable `score` if the expression used in the `if` statement evaluates to true:

```
String name = "Lion";
int score = 100;
if (name.equals("Lion"))
 score = 200;
```

What happens if you want to execute another line of code if the value of the variable `name` is equal to `Lion`? Is the following code correct?

```
String name = "Lion";
int score = 100;
if (name.equals("Lion"))
 score = 200;
 name = "Larry";
```

Set name  
to Larry

The statement `score = 200;` executes if the `if` condition is true. Although it looks like the statement `name = "Larry";` is part of the `if` statement, it isn't. It will execute regardless of the result of the `if` condition because of the lack of braces, `{}`.



**EXAM TIP** In the exam, watch out for code like this that uses misleading indentation in `if` constructs. In the absence of a defined code block (marked with a pair of `{}`), only the statement following the `if` construct will be considered to be part of it.

What happens to the same code if you define an `else` part for your `if` construct, as follows:

```
String name = "Lion";
int score = 100;
if (name.equals("Lion"))
 score = 200;
 name = "Larry";
else
 score = 129;
```

This statement isn't  
part of the if construct

In this case, the code won't compile. The compiler will report that the `else` part is defined without an `if` statement. If this leaves you confused, examine the following code, which is indented in order to emphasize the fact that the `name = "Larry"` line isn't part of the `else` construct:

```
String name = "Lion";
int score = 100;
if (name.equals ("Lion"))
 score = 200;
name = "Larry"; ← This statement
else ← isn't part of the
 score = 129; ← if construct
 ← The else statement seems
 ← to be defined without a
 ← preceding if construct
```

If you want to execute multiple statements for an `if` construct, define them within a block of code. You can do so by defining all this code within curly braces: `{}`. Here's an example:

```
String name = "Lion";
int score = 100;
if (name.equals("Lion")) { ← Start of
 score = 200; ← code block
 name = "Larry"; ← Statements to execute if (name.equals("Lion"))
} ← evaluates to true
else ← End of code
 score = 129; ← block
```

Similarly, you can define multiple lines of code for the `else` part. The following example does so incorrectly:

```
String name = "Lion";
if (name.equals("Lion"))
 System.out.println("Lion");
else
 System.out.println("Not a Lion");
 System.out.println("Again, not a Lion"); ← 1 Not part of the else
 ← construct. Will execute
 ← regardless of value of
 ← variable name.
```

The output of the previous code is as follows:

```
Lion
Again, not a Lion
```

Though the code at ① *looks* like it will execute only if the value of the variable `name` matches the value `Lion`, this is not the case. It is indented incorrectly to trick you into believing that it is a part of the `else` block. The previous code is the same as the following code (with correct indentation):

```
String name = "Lion";
if (name.equals("Lion"))
 System.out.println("Lion");
else
 System.out.println("Not a Lion");
 System.out.println("Again, not a Lion"); ← Not part of the else
 ← construct. Will execute
 ← regardless of value of
 ← variable name.
```

If you wish to execute the last two statements in the previous code only if the `if` condition evaluates to `false`, you can do so by using `{}`:

```
String name = "Lion";
if (name.equals("Lion"))
 System.out.println("Lion");
else {
 System.out.println("Not a Lion");
 System.out.println("Again, not a Lion");
}
```

**Now part of the else construct. Will execute only when if condition evaluates to false.**

You can define another statement, construct, or loop to execute for an `if` condition, without using `{}`, as follows:

```
String name = "Lion";
if (name.equals("Lion"))
 for (int i = 0; i < 3; ++i)
 System.out.println(i);
```

**An if condition**

**A for loop is a single construct that will execute if name.equals("Lion") evaluates to true**

**This code is part of the for loop defined on previous line**

`System.out.println(i)` is part of the `for` loop, not an unrelated statement that follows the `for` loop. So this code is correct and gives the following output:

```
0
1
2
```

### 5.1.4 Appropriate versus inappropriate expressions passed as arguments to an if statement

The result of a variable or an expression used in an `if` construct must evaluate to `true` or `false`. Assume the following definitions of variables:

```
int score = 100;
boolean allow = false;
String name = "Lion";
```

Let's look at a few examples of some of the valid variables and expressions that can be passed to an `if` statement.

```
(score == 100) ← Evaluates to true
(name == "Lio") ← Evaluates to false
(score <= 100 || allow) ← Evaluates to true
(allow) ← Evaluates to false
```

**Evaluates to true**

**Evaluates to false**

**Evaluates to true**

**Evaluates to false**

Note that using `==` is not good practice for comparing two `String` objects for equality. As mentioned in chapter 4, the correct approach for comparing two `String` objects is to use the `equals` method from the `String` class. But comparing two `String` values using `==` is a valid expression that returns a boolean value, and it may be used in the exam.

Now comes the tricky part of passing an assignment operation to an `if` construct. What do you think is the output of the following code?

```
boolean allow = false;
if (allow = true)
 System.out.println("value is true");
```

**This is assignment, not comparison**

```

else
 System.out.println("value is false");

```

You may think that because the value of the boolean variable `allow` is set to `false`, the previous code output's value is `false`. Revisit the code and notice that the assignment operation `allow = true` assigns the value `true` to the boolean variable `allow`. Also, its result is also a boolean value, which makes it eligible to be passed on as an argument to the `if` construct.

Although the previous code has no syntactical errors, there is a *logical error*—an error in the program logic. The correct code to compare a boolean variable with a boolean literal value is as follows:

```

boolean allow = false;
if (allow == true)
 System.out.println("value is true");
else
 System.out.println("value is false");

```

This is  
comparison



**EXAM TIP** Watch out for code in the exam that uses the assignment operator (`=`) to compare a boolean value in the `if` condition. It won't compare the boolean value; it'll assign a value to it. The correct operator for comparing a boolean value is the equality operator (`==`).

### 5.1.5 Nested if constructs

A nested `if` construct is an `if` construct defined within another `if` construct. Theoretically, there is no limit on the levels of nested `if` and `if-else` constructs.

Whenever you come across nested `if` and `if-else` constructs, you need to be careful about determining the `else` part of an `if` statement. If this statement doesn't make a lot of sense, take a look at the following code and determine its output:

```

int score = 110;
if (score > 200) ① if (score>200)
 if (score < 400) ② if (score<400)
 if (score > 300)
 System.out.println(1);
 else
 System.out.println(2);
 else
 System.out.println(3); ③ To which if does
 this else belong?

```

Based on the way the code is indented, you may believe that the `else` at ③ belongs to the `if` defined at ①. But it belongs to the `if` defined at ②. Here's the code with the correct indentation:

```

int score = 110;
if (score > 200)
 if (score < 400)
 if (score > 300)
 System.out.println(1);
 else
 System.out.println(2);

```

```
else
 System.out.println(3);
```

This else belongs to the if  
with condition (score < 400)

Next, you need to understand how to do the following:

- How to define an else for an outer if other than the one that it'll be assigned to by default
- How to determine to which if an else belongs in nested if constructs

Both of these tasks are simple. Let's start with the first one.

#### HOW TO DEFINE AN ELSE FOR AN OUTER IF OTHER THAN THE ONE THAT IT'LL BE ASSIGNED TO BY DEFAULT

The key point is to use curly braces, as follows:

```
int score = 110;
if (score > 200) {
 if (score < 400)
 if (score > 300)
 System.out.println(1);
 else
 System.out.println(2);
}
else
 System.out.println(3);
```

Curly braces at ① and ② mark the start and end of the if condition (score > 200) defined at ①. Hence, the else at ③ that follows ② belongs to the if defined at ①.

#### HOW TO DETERMINE TO WHICH IF AN ELSE BELONGS IN NESTED IF CONSTRUCTS

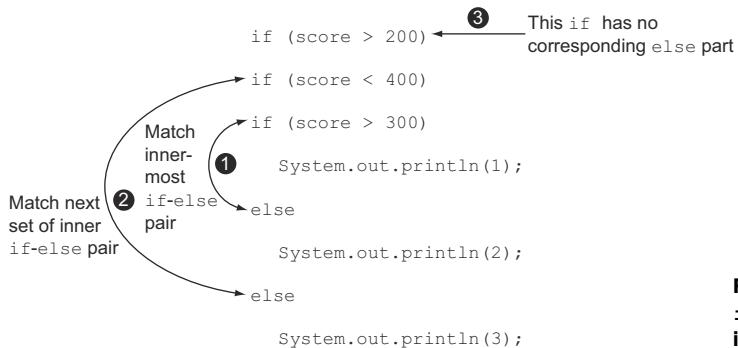
If code uses curly braces to mark the start and end of the territory of an if or else construct, it can be simple to determine which else goes with which if, as mentioned in the previous section. When the if constructs don't use curly braces, don't get confused by the code indentation, which may or may not be correct.

Try to match the ifs with their corresponding elses in the following poorly indented code:

```
if (score > 200)
if (score < 400)
if (score > 300)
 System.out.println(1);
else
 System.out.println(2);
else
 System.out.println(3);
```

Start working from the inside out, with the innermost if-else statement, matching each else with its nearest unmatched if statement. Figure 5.4 shows how to match the if-else pairs for the previous code, marked with 1, 2, and 3.

You can alternatively use the switch statement to execute code conditionally. Even though both if-else constructs and switch statements are used to execute statements selectively, they differ in their usage, which you'll notice as you work with the switch statement in the next section.



**Figure 5.4** How to match if-else pairs for poorly indented code

## 5.2 The switch statement



[3.5] Use a switch statement

In this section, you'll learn how to use the switch statement and see how it compares to nested if-else constructs. You'll learn the right ingredients for defining values that are passed to the switch labels and the correct use of the break statement in these labels.

### 5.2.1 Create and use a switch statement

You can use a switch statement to compare the value of a variable with multiple values. For each of these values, you can define a set of statements to execute.

The following example uses a switch statement to compare the value of the variable marks with the literal values 10, 20, and 30, defined using the case keyword:

```

int marks = 20;
switch (marks) {
 case 10: System.out.println(10);
 break;
 case 20: System.out.println(20);
 break;
 case 30: System.out.println(30);
 break;
 default: System.out.println("default");
 break;
}

```

Marks the end of a case label → Compare value of marks → Values that are compared to variable marks → Default case to execute if no matching cases found

A switch statement can define multiple case labels within its switch block, but only a single default label. The default label executes when no matching value is found in the case labels. A break statement is used to exit a switch statement, after the code completes its execution for a matching case.

### 5.2.2 Comparing a switch statement with multiple if-else constructs

A switch statement can improve the readability of your code by replacing a set of (rather complicated-looking) related if-else-if-else statements with a switch and multiple case statements.

Examine the following code, which uses if-else-if-else statements to check the value of a String variable day and display an appropriate message:

```
String day = "SUN";
if (day.equals("MON") || day.equals("TUE") ||
 day.equals("WED") || day.equals("THU"))
 System.out.println("Time to work");
else if (day.equals("FRI"))
 System.out.println("Nearing weekend");
else if (day.equals("SAT") || day.equals("SUN"))
 System.out.println("Weekend!");
else
 System.out.println("Invalid day?");
```

Multiple comparisons

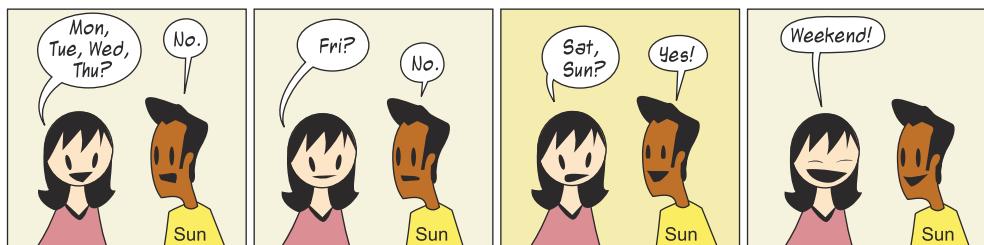
Now examine this implementation of the previous logic using the switch statement:

```
String day = "SUN";
switch (day) {
 case "MON":
 case "TUE":
 case "WED":
 case "THU": System.out.println("Time to work");
 break;
 case "FRI": System.out.println("Nearing weekend");
 break;
 case "SAT":
 case "SUN": System.out.println("Weekend!");
 break;
 default: System.out.println("Invalid day?");
}
```

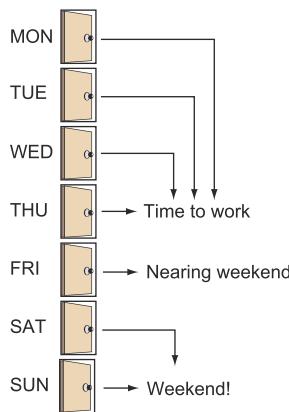
The two previous snippets of code perform the same function of comparing the value of the variable day and printing an appropriate value. But the latter code, which uses the switch statement, is simpler and easier to read and follow.

Note that the previous switch statement doesn't define code for all the case values. What happens if the value of the variable day matches TUE? When the code control enters the label matching TUE in the switch construct, it'll execute all of the code until it encounters a break statement or it reaches the end of the switch statement.

Figure 5.5 depicts the execution of the multiple if-else-if-else statements used in the example code in this section. You can compare it to a series of questions and answers that continue until a match is found or all the conditions are evaluated.



**Figure 5.5** The if-else-if-else construct is like a series of questions and answers.



**Figure 5.6** A switch statement is like asking a question and acting on the answer.

As opposed to an if-else-if-else construct, you can compare a switch statement to asking a single question and evaluating its answer to determine which code to execute. Figure 5.6 illustrates the switch statement and its case labels.



**EXAM TIP** The if-else-if-else construct evaluates all of the conditions until it finds a match. A switch construct compares the argument passed to it with its labels.

Let's see if you can find the twist in the next exercise. Hint: it defines code to compare String values (answers can be found in the appendix).

#### Twist in the Tale 5.2

Let's modify the code used in the previous example as follows. What is the output of this code?

```

String day = new String("SUN");
switch (day) {
 case "MON":
 case "TUE":
 case "WED":
 case "THU": System.out.println("Time to work");
 break;
 case "FRI": System.out.println("Nearing weekend");
 break;
 case "SAT":
 case "SUN": System.out.println("Weekend!");
 break;
 default: System.out.println("Invalid day?");
}

```

- a Time to work
- b Nearing weekend
- c Weekend!
- d Invalid day?

### 5.2.3 Arguments passed to a switch statement

You can't use the switch statement to compare all types of values, such as all types of objects and primitives. There are limitations on the types of arguments that a switch statement can accept.

Figure 5.7 shows the types of arguments that can be passed to a switch statement and to an if construct.

A switch statement accepts arguments of type char, byte, short, int, and String (starting in Java version 7). It also accepts arguments and expressions of types enum, Character, Byte, Integer, and Short, but because these aren't on the OCA Java SE 7 Programmer I exam objectives, I won't cover them any further. The switch statement doesn't accept arguments of type long, float, or double, or any object besides String.

Apart from passing a variable to a switch statement, you can also pass an expression to the switch statement as long as it returns one of the allowed types. The following code is valid:

```
int score = 10, num = 20;
switch (score+num) {
 // ..code
}
```

Type of score+num is int and  
can thus be passed as an  
argument to switch statement

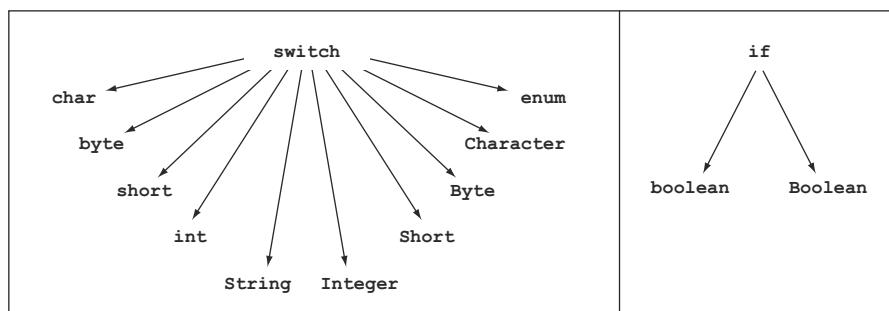
The following code won't compile because the type of history is double, which is a type that isn't accepted by the switch statement:

```
double history = 20;
switch (history) {
 // ..code
}
```

Double variable can't be  
passed as an argument to  
switch statement



**EXAM TIP** Watch out for questions in the exam that try to pass a primitive decimal type such as float or double to a switch statement. Code that tries to do so will not compile.



**Figure 5.7 Types of arguments that can be passed to a switch statement and an if construct**

### 5.2.4 Values passed to the label case of a switch statement

You're constrained in a couple of ways when it comes to the value that can be passed to the case label in a switch statement, as the following subsections explain.

#### CASE VALUES SHOULD BE COMPILE-TIME CONSTANTS

The value of a case label must be a compile-time constant value; that is, the value should be known at the time of code compilation:

```
int a=10, b=20, c=30;
switch (a) {
 case b+c: System.out.println(b+c); break;
 case 10*7: System.out.println(10*7512+10); break;
}
```

Note that `b+c` in the previous code defined at ① can't be determined at the time of compilation and isn't allowed. But `10*7` defined at ② is a valid case label value.

You can use variables in an expression if they're marked final because the value of final variables can't change once they're initialized:

```
final int a = 10;
final int b = 20;
final int c = 30;

switch (a) {
 case b+c: System.out.println(b+c); break;
}
```

Because the variables `b` and `c` are final variables here, at ① the value of `b+c` can be known at compile time. This makes it a compile-time constant value, which can be used in a case label.

You may be surprised to learn that if you don't assign a value to a final variable with its declaration, it isn't considered a compile-time constant:

```
final int a = 10;
final int b = 20;
final int c;
c = 30;

switch (a) {
 case b+c: System.out.println(b+c); break;
}
```

This code defines a final variable `c` at line ① but doesn't initialize it. The final variable `c` is initialized at line ②. Because the final variable `c` isn't initialized with its declaration, at ③ the expression `b+c` isn't considered a compile-time constant, so it can't be used as a case label.

#### CASE VALUES SHOULD BE ASSIGNABLE TO THE ARGUMENT PASSED TO THE SWITCH STATEMENT

Examine the following code, in which the type of argument passed to the switch statement is `byte` and the case label value is of the type `float`. Such code won't compile:

```
byte myByte = 10;
switch (myByte) {
 case 1.2: System.out.println(1); break;
}
```

Floating-point number can't be assigned to byte variable

#### NULL ISN'T ALLOWED AS A CASE LABEL

Code that tries to compare the variable passed to the switch statement with null won't compile, as demonstrated in the following code:

```
String name = "Paul";
switch (name) {
 case "Paul": System.out.println(1);
 break;
 case null: System.out.println("null");
}
```

null isn't allowed as a case label

#### ONE CODE BLOCK CAN BE DEFINED FOR MULTIPLE CASES

It's acceptable to define a single code block for multiple case labels in a switch statement, as shown by the following code:

```
int score =10;
switch (score) {
 case 100:
 case 50 :
 case 10 : System.out.println("Average score");
 break;
 case 200: System.out.println("Good score");
}
```

You can define multiple cases, which should execute the same code block

This example code will output Average score if the value of the variable score matches any of the values 100, 50, and 10.

### 5.2.5 Use of break statements within a switch statement

In the previous examples, note the use of break to exit the switch construct once a matching case is found. In the absence of the break statement, control will *fall through* the remaining code and execute the code corresponding to all the *remaining* cases that *follow* that matching case.

Consider the examples shown in figure 5.8—one with a break statement and the other without a break statement. Examine the flow of code (depicted using arrows) in this figure when the value of the variable score is equal to 50.

Our (hypothetical) enthusiastic programmers, Harry and Selvan, who are also preparing for this exam, sent in some of their code. Can you choose the correct code for them in the following Twist in the Tale exercise? (Answers are in the appendix).

#### Twist in the Tale 5.3

Which of the following code submissions by our two hypothetical programmers, Harry and Selvan, examines the value of the long variable dayCount and prints out the name of any one month that matches the day count?

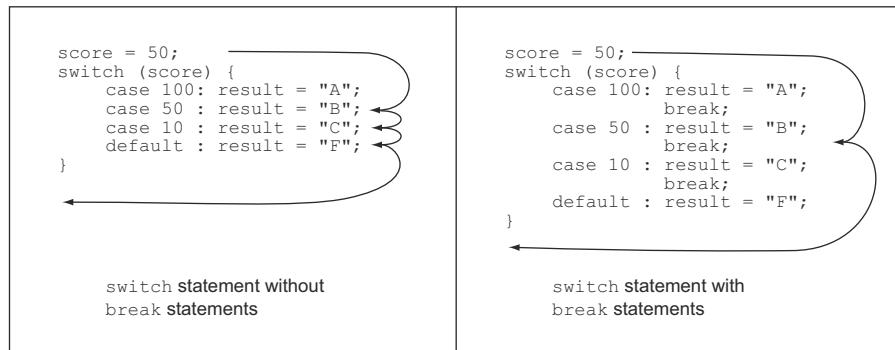
a Submission by Harry:

```
long dayCount = 31;
if (dayCount == 28 || dayCount == 29)
 System.out.println("Feb");
else if (dayCount == 30)
 System.out.println("Apr");
else if (dayCount == 31)
 System.out.println("Jan");
```

b Submission by Selvan:

```
long dayCount = 31;
switch (dayCount) {
 case 28:
 case 29: System.out.println("Feb"); break;
 case 30: System.out.println("Apr"); break;
 case 31: System.out.println("Jan"); break;
}
```

In the next section, I'll cover the iteration statements known as loop statements. Just as you'd like to repeat the action of "eating an ice cream" every day, loops are used to execute the same lines of code multiple times. You can use a `for` loop, an enhanced `for` (for-each) loop, or the `do-while` and `while` loops to repeat a block of code. Let's start with the `for` loop.



**Figure 5.8 Differences in code flow for a `switch` statement with and without `break` statements**

### 5.3 The `for` loop



[5.2] Create and use for loops including the enhanced for loop

In this section, I'll cover the regular `for` loop. The enhanced `for` loop is covered in the next section.

A for loop is *usually* used to execute a set of statements a fixed number of times. It takes the following form:

```
for (initialization; condition; update) {
 statements;
}
```

Here's a simple example:

```
int tableOf = 25;
for (int ctr = 1; ctr <= 5; ctr++) {
 System.out.println(tableOf * ctr);
}
```

① Executes multiple times

The output of the previous code is as follows:

```
25
50
75
100
125
```

In the previous example, the code at ① will execute five times. It'll start with an initial value of 1 for the variable `ctr` and execute while the value of the variable `ctr` is less than or equal to 5. The value of variable `ctr` will increment by 1 (`ctr++`) after the execution of the code at ①.

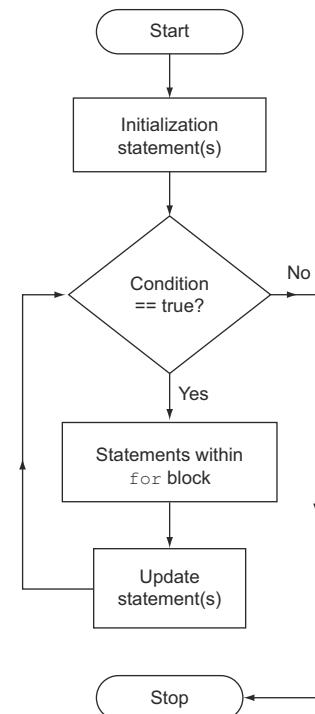
The code at ① executes for `ctr` values 1, 2, 3, 4, and 5. Because `6 <= 5` evaluates to false, the for loop completes its execution without executing the code at ① any further.

In the previous example, notice that the for loop defines three types of statements separated with semicolons (;), as follows:

- Initialization statements
- Termination condition
- Update clause (executable statement)

This loop is depicted as a flowchart in figure 5.9. The statements defined within the loop body execute until the termination condition is false.

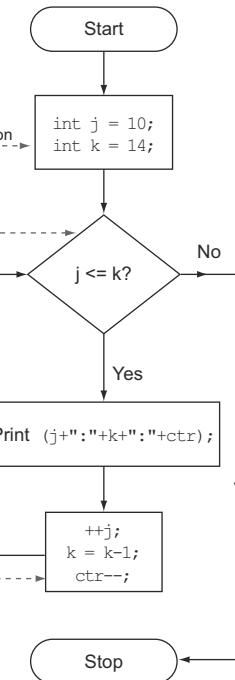
One important point to note with respect to the for loop is that the update clause executes after all the statements defined within the for loop body. In other words, you can consider the update clause to be a last statement in the for loop. The initialization section, which executes only once, may define multiple initialization statements. Similarly, the update clause may define multiple statements. But there can be only one termination condition for a for loop.



**Figure 5.9** The flow of control in a **for loop**

```
public class DemonstrateFor {
 public static void main(String args[]) {
 int ctr = 12;
 for (int j=10, k=14; -----)
 j <= k; -----
 { --- ++j, k=k-1, ctr--)
 System.out.println(j+"."+k+"."+ctr);
 }
 }
}
```

Multiple increment and decrement statements execute at the end



**Figure 5.10** The flow of control in a `for` loop using a code example

In figure 5.10, I've provided a code snippet and a flowchart that depicts the corresponding flow of execution of statements to explain the previous concept.

Let's explore the initialization block, termination condition, and update clause of a `for` loop in detail.

### 5.3.1 Initialization block

An initialization block executes only once. A `for` loop can declare and initialize multiple variables in its initialization block, but the variables it declares should be of the same type. The following code is valid:

```
int tableOf = 25;
for (int ctr = 1, num = 100000; ctr <= 5; ++ctr) {
 System.out.println(tableOf * ctr);
 System.out.println(num * ctr);
}
```

Define and assign multiple variables

But you can't declare variables of different types in an initialization block. The following code will fail to compile:

```
for (int j=10, long longVar = 10; j <= 1; ++j) { }
```

Can't define variables of different types in an initialization block

It's a common programming mistake to try to use the variables defined in a `for`'s initialization block outside the `for` block. Please note that the scope of the variables declared in the initialization block is limited to the `for` block. An example follows:

```

int tableOf = 25;
for (int ctr = 1; ctr <= 5; ++ctr) {
 System.out.println(tableOf * ctr);
}
ctr = 20;

```

Variable ctr is accessible  
only within for loop body

Variable ctr isn't accessible  
outside for loop

### 5.3.2 Termination condition

The termination condition is evaluated once for each iteration before executing the statements defined within the body of the loop. The for loop terminates when the termination condition evaluates to false:

```

for (int ctr = 1; ctr <= 5; ++ctr) {
 System.out.println(ctr);
}
...

```

1 for loop body

2 Code following  
the for loop

The termination condition—`ctr <= 5` in this example—is checked before ① executes. If the condition evaluates to false, control is transferred to ②. A for loop can define exactly one termination condition—no more, no less.

### 5.3.3 The update clause

Usually, you'd use this block to manipulate the value of the variable that you used to specify the termination condition. In the previous example, I defined the following code in this section:

```
++ctr;
```

Code defined in this block executes *after* all the code defined in the body of the for loop. The previous code increments the value of the variable `ctr` by 1 after the following code executes:

```
System.out.println(ctr);
```

The termination condition is evaluated next. This execution continues until the termination condition evaluates to false.

You can define multiple statements in the update clause, including calls to other methods. The only limit is that these statements will execute in the order in which they appear, at the end of all the statements defined in the for block. Examine the following code, which calls a method in the update block:

```

public class ForIncrementStatements {
 public static void main(String args[]) {
 String line = "ab";
 for (int i=0; i < line.length(); ++i, printMethod())
 System.out.println(line.charAt(i));
 }
 private static void printMethod() {
 System.out.println("Happy");
 }
}

```

The increment  
block can also  
call methods

printMethod is called  
by the for loop's  
increment block

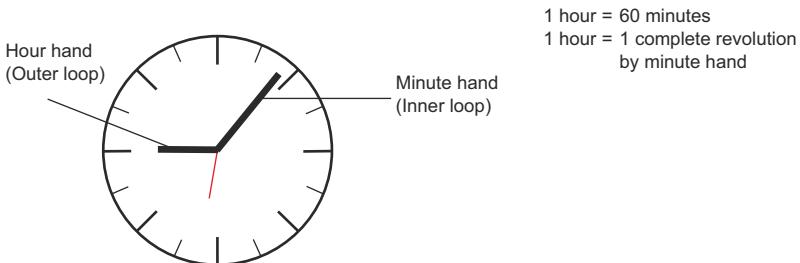
The output of this code is as follows:

```
a
Happy
b
Happy
```

### 5.3.4 Nested for loop

If a loop encloses another loop, they are called *nested loops*. The loop that encloses another loop is called the *outer loop*, and the enclosed loop is called the *inner loop*. Theoretically, there are no limits on the levels of nesting for loops.

Let's get started with a single-level nested loop. For an example, you can compare the hour hand of a clock to an outer loop and its minute hand to an inner loop. Each hour can be compared with an iteration of the outer loop, and each minute can be compared with an iteration of the inner loop. Because an hour has 60 minutes, the inner loop should iterate 60 times *for each iteration* of the outer loop. This comparison between a clock and a nested loop is shown in figure 5.11.



**Figure 5.11 Comparison of the hands of a clock to a nested loop**

You can use the following nested for loops to print out each minute (1 to 60) for hours from 1 to 6:

```
for (int hrs=1; hrs<=6; hrs++) {
 for (int min=1; min<=60; min++) {
 System.out.println(hrs+":"+min);
 }
}
```

**Outer loop iterates for values 1 through 6**  
**Inner loop iterates for values 1 through 60**  
**Executes  $6 \times 60$  times (total outer loop iterations  $\times$  total inner loop iterations)**

Nested loops are often used to initialize or iterate multidimensional arrays. The following code initializes a multidimensional array using nested for loops:

```
int multiArr[][];
multiArr = new int[2][3];

for (int i=0; i<multiArr.length; i++) {
 for (int j=0; j<multiArr[i].length; j++) {
 multiArr[i][j] = i + j;
 }
}
```

**① Array declaration**  
**② Array allocation**  
**③ Outer for loop**  
**④ Inner for loop**  
**Outer for loop ends**  
**Inner for loop ends**

❶ defines a two-dimensional array `multiArr`. ❷ allocates this array, creating two rows and three columns, and assigns all array members the default `int` value of 0.

❸ defines an outer `for` loop. Because the value of `multiArr.length` is 2 (the value of the first subscript at ❷), the outer `for` loop executes twice, with variable `i` having values 0 and 1. The inner `for` loop is defined at ❹. Because the length of each of the rows of the `multiArr` array is 3 (the value of the second subscript at ❷), the inner loop executes three times for each iteration of the outer `for` loop, with variable `j` having values 0, 1, and 2.

Figure 5.12 illustrates the array `multiArr` after it's initialized using the previous code.

In the next section, I discuss another flavor of the `for` loop: the *enhanced for* loop or `for-each` loop.

## 5.4 The enhanced for loop



[5.2] Create and use for loops including the enhanced for loop

The enhanced `for` loop is also called the *for-each* loop, and it offers some advantages over the regular `for` loop. It also has some limitations.

To start with, the regular `for` loop is cumbersome to use when it comes to iterating through a collection or an array. You need to create a looping variable and specify the start and end positions of the collection or the array, even if you want to iterate through the complete collection or list. The enhanced `for` loop makes the previously mentioned routine task quite a breeze, as the following example demonstrates for an `ArrayList` `myList`:

```
ArrayList<String> myList= new ArrayList<String>();
myList.add("Java");
myList.add("Loop");
```

The following code uses the regular `for` loop to iterate through this list:

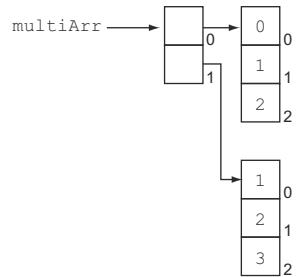
```
for(Iterator<String> i = myList.iterator(); i.hasNext();
 System.out.println(i.next());
```

The following code uses the enhanced `for` loop to iterate through the list `myList`:

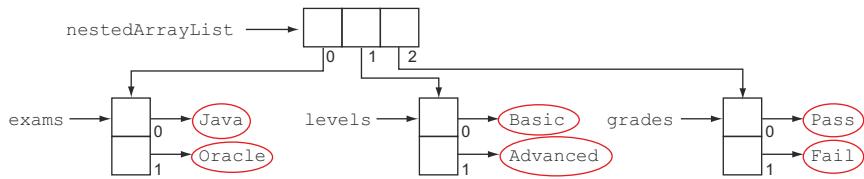
```
for (String val : myList)
 System.out.println(val);
```

You can read the colon (:) in a `for-each` loop as “in”.

The `for-each` loop is a breeze to implement: there's no code clutter, and the code is easy to write and comprehend. In the previous example, the `for-each` loop is read as “for each element `val` in collection `myList`, print the value of `val`.”



**Figure 5.12** The array `multiArr` after it's initialized using the previous code



**Figure 5.13 Pictorial representation of nestedArrayList**

You can also easily iterate through *nested collections* using the enhanced for loop. In this example, assume that an ArrayList of exams, levels, and grades are defined as follows:

```
ArrayList<String> exams= new ArrayList<String>();
exams.add("Java"); exams.add("Oracle");

ArrayList<String> levels= new ArrayList<String>();
levels.add("Basic"); levels.add("Advanced");

ArrayList<String> grades= new ArrayList<String>();
grades.add("Pass"); grades.add("Fail");
```

The following code creates a nested ArrayList, nestedArrayList, every element of which is itself an ArrayList of String objects:

```
ArrayList<ArrayList<String>> nestedArrayList =
 new ArrayList< ArrayList<String>>();
nestedArrayList.add(exams);
nestedArrayList.add(levels);
nestedArrayList.add(grades);
```

**ArrayList of  
ArrayList**

←

**Add object of ArrayList  
to nestedArrayList**

The nestedArrayList can be compared to a multidimensional array, as shown in figure 5.13.

A nested enhanced for loop can be used to iterate through the nested ArrayList nestedArrayList. Here's the relevant code:

```
for (ArrayList<String> nestedListElement : nestedArrayList)
 for (String element : nestedListElement)
 System.out.println(element);
```

The output of this code is as follows:

```
Java
Oracle
Basic
Advanced
Pass
Fail
```

The enhanced for loop is again a breeze to use to iterate through *nested or non-nested* arrays. For example, you can use the following code to iterate through an array of elements and calculate its total:

```
int total = 0;
int primeNums[] = {2, 3, 7, 11};
for (int num : primeNums)
 total += num;
```

What happens when you try to modify the value of the loop variable in an enhanced for loop? The result depends on whether you're iterating through a collection of primitive values or objects. If you're iterating through an array of primitive values, manipulation of the loop variable will never change the value of the array being iterated because the primitive values are passed by value to the loop variable in an enhanced for loop.

When you iterate through a collection of objects, the value of the collection is passed by reference to the loop variable. Therefore, if the value of the loop variable is manipulated by executing methods on it, the modified value will be reflected in the collection of objects being iterated:

```
StringBuilder myArr[] = {
 new StringBuilder("Java"),
 new StringBuilder("Loop")
};

for (StringBuilder val : myArr)
 System.out.println(val);
```

**Iterates through array myArr and prints Java and Loop**

```
for (StringBuilder val : myArr)
 val.append("Oracle");
```

**Appends Oracle to value referred by loop variable val**

```
for (StringBuilder val : myArr)
 System.out.println(val);
```

**Iterates through array myArr and prints JavaOracle and LoopOracle**

The output of the previous code is:

```
Java
Loop
JavaOracle
LoopOracle
```

Let's modify the previous code. Instead of calling the method append on the loop variable val, let's assign to it another StringBuilder object. In this case, the original elements of the array being iterated will not be affected and will remain the same:

```
StringBuilder myArr[] = {
 new StringBuilder("Java"),
 new StringBuilder("Loop")
};

for (StringBuilder val : myArr)
 System.out.println (val);
```

**Iterates through array myArr and prints Java and Loop**

```
for (StringBuilder val : myArr)
 val = new StringBuilder("Oracle");
```

**Assigns new StringBuilder object to reference variable val with value Oracle**

```
for (StringBuilder val : myArr)
 System.out.println (val);
```

**Iterates through array myArray and still prints Java and Loop**

The output of previous code is:

```
Java
Loop
Java
Loop
```



**EXAM TIP** Watch out for code that uses an enhanced for loop and its loop variable to change the values of elements in the collection that it iterates. This behavior often serves as food for thought for the exam authors.

### 5.4.1 Limitations of the enhanced for loop

Though a for-each loop is a good choice for iterating through collections and arrays, it can't be used in some places.

#### CAN'T BE USED TO INITIALIZE AN ARRAY AND MODIFY ITS ELEMENTS

Can you use an enhanced for loop in place of the regular for loop in the following code?

```
int[] myArray = new int[5];
for (int i=0; i<myArray.length; ++i) {
 myArray[i] = i;
 if ((myArray[i] % 2) == 0)
 myArray[i] = 20;
}
```

The simple answer is “no.” Although you can define a “counter” outside of the enhanced for loop and use it to initialize and modify the array elements, this approach defeats the purpose of the for-each loop. The existing for loop is easier to use in this case.

#### CAN'T BE USED TO DELETE OR REMOVE THE ELEMENTS OF A COLLECTION

Because the for loop hides the *iterator* used to iterate through the elements of a collection, you can't use it to remove or delete the existing collection values because you can't call the *remove* method.

If you assign a null value to the loop variable, it won't remove the element from a collection:

```
ArrayList<StringBuilder> myList = new ArrayList<>();
myList.add(new StringBuilder("One"));
myList.add(new StringBuilder("Two"));

for (StringBuilder val : myList)
 System.out.println(val);

for (StringBuilder val : myList)
 val = null;

for (StringBuilder val : myList)
 System.out.println(val);
```

The output of the previous code is:

```
One
Two
One
Two
```

#### CAN'T BE USED TO ITERATE OVER MULTIPLE COLLECTIONS OR ARRAYS IN THE SAME LOOP

Though it's perfectly fine for you to iterate through nested collections or arrays using a `for` loop, you can't iterate over multiple collections or arrays in the same `for-each` loop because the `for-each` loop allows for the creation of only one looping variable. Unlike the regular `for` loop, you can't define multiple looping variables in a `for-each` loop.



**EXAM TIP** Use the `for-each` loop to iterate arrays and collections. Don't use it to initialize, modify, or filter them.

### 5.4.2 Nested enhanced for loop

First of all, working with a nested collection is not the same as working with a nested loop. A nested loop can also work with unrelated collections.

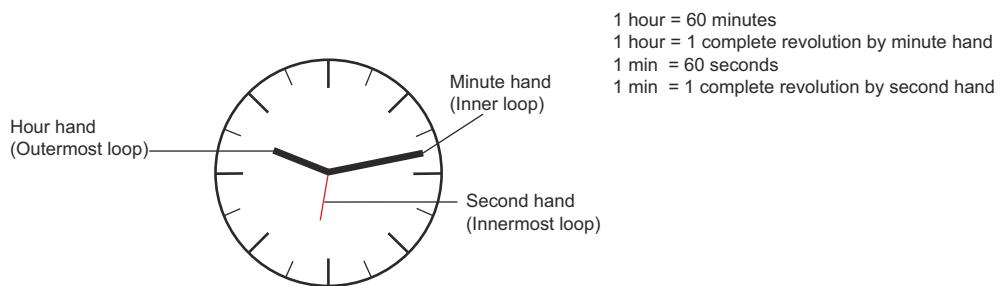
As discussed in section 5.3.4, loops defined within another loop are called *nested loops*. The loop that defines another loop within itself is called the *outer loop*, and the loop that's defined within another loop is called the *inner loop*. Theoretically, the level of nesting for any of the loops has no limits, including the enhanced `for` loop.

In this section, we'll work with three nested enhanced `for` loops. You can compare a three-level nested loop with a clock that has hour, minute, and second hands. The second hand of the clock completes a full circle each minute. Similarly, the minute hand completes a full circle each hour. This comparison is shown in figure 5.14.

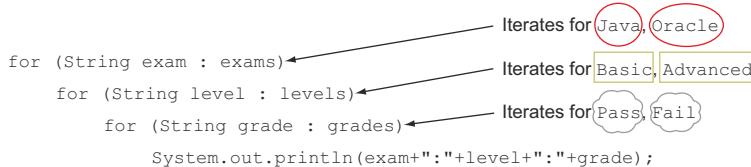
The following is a coding example of the nested, enhanced `for` loop, which I discussed in a previous section:

```
ArrayList<String> exams= new ArrayList<String>();
exams.add("Java"); exams.add("Oracle");
ArrayList<String> levels= new ArrayList<String>();
levels.add("Basic"); levels.add("Advanced");
ArrayList<String> grades= new ArrayList<String>();
grades.add("Pass"); grades.add("Fail");
for (String exam : exams)
 for (String level : levels)
 for (String grade : grades)
 System.out.println(exam+":"+level+":"+grade);
```

An inner loop in a nested loop executes for each iteration of its outer loop. The previous example defines three enhanced `for` loops: the outermost loop at ①, the inner nested loop at ②, and the innermost loop at ③. The complete innermost loop at ③ executes for each iteration of its immediate outer loop defined at ②. Similarly, the complete inner loop defined at ② executes for each iteration of its



**Figure 5.14 Comparison between a clock with three hands and the levels of a nested for loop**



**Figure 5.15 Nested for loop with the loop values for which each of these nested loop iterates**

immediate outer loop defined at ①. Figure 5.15 shows the loop values for which all of these loops iterate.

The output of the previous code is as follows:

```

Java:Basic:Pass
Java:Basic:Fail
Java:Advanced:Pass
Java:Advanced:Fail
Oracle:Basic:Pass
Oracle:Basic:Fail
Oracle:Advanced:Pass
Oracle:Advanced:Fail

```



**EXAM TIP** A nested loop executes all its iterations for each single iteration of its immediate outer loop.

Apart from the for loops, the other looping statements on the exam are while and do-while, which are discussed in the next section.

## 5.5 The while and do-while loops



[5.1] Create and use while loops



[5.3] Create and use do-while loops

You'll learn about while and do-while loops in this section. Both of these loops execute a set of statements as long as their condition evaluates to true. Both of these

loops work in exactly the same manner, except for one difference: the while loops checks its condition before evaluating its loop body, and the do-while loop checks its condition after executing the statements defined in its loop body.

Does this difference in behavior make a difference in their execution? Yes, it does, and in this section, you'll see how.

### 5.5.1 The while loop

A while loop is used to repeatedly execute a set of statements as long as its condition evaluates to true. This loop checks the condition *before* it starts the execution of the statement.

For example, at famous fast-food chain Superfast Burgers, an employee may be instructed to prepare burgers as long as buns are available. In this example, the availability of buns is the while condition and the preparation of burgers is the while's loop body. We can represent this in code as follows:

```
boolean bunsAvailable = true;
while (bunsAvailable) {
 ... prepare burger ...
 if (noMoreBuns)
 bunsAvailable = false;
}
```

The previous example is for demonstration purposes only, because the loop body isn't completely defined. The condition used in the while loop to check whether or not to execute the loop body again should evaluate to false at some point in time; otherwise, the loop will execute indefinitely. The value of this loop variable may be changed by the while loop or by another method if it's an instance or a static variable.

The while loop accepts arguments of type boolean or Boolean. Because the Boolean wrapper class isn't covered in the OCA Java SE 7 Programmer I exam, I won't cover it any further. In the previous code, the loop body checks whether more buns are available. If none are available, it sets the value of the variable bunsAvailable to false. The loop body doesn't execute for the next iteration because bunsAvailable evaluates to false.

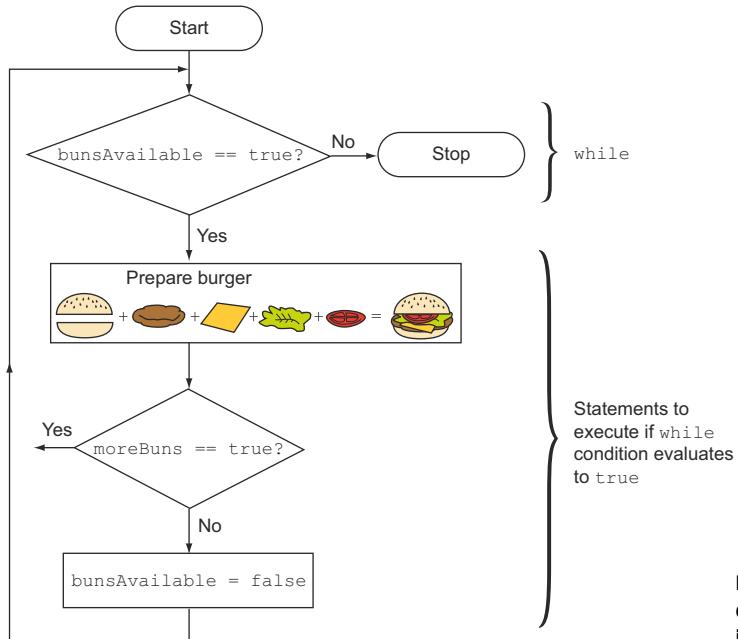
The execution of the previous while loop is shown in figure 5.16 as a simple flowchart to help you understand the concept better.

Now, let's examine another simple example that uses the while loop:

```
int num = 9;
boolean divisibleBy7 = false;
while (!divisibleBy7) {
 System.out.println(num);
 if (num % 7 == 0) divisibleBy7 = true;
 --num;
}
```

The output of this code is as follows:

```
9
8
7
```



**Figure 5.16** A flowchart depicting the flow of code in a `while` loop

What happens if you change the code as follows (changes in bold):

```
int num = 9;
boolean divisibleBy7 = true;
while (divisibleBy7 == false) {
 System.out.println(num);
 if (num % 7 == 0) divisibleBy7 = true;
 --num;
}
```

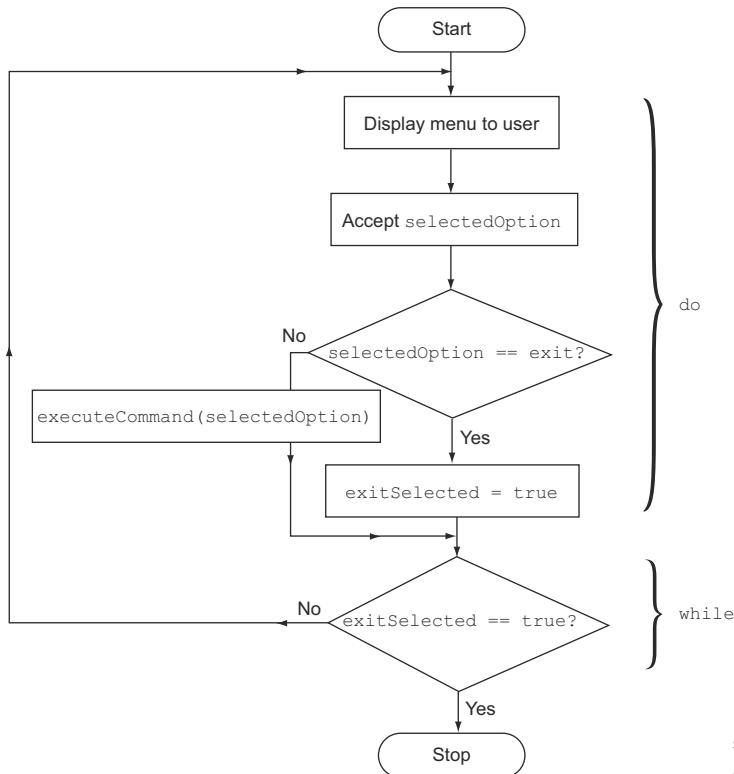
The code won't enter the loop because the condition `divisibleBy7==false` isn't true.

### 5.5.2 The do-while loop

A do-while loop is used to repeatedly execute a set of statements until the condition that it uses evaluates to `false`. This loop checks the condition *after* it completes the execution of all the statements in its loop body.

You could compare this structure to a software application that displays a menu at startup. Each menu option will execute a set of steps and redisplay the menu. The last menu option is “exit,” which exits the application and does not redisplay the menu:

```
boolean exitSelected = false;
do {
 String selectedOption = displayMenuToUser();
 if (selectedOption.equals("exit"))
 exitSelected = true;
 else
 executeCommand(selectedOption);
} while (exitSelected == false);
```



**Figure 5.17 Flowchart showing the flow of code in a do-while loop**

The previous code is represented by a simple flowchart in figure 5.17 that will help you to better understand the code.

The previous example is for demonstration purposes only because the methods used in the do-while loop aren't defined. As discussed in the previous section on while loops, the condition that's used in the do-while loop to check whether or not to execute the loop body again should evaluate to false at some point in time, or the loop will execute indefinitely. The value of this loop variable may be changed by the while loop or by another method, if it's an instance or static variable.



**NOTE** Don't forget to use a semicolon (;) to end the do-while loop after specifying its condition. Even some experienced programmers overlook this step!

The do-while loop accepts arguments of type boolean or Boolean. Because the Boolean wrapper class isn't covered in the OCA Java SE 7 Programmer I exam, I won't cover it any further.

Let's modify the example used in section 5.5.1 to use the do-while loop instead of a while loop, as follows:

```

int num = 9;
boolean divisibleBy7 = false;
do {

```

```

 System.out.println(num);
 if (num % 7 == 0) divisibleBy7 = true;
 num--;
 } while (divisibleBy7 == false);
}

```

The output of this code is as follows:

```

9
8
7

```

What happens if you change the code as follows (changes in bold):

```

int num = 9;
boolean divisibleBy7 = true;
do {
 System.out.println(num);
 if (num % 7 == 0) divisibleBy7 = true;
 num--;
} while (divisibleBy7 == false);

```

The output of the previous code is as follows:

```

9

```

The do-while loop executes once, even though the condition specified in the do-while loop evaluates to `false` because the condition is evaluated at the end of execution of the loop body.

### 5.5.3 **While and do-while block, expression, and nesting rules**

You can use the curly braces {} with while and do-while loops to define multiple lines of code to execute for every iteration. Without the use of curly braces, only the first line of code will be considered a part of the while or do-while loop, as specified in the if-else construct in section 5.1.3.

Similarly, the rules that define an appropriate expression to be passed to while and do-while loops are as for the if-else construct in section 5.1.4. Also, the rules for defining nested while and do-while loops are the same as for an if-else construct in section 5.1.5.

## 5.6 **Comparing loop constructs**

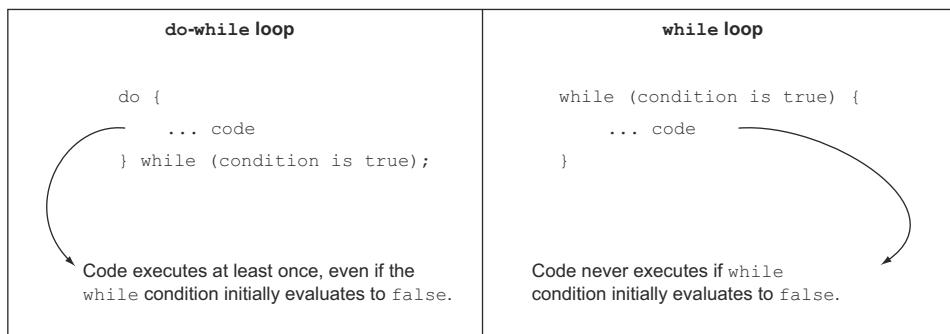


[5.4] Compare loop constructs

In this section, I'll discuss the differences and similarities between the following looping constructs: do-while, while, for, and enhanced for.

### 5.6.1 **Comparing do-while and while loops**

Both do-while and while loops execute a set of statements until their termination condition evaluates to `false`. The only difference between these two statements is that the do-while loop executes the code at least once, even if the condition evaluates to



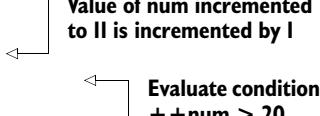
**Figure 5.18 Comparing do-while and while loops**

false. The do-while loop evaluates the termination condition *after* executing the statements, whereas the while loop evaluates the termination condition *before* executing its statements.

The forms taken by these statements are depicted in figure 5.18.

What do you think the output of the following code is?

```
int num=10;
do {
 num++;
} while (++num > 20);
System.out.println (num);
```



The output of the previous code is as follows:

12

What do you think the output of the following code is?

```
int num=10;
while (++num > 20) {
 num++;
}
System.out.println(num);
```



The output of the previous code is as follows

11

## 5.6.2 Comparing for and enhanced for loops

The regular for loop, although cumbersome to use, is much more powerful than the enhanced for loop (as mentioned in section 5.4.1):

- The enhanced for loop can't be used to initialize an array and modify its elements.
- The enhanced for loop can't be used to delete the elements of a collection.
- The enhanced for loop can't be used to iterate over multiple collections or arrays in the same loop.

### 5.6.3 Comparing for and while loops

You should *try* to use a `for` loop when you know the number of iterations—for example, when you’re iterating through a collection or an array, or when you’re executing a loop for a fixed number of times, say to “ping” a server five times.

You should *try* to use a `do-while` or a `while` loop when you don’t know the number of iterations beforehand, and when the number of iterations depends on a condition being `true`—for example, when accepting passport renewal applications from applicants until there are no more applicants. In this case, you’d be unaware of the number of applicants who have submitted their applications on a given day.

## 5.7 Loop statements: break and continue



[5.5] Use `break` and `continue`

Imagine that you’ve defined a loop to iterate through a list of managers, and you’re looking for at least one manager whose name starts with the letter `D`. You’d like to exit the loop after you find the first match, but how? You can do this by using the `break` statement in your loop.

Now imagine that you want to iterate through all of the folders on your laptop and scan any files larger than 10 MB for viruses. If all those files are found to be okay, you want to upload them to a server. But what if you’d like to skip the steps of *virus checking* and *file uploading* for file sizes less than 10 MB, yet still proceed with the remaining files on your laptop? You can! You’d use the `continue` statement in your loop.

In this section, I’ll discuss the `break` and `continue` statements, which you can use to exit a loop completely or to skip the remaining statements in a loop iteration. At the end of this section, I’ll discuss labeled statements.

### 5.7.1 The `break` statement

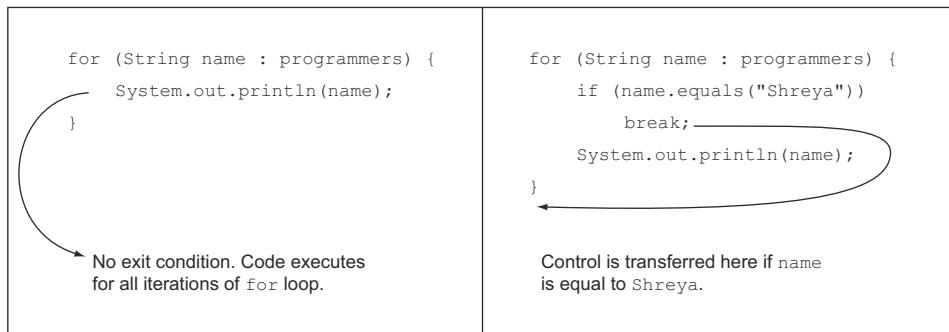
The `break` statement is used to *exit*—or *break out of*—the `for`, `for-each`, `do`, and `do-while` loops, as well as `switch` constructs. Alternatively, the `continue` statement can be used to skip the remaining steps in the current iteration and start with the next loop iteration.

The difference between these statements can be best demonstrated with an example. You could use the following code to browse and print all of the values of a `String` array:

```
String[] programmers = {"Paul", "Shreya", "Selvan", "Harry"};
for (String name : programmers) {
 System.out.println(name);
}
```

The output of the previous code is as follows:

```
Paul
Shreya
Selvan
Harry
```



**Figure 5.19** The flow of control when the **break** statement executes within a loop

Let's modify the previous code to exit the loop when the array value is equal to Shreya. Here's the required code:

```

String[] programmers = {"Paul", "Shreya", "Selvan", "Harry"};
for (String name : programmers) {
 if (name.equals("Shreya"))
 break; ← | Break out
 System.out.println(name); of the loop
}

```

The output of the previous code is as follows:

Paul

As soon as a loop encounters a **break**, it exits the loop. Hence, only the first value of this array—that is, Paul—is printed. As mentioned in the section on the **switch** construct, the **break** statement can be defined after every case in order for the control to exit the **switch** construct once it finds a matching case.

The previous code snippets are depicted in figure 5.19, which shows the transfer of control upon execution of the **break** statement.

When you use the **break** statement with nested loops, it exits the inner loop. The next Twist in the Tale exercise looks at a small code snippet to see how the control transfers when you use a **break** statement in nested **for** loops (answers in the appendix).

#### Twist in the Tale 5.4

Let's modify the code used in the previous example as follows. What is the output of this code?

```

String[] programmers = {"Outer", "Inner"};
for (String outer : programmers) {
 for (String inner : programmers) {
 if (inner.equals("Inner"))
 break;
 System.out.print(inner + ":");

 }
}

```

- a Outer:Outer:
  - b Outer:Inner:Outer:Inner:
  - c Outer:
  - d Outer:Inner:
  - e Inner:Inner:
- 

### 5.7.2 The continue statement

The `continue` statement is used to skip the remaining steps in the current iteration and start with the next loop iteration. Let's replace the `break` statement in the previous example with `continue` and examine its output:

```
String[] programmers = {"Paul", "Shreya", "Selvan", "Harry"};
for (String name : programmers) {
 if (name.equals("Shreya"))
 continue; ← Skip the remaining
 System.out.println(name); ← loop statements
}
```

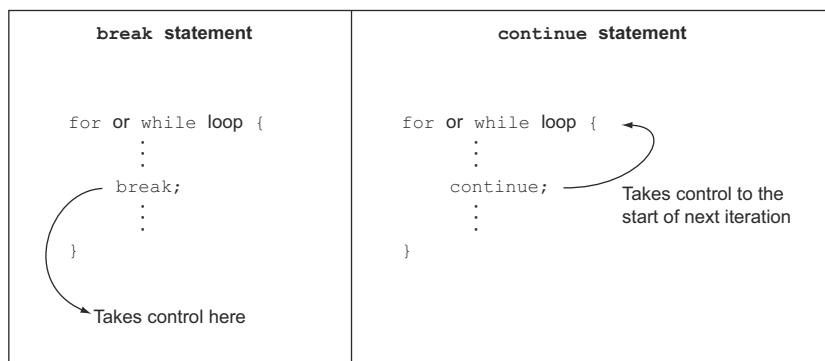
The output of the previous code is as follows:

```
Paul
Selvan
Harry
```

As soon as a loop encounters `continue`, it exits the current iteration of the loop. In this example, it skips the printing step for the array value `Shreya`. Unlike the `break` statement, `continue` doesn't exit the loop—it restarts with the next loop iteration, printing the remaining array values (that is, `Selvan` and `Harry`).

When you use the `continue` statement with nested loops, it exits the current iteration of the inner loop.

Figure 5.20 compares how the control transfers out of the loop and to the next iteration when `break` and `continue` statements are used.



**Figure 5.20 Comparing the flow of control when using break and continue statements in a loop**

### 5.7.3 Labeled statements

In Java, you can add labels to the following types of statements:

- A code block defined using {}
- All looping statements (for, enhanced for, while, do-while)
- Conditional constructs (if and switch statements)
- Expressions
- Assignments
- return statements
- try blocks
- throws statements

An example of a labeled loop is given here:

```
String[] programmers = {"Outer", "Inner"};
outer:
for (int i = 0; i < programmers.length; i++) {
```

You can't add labels to declarations. The following labeled declaration won't compile:

```
outer :
 int[] myArray = {1,2,3};
```

**Variable declaration  
that fails compilation**

It's interesting to note that the previous declaration can be defined within a block statement, as follows:

```
outer : {
 int[] myArray = {1,2,3};
}
```

**Start definition  
of block**

**End block**

**Variable declaration,  
compiles**

#### LABELED BREAK STATEMENTS

You can use a labeled break statement to exit an outer loop. Here's an example:

```
String[] programmers = {"Outer", "Inner"};
outer:
for (String outer : programmers) {
 for (String inner : programmers) {
 if (inner.equals("Inner"))
 break outer;
 System.out.print(inner + ":");
 }
}
```

**Exits the outer loop,  
marked with label outer**

The output of the previous code is:

```
Outer:
```

When this code executes break outer:, control transfers to the line of text that marks the end of this block. It doesn't transfer control to the label outer.

#### LABELED CONTINUE STATEMENTS

You can use a labeled continue statement to skip an iteration of the outer loop. Here's an example:

```

String[] programmers = {"Paul", "Shreya", "Selvan", "Harry"};
outer:
for (String name1 : programmers) {
 for (String name : programmers) {
 if (name.equals("Shreya"))
 continue outer;
 System.out.println(name);
 }
}

```

**Skips remaining code for current iteration of outer loop and starts with its next iteration**

The output of the previous code is:

```

Paul
Paul
Paul
Paul

```

## 5.8 Summary

We started this chapter with the selection statements `if` and `switch`. We covered the different flavors of the `if` construct. Then we looked at the `switch` construct, which accepts a limited set of argument types including `byte`, `char`, `short`, `int`, and `String`. The humble `if-else` construct can define virtually any set of simple or complicated conditions.

We also saw how you can execute your code using all types of loops: `for`, `for-each`, `do`, and `do-while`. The `for`, `do`, and `do-while` loops have been around since the Java language was first introduced, whereas the enhanced `for` loop (the `for-each` loop) was added to the language as of Java version 5.0. I recommend that you use the `for-each` loop to iterate through arrays and collections.

At the end of this chapter, we looked at the `break` and `continue` statements. You use the `break` statement to *exit*—or *break out of*—a `for`, `for-each`, `do`, `do-while`, or `switch` construct. You use the `continue` statement to skip the remaining steps in the current iteration and start with the next loop iteration.

## 5.9 Review notes

`if` and `if-else` constructs:

- The `if` statement enables you to execute a set of statements in your code based on the result of a condition, which should evaluate to a `boolean` or `Boolean` value.
- The multiple flavors of an `if` statement are `if`, `if-else`, and `if-else-if-else`.
- The `if` construct doesn't use the keyword `then` to define code to execute when an `if` condition evaluates to true. The `then` part of the `if` construct follows the `if` condition.
- An `if` construct may or may not define its `else` part.
- The `else` part of an `if` construct can't exist without the definition of its `then` part.
- It's easy to get confused with the common `if-else` syntax used in other programming languages. The `if-elsif` and `if-elseif` statements aren't used in Java to define `if-else-if-else` constructs. The correct keywords are `if` and `else`.

- You can execute a single statement or a block of statements for corresponding true and false conditions. A pair of braces marks a block of statements: {}.
- If an if construct doesn't use {} to define a block of code to execute for its then or else part, only the first line of code is part of the if construct.
- An assignment of a boolean variable can also be passed as an argument to the if construct. It's valid because the resultant value is boolean, which is accepted by if constructs.
- Theoretically, nested if and if-else constructs have no limits on their levels. When using nested if-else constructs, be careful about matching the else part with the right if part.

switch statements:

- A switch statement is used to compare the value of a variable with multiple pre-defined values.
- A switch statement accepts arguments of type char, byte, short, int, and String. It also accepts arguments of wrapper classes: Character, Byte, Short, Integer, and Enum. These wrapper classes aren't on the OCA Java SE 7 Programmer I exam.
- A switch statement can be compared with multiple related if-else-if-else constructs.
- You can pass an expression as an argument to a switch statement, as long as the type of the expression is one of the acceptable data types.
- The case value should be a compile-time constant, assignable to the argument passed to the switch statement.
- The case value can't be the literal value null.
- The case value can define expressions that use literal values; that is, they can be evaluated at compile time, as in 7+2.
- One code block can be defined to execute for multiple case values in a switch statement.
- A break statement is used to exit a switch construct once a matching case is found and the required code statements have executed.
- In absence of the break statement, control will *fall through* all the remaining case values in a switch statement until the first break statement is found, evaluating the code for the case statements in order.

for loops:

- A for loop is usually used to execute a set of statements a fixed number of times.
- A for loop defines three types of statements separated by semicolons (;): initialization statements, termination condition, and update clause.
- The definition of any of the three for statements—initialization statements, termination condition, and update clause—is optional. For example, for (;;) ;

and `for ( ; ; ) { }` are valid code for defining a `for` loop. Also, defining any one of these statements is also valid code.

- An initialization block executes only once. A `for` loop can declare and initialize multiple variables in its initialization block, but the variables that it declares should be of the same type.
- The termination condition is evaluated once, for all the iterations, before the statements defined within the body of the loop are executed.
- The `for` loop terminates when the termination condition evaluates to `false`.
- The update block is usually used to increment or decrement the value of the variables that are defined in the initialization block. It can also execute multiple other statements, including method calls.
- Nested `for` loops have no limits on levels.
- Nested `for` loops are frequently used to work with multidimensional arrays.

Enhanced `for` loops:

- The enhanced `for` loop is also called the `for-each` loop.
- The enhanced `for` loop offers some benefits over the regular `for` loop, but it's not as flexible as the regular `for` loop.
- The enhanced `for` loop offers simple syntax to iterate through a collection of values—an array, `ArrayList`, or other classes from Java's Collection framework that store a collection of values.
- The enhanced `for` loop can't be used to initialize an array and modify its elements.
- The enhanced `for` loop can't be used to delete the elements of a collection.
- The enhanced `for` loop can't be used to iterate over multiple collections or arrays in the same loop.
- Nested enhanced `for` loops have no limits on levels.

`while` and `do-while` loops:

- A `while` loop is used to keep executing a set of statements until the condition that it uses evaluates to `false`. This loop checks the condition *before* it starts the execution of the statement.
- A `do-while` loop is used to keep executing a set of statements until the condition that it uses evaluates to `false`. This loop checks the condition *after* it completes the execution of all the statements in its loop body.
- The levels of nested `do-while` or `while` loops have no limitations.
- Both `do-while` and `while` loops can define either a single line of code or a code block to execute. The latter is defined by using curly braces, `{ }`.

Comparing loop constructs:

- Both the `do-while` and `while` loops execute a set of statements until the termination condition evaluates to `false`. The only difference between these two

statements is that the do-while loop executes the code at least once, even if the condition evaluates to false.

- The regular for loop, though cumbersome to use, is much more powerful than the enhanced for loop.
- The enhanced for loop can't be used to initialize an array and modify its elements. The enhanced for loop can't be used to delete or remove the elements of a collection.
- The enhanced for loop can't be used to iterate over multiple collections or arrays in the same loop.
- You should try to use a for loop when you know the number of iterations—for example, iterating through a collection or an array, or executing a loop for a fixed number of times, say to “ping” a server five times.
- You should try to use a do-while or a while loop when you don't know the number of iterations beforehand and the number of iterations depends on a condition being true—for example, accepting passport renewal applications until all applicants have been attended to.

Loop statements (break and continue):

- The break statement is used to *exit*—or *break out of*—the for, for-each, do, and do-while loops and the switch construct.
- The continue statement is used to skip the remaining steps in the current iteration and start with the next loop iteration. The continue statement works with the for, for-each, do, and do-while loops and the switch construct.
- When you use the break statement with nested loops, it exits the inner loop.
- When you use the continue statement with nested loops, it exits the current iteration of the inner loop.

Labeled statements:

- You can add labels to a code block defined using braces, {}, all looping statements (for, enhanced for loop, while, do-while), conditional constructs (if and switch statements), expressions and assignments, return statements, try blocks, and throws statements.
- You can't add labels to declarations of variables.
- You can use a labeled break statement to exit an outer loop.
- You can use a labeled continue statement to skip the iteration of the outer loop.

## 5.10 Sample exam questions

**Q5-1.** What's the output of the following code?

```
class Loop2 {
 public static void main(String[] args) {
 int i = 10;
 do
```

```

 while (i < 15)
 i = i + 20;
 while (i < 2);
 System.out.println(i);
 }
}

a 10
b 30
c 31
d 32

```

**Q5-2.** What's the output of the following code?

```

class Loop2 {
 public static void main(String[] args) {
 int i = 10;
 do
 while (i++ < 15)
 i = i + 20;
 while (i < 2);
 System.out.println(i);
 }
}

a 10
b 30
c 31
d 32

```

**Q5-3.** Which of the following statements is true?

- a The enhanced for loop can't be used within a regular for loop.
- b The enhanced for loop can't be used within a while loop.
- c The enhanced for loop can be used within a do-while loop.
- d The enhanced for loop can't be used within a switch construct.
- e All of the above statements are false.

**Q5-4.** What's the output of the following code?

```

int a = 10;
if (a++ > 10) {
 System.out.println("true");
}
{
 System.out.println("false");
}
System.out.println("ABC");

a true
false
ABC

```

- b** false  
ABC
- c** true  
ABC
- d** Compilation error

**Q5-5.** Given the following code, which of the following lines of code can individually replace the //INSERT CODE HERE line so that the code compiles successfully?

```
class EJavaGuru {
 public static int getVal() {
 return 100;
 }
 public static void main(String args[]) {
 int num = 10;
 final int num2 = 20;
 switch (num) {
 // INSERT CODE HERE
 break;
 default: System.out.println("default");
 }
 }
}

a case 10*3: System.out.println(2);
b case num: System.out.println(3);
c case 10/3: System.out.println(4);
d case num2: System.out.println(5);
```

**Q5-6.** What's the output of the following code?

```
class EJavaGuru {
 public static void main(String args[]) {
 int num = 20;
 final int num2;
 num2 = 20;

 switch (num) {
 default: System.out.println("default");
 case num2: System.out.println(4);
 break;
 }
 }
}

a default
b default
4
c 4
d Compilation error
```

**Q5-7.** What's the output of the following code?

```
class EJavaGuru {
 public static void main(String args[]) {
 int num = 120;

 switch (num) {
 default: System.out.println("default");
 case 0: System.out.println("case1");
 case 10*2-20: System.out.println("case2");
 break;
 }
 }

 a default
 case1
 case2
 b case1
 case2
 c case2
 d Compilation error
 e Runtime exception
```

**Q5-8.** What's the output of the following code?

```
class EJavaGuru3 {
 public static void main(String args[]) {
 byte foo = 120;
 switch (foo) {
 default: System.out.println("ejavaguru"); break;
 case 2: System.out.println("e"); break;
 case 120: System.out.println("ejava");
 case 121: System.out.println("enum");
 case 127: System.out.println("guru"); break;
 }
 }

 a ejava
 enum
 guru
 b ejava
 c ejavaguru
 e
 d ejava
 enum
 guru
 ejavaguru
```

**Q5-9.** What's the output of the following code?

```
class EJavaGuru4 {
 public static void main(String args[]) {
```

```

 boolean myVal = false;
 if (myVal=true)
 for (int i = 0; i < 2; i++) System.out.println(i);
 else System.out.println("else");
 }
}

a else
b 0
 1
 2
c 0
 1
d Compilation error

```

**Q5-10.** What's the output of the following code?

```

class EJavaGuru5 {
 public static void main(String args[]) {
 int i = 0;
 for (; i < 2; i=i+5) {
 if (i < 5) continue;
 System.out.println(i);
 }
 System.out.println(i);
 }
}

a Compilation error
b 0
 5
c 0
 5
 10
d 10
e 0
 1
 5
f 5

```

## 5.11 Answers to sample exam questions

**Q5-1.** What's the output of the following code?

```

class Loop2 {
 public static void main(String[] args) {
 int i = 10;
 do
 while (i < 15)
 i = i + 20;
 while (i < 2);
 System.out.println(i);
 }
}

```

- a 10
- b 30
- c 31
- d 32

Answer: b

Explanation: The condition specified in the do-while loop evaluates to false (because  $10 < 2$  evaluates to false). But the control enters the do-while loop because the do-while loop executes at least once—its condition is checked at the end of the loop. The while evaluates to true for the first iteration and adds 20 to i, making it 30. The while loop doesn't execute for the second time. Hence, the value of the variable i at the end of the execution of the previous code is 30.

**Q5-2.** What's the output of the following code?

```
class Loop2 {
 public static void main(String[] args) {
 int i = 10;
 do
 while (i++ < 15)
 i = i + 20;
 while (i < 2);
 System.out.println(i);
 }
 }
 a 10
 b 30
 c 31
 d 32
```

Answer: d

Explanation: If you've attempted to answer question 5-1, it's likely that you would select the same answer for this question, too. I've deliberately used the same question text and variable names (with a small difference) because you may encounter a similar pattern in the OCA Java SE 7 Programmer I exam. This question includes one difference: unlike question 5-1, it uses a postfix unary operator in the while condition.

The condition specified in the do-while loop evaluates to false (because  $10 < 2$  evaluates to false). But the control enters the do-while loop because the do-while loop executes at least once—its condition is checked at the end of the loop. This question prints outs 32, not 30, because the condition specified in the while loop (which has an increment operator) executes twice.

In this question, the while loop condition executes twice. For the first evaluation,  $i++ < 15$  (that is,  $10 < 15$ ) returns true and increments the value of variable i by 1 (due to the postfix increment operator). The loop body modifies the value of i to 31. The

second condition evaluates `i++<15` (that is, `31<15`) to false. But due to the postfix increment operator value of `i`, it increments to 32. The final value is printed as 32.

**Q5-3.** Which of the following statements is true?

- a The enhanced for loop can't be used within a regular for loop.
- b The enhanced for loop can't be used within a while loop.
- c **The enhanced for loop can be used within a do-while loop.**
- d The enhanced for loop can't be used within a switch construct.
- e All of the above statements are false.

Answer: c

Explanation: The enhanced for loop can be used within all types of looping and conditional constructs. Notice the use of “can” and “can't” in the answer options. It's important to take note of these subtle differences.

**Q5-4.** What's the output of the following code?

```
int a = 10;
if (a++ > 10) {
 System.out.println("true");
}
{
 System.out.println("false");
}
System.out.println("ABC");
```

- a true  
false  
ABC
- b **false**  
ABC
- c true  
ABC
- d Compilation error

Answer: b

Explanation: First of all, the code has no compilation errors. This question has a trick—the following code snippet isn't part of the if construct:

```
{
 System.out.println("false");
}
```

Hence, the value false will print no matter what, regardless of whether the condition in the if construct evaluates to true or false.

Because the opening and closing braces for this code snippet are placed right after the if construct, it leads us to believe that this code snippet is the else part of the if construct. Also, note that an if construct uses the keyword else to define the else part. This keyword is missing in this question.

The `if` condition (that is, `a++ > 10`) evaluates to `false` because the postfix increment operator (`a++`) increments the value of the variable `a` immediately after its earlier value is used. `10` isn't greater than `10` so this condition evaluates to `false`.

**Q5-5.** Given the following code, which of the following lines of code can individually replace the `// INSERT CODE HERE` line so that the code compiles successfully?

```
class EJavaGuru {
 public static int getVal() {
 return 100;
 }
 public static void main(String args[]) {
 int num = 10;
 final int num2 = 20;
 switch (num) {
 // INSERT CODE HERE
 break;
 default: System.out.println("default");
 }
 }
}

a case 10*3: System.out.println(2);
b case num: System.out.println(3);
c case 10/3: System.out.println(4);
d case num2: System.out.println(5);
```

Answer: a, c, d

Explanation: Option (a) is correct. Compile-time constants, including expressions, are permissible in the `case` labels.

Option (b) is incorrect. The `case` labels should be compile-time constants. A non-final variable isn't a compile-time constant because it can be reassigned a value during the course of a class's execution. Although the previous class doesn't assign a value to it, the compiler still treats it as a changeable variable.

Option (c) is correct. The value specified in the `case` labels should be assignable to the variable used in the `switch` construct. You may think that `10/3` will return a decimal number, which can't be assigned to the variable `num`, but this operation discards the decimal part and compares 3 with the variable `num`.

Option (d) is correct. The variable `num2` is defined as a `final` variable and assigned a value on the same line of code, with its declaration. Hence, it's considered to be a compile-time constant.

**Q5-6.** What's the output of the following code?

```
class EJavaGuru {
 public static void main(String args[]) {
 int num = 20;
 final int num2;
 num2 = 20;
```

```

 switch (num) {
 default: System.out.println("default");
 case num2: System.out.println(4);
 break;
 }
 }

a default
b default
c 4
d Compilation error

```

Answer: d

Explanation: The code will fail to compile. The case labels require compile-time constant values, and the variable num2 doesn't qualify as such. Although the variable num2 is defined as a final variable, it isn't assigned a value with its declaration. The code assigns a literal value 20 to this variable after its declaration, but it isn't considered to be a compile-time constant by the Java compiler.

**Q5-7.** What's the output of the following code?

```

class EJavaGuru {
 public static void main(String args[]) {
 int num = 120;

 switch (num) {
 default: System.out.println("default");
 case 0: System.out.println("case1");
 case 10*2-20: System.out.println("case2");
 break;
 }
 }

a default
b case1
c case2
d Compilation error
e Runtime exception

```

Answer: d

Explanation: The expressions used for both case labels—that is, 0 and  $10*2-20$ —evaluate to the constant value 0. Because you can't define duplicate case labels for the

switch statement, the code will fail to compile with an error message that states that the code defines a duplicate case label.

**Q5-8.** What's the output of the following code?

```
class EJavaGuru3 {
 public static void main(String args[]) {
 byte foo = 120;
 switch (foo) {
 default: System.out.println("ejavaguru"); break;
 case 2: System.out.println("e"); break;
 case 120: System.out.println("ejava");
 case 121: System.out.println("enum");
 case 127: System.out.println("guru"); break;
 }
 }
}

a ejava
enum
guru
b ejava
c ejavaguru
e
d ejava
enum
guru
ejavaguru
```

Answer: a

Explanation: For a switch case construct, control enters the case labels when a matching case is found. The control then falls through the remaining case labels until it's terminated by a break statement. The control exits the switch construct when it encounters a break statement or it reaches the end of the switch construct.

In this example, a matching label is found for case label 120. The control executes the statement for this case label and prints ejava to the console. Because a break statement doesn't terminate the case label, the control falls through to case label 121. The control executes the statement for this case label and prints enum to the console. Because a break statement also doesn't terminate this case label, the control falls through to case label 127. The control executes the statement for this case label and prints guru to the console. This case label is terminated by a break statement, so the control exits the switch construct.

**Q5-9.** What's the output of the following code?

```
class EJavaGuru4 {
 public static void main(String args[]) {
 boolean myVal = false;
 if (myVal=true)
 for (int i = 0; i < 2; i++) System.out.println(i);
```

```
 else System.out.println("else");
 }
}

a else
b 0
 1
 2
c 0
 1
d Compilation error
```

Answer: c

Explanation: First of all, the expression used in the `if` construct isn't comparing the value of the variable `myVal` with the literal value `true`—it's assigning the literal value `true` to it. The assignment operator (`=`) assigns the literal value. The comparison operator (`==`) is used to compare values. Because the resulting value is a boolean value, the compiler doesn't complain about the assignment in the `if` construct.

The code is deliberately poorly indented because you may encounter similarly poor indentation in the OCA Java SE 7 Programmer I exam. The `for` loop is part of the `if` construct, which prints 0 and 1. The `else` part doesn't execute because the `if` condition evaluates to `true`. The code has no compilation errors.

**Q5-10.** What's the output of the following code?

```
class EJavaGuru5 {
 public static void main(String args[]) {
 int i = 0;
 for (; i < 2; i=i+5) {
 if (i < 5) continue;
 System.out.println(i);
 }
 System.out.println(i);
 }
}

a Compilation error
b 0
 5
c 0
 5
 10
d 10
e 0
 1
 5
f 5
```

Answer: f

Explanation: First of all, the following line of code has no compilation errors:

```
for (; i < 2; i=i+5) {
```

Using the initialization block is optional in a `for` loop. In this case, using a semicolon (`;`) terminates it.

For the first `for` iteration, the variable `i` has a value of 0. Because this value is less than 2, the following `if` construct evaluates to `true` and the `continue` statement executes:

```
if (i < 5) continue;
```

Because the `continue` statement ignores all of the remaining statements in a `for` loop iteration, the control doesn't print the value of the variable `i`, which leads the control to move on to the next `for` iteration. In the next `for` iteration, the value of the variable `i` is 5. The `for` loop condition evaluates to `false` and the control moves out of the `for` loop. After the `for` loop, the code prints out the value of the variable `i`, which increments once using the code `i=i+5`.

# *Working with inheritance*

| Exam objectives covered in this chapter                                                | What you need to know                                                                                                                                                                                                                                                                            |
|----------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [7.1] Implement inheritance.                                                           | The need for inheriting classes.<br>How to implement inheritance using classes.                                                                                                                                                                                                                  |
| [7.2] Develop code that demonstrates the use of polymorphism.                          | How to implement polymorphism with classes and interfaces.<br>How to define polymorphic or overridden methods.                                                                                                                                                                                   |
| [7.3] Differentiate between the type of a reference and the type of an object.         | How to determine the valid types of the variables that can be used to refer to an object.<br>How to determine the differences in the members of an object, which ones are accessible, and when an object is referred to using a variable of an inherited base class or an implemented interface. |
| [7.4] Determine when casting is necessary.                                             | The need for casting.<br>How to cast an object to another class or an interface.                                                                                                                                                                                                                 |
| [7.5] Use <code>super</code> and <code>this</code> to access objects and constructors. | How to access variables, methods, and constructors using <code>super</code> and <code>this</code> .<br>What happens if a derived class tries to access variables of a base class when they're not accessible to the derived class.                                                               |
| [7.6] Use abstract classes and interfaces.                                             | The role of abstract classes and interfaces in implementing polymorphism.                                                                                                                                                                                                                        |

All living beings inherit the characteristics and behaviors of their parents. The offspring of a fly looks and behaves like a fly, and that of a lion looks and behaves like

a lion. But despite being similar to their parents, all offspring are also different and unique in their own ways. Additionally, a single action may have different meanings for different beings. For example, the action “eat” has different meanings for a fly and a lion. A fly eats nectar, whereas a lion eats antelope.

Something similar happens in Java. The concept of inheriting characteristics and behaviors from parents can be compared to classes inheriting variables and methods from a parent class. Being different and unique in one’s own way is similar to how a class can both inherit from a parent and also define additional variables and methods. Single actions having different meanings can be compared to polymorphism in Java.

In the OCA Java SE 7 Programmer I exam, you’ll be asked questions on how to implement inheritance and polymorphism and how to use classes and interfaces. Hence, this chapter covers the following:

- Understanding and implementing inheritance
- Developing code that demonstrates the use of polymorphism
- Differentiating between the type of a reference and an object
- Determining when casting is required
- Using `super` and `this` to access objects and constructors
- Using abstract classes and interfaces

## 6.1 Inheritance with classes



### [7.1] Implement inheritance

When we discuss inheritance in the context of an object-oriented programming language such as Java, we talk about how a class can inherit the properties and behavior of another class. The class that inherits from another class can also define additional properties and behaviors. The exam will ask you explicit questions about the need to inherit classes and how to implement inheritance using classes.

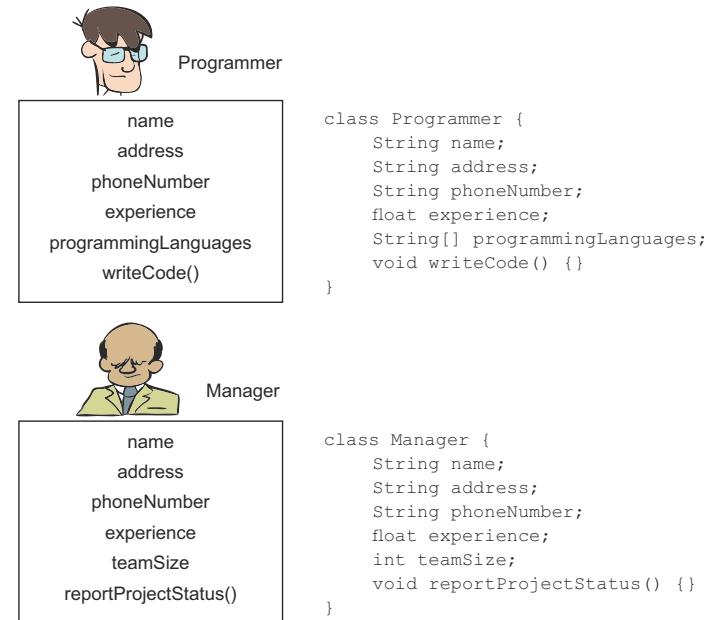
Let’s get started with the need to inherit classes.

#### 6.1.1 Need to inherit classes

Imagine the positions *Programmer* and *Manager* within an organization. Both of these positions have a common set of properties, including name, address, and phone number. These positions also have different properties. A *Programmer* may be concerned about a project’s programming languages, whereas a *Manager* may be concerned with project status reports.

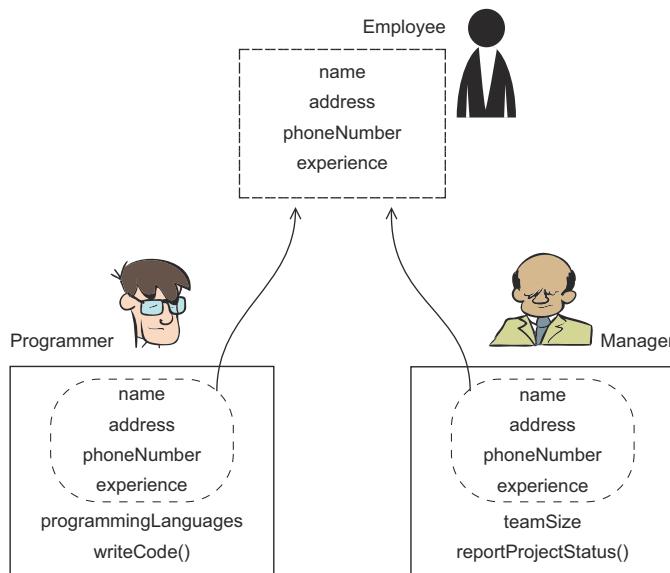
Let’s assume you’re supposed to store details of all Programmers and Managers in your office. Figure 6.1 shows the properties and behavior that you may have identified for a Programmer and a Manager, together with their representations as classes.

Did you notice that the classes *Programmer* and *Manager* have common properties, namely, `name`, `address`, `phoneNumber`, and `experience`? The next step is to pull out these common properties into a new position and name it something like *Employee*. This step is shown in figure 6.2.

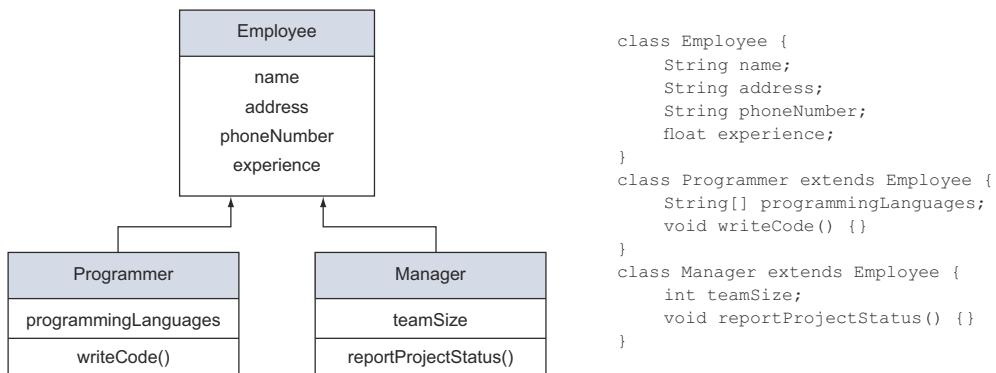


**Figure 6.1 Properties and behavior of a Programmer and a Manager, together with their representations as classes**

This new position, Employee, can be defined as a new class, Employee, which is inherited by the classes Programmer and Manager. A class uses the keyword `extends` to *inherit* a class, as shown in figure 6.3.



**Figure 6.2 Identify common properties and behaviors of a Programmer and a Manager, pull them out into a new position, and name it Employee**



**Figure 6.3 The classes Programmer and Manager extend the class Employee**

Inheriting a class is also referred to as *subclassing*. In figure 6.3, the inherited class `Employee` is also referred to as the *superclass*, *base class*, or *parent class*. The classes `Programmer` and `Manager` that inherit the class `Employee` are called *subclasses*, *derived classes*, *extended classes*, or *child classes*.

Why do you think you need to pull out the common properties and behaviors into a separate class `Employee` and make the `Programmer` and `Manager` classes inherit it?

#### SMALLER DERIVED CLASS DEFINITIONS

What if you were supposed to write more specialized classes, such as `Astronaut` and `Doctor`, which have the same common characteristics and behaviors as those of the class `Employee`? With the class `Employee` in place, you only need to define the variables and methods that are specific to the classes `Astronaut` and `Doctor`, and have the classes inherit `Employee`.

Figure 6.4 is a UML representation of the classes `Astronaut`, `Doctor`, `Programmer`, and `Manager`, both with and without inheritance from class `Employee`. As you can see in this figure, the definitions of these classes is smaller when they inherit the class `Employee`.

#### EASE OF MODIFICATION TO COMMON PROPERTIES AND BEHAVIOR

What happens if your boss steps in and tells you that all of these specialized classes—`Astronaut`, `Doctor`, `Programmer`, and `Manager`—should now have a property `facebookId`? Figure 6.5 shows that with the base class `Employee` in place, you just need to add this variable to that base class. If you haven't inherited from the class `Employee`, you need to add the variable `facebookId` to *each* of these four classes.

Note that common code can be modified and deleted from the base class `Employee` fairly easily.

#### EXTENSIBILITY

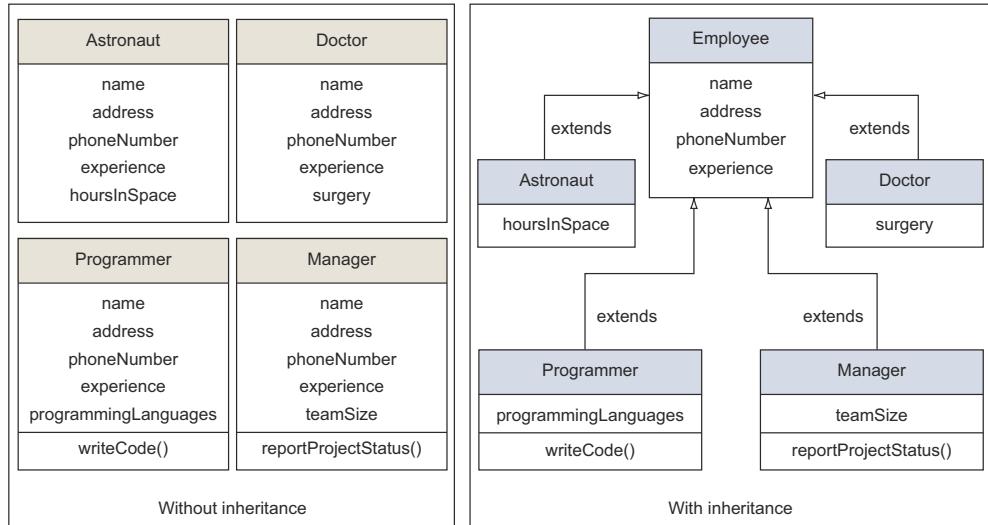
Code that works with the base class in a hierarchy tree can work with all classes that are added using inheritance later.

Assume that an organization needs to send out invitations to all its employees and that it uses the following method to do so:

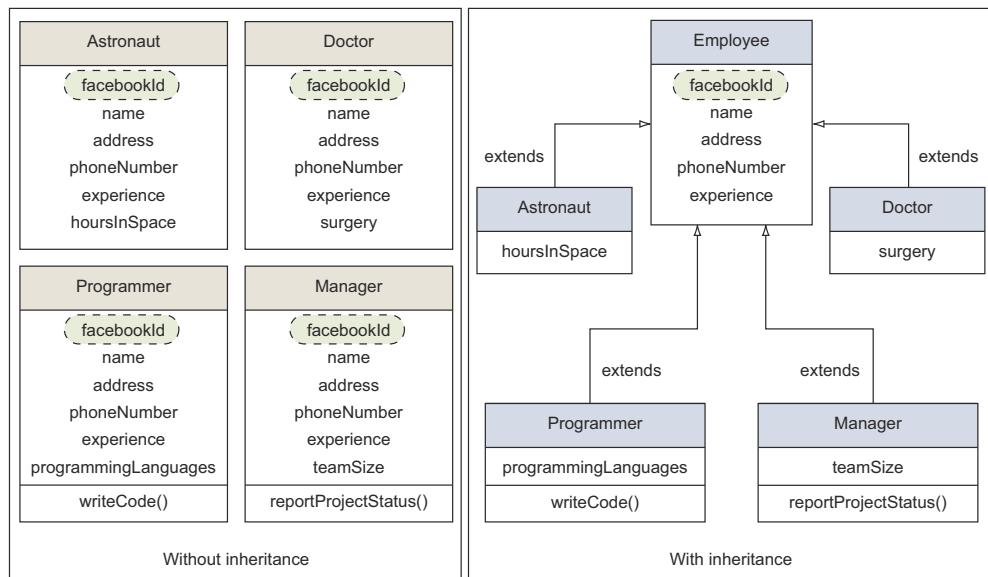
```

class HR {
 void sendInvitation(Employee emp) {
 System.out.println("Send invitation to" +
 emp.name + " at " + emp.address);
 }
}

```



**Figure 6.4 Differences in the size of the classes Astronaut, Doctor, Programmer, and Manager, both with and without inheriting from the class Employee**



**Figure 6.5 Adding a new property, facebookId, to all classes, with and without the base class Employee**

Because method `sendInvitation` accepts an argument of type `Employee`, you can also pass to it a subclass of `Employee`. Essentially, this design means that you can use the previous method with a class defined later that has `Employee` as its base class. Inheritance makes code extensible.

#### **USE TRIED-AND-TESTED CODE FROM A BASE CLASS**

You don't need to reinvent the wheel. With inheritance in place, subclasses can use tried-and-tested code from a base class.

#### **CONCENTRATE ON THE SPECIALIZED BEHAVIOR OF YOUR CLASSES**

Inheriting a class enables you to concentrate on the variables and methods that define the special behavior of your class. Inheritance lets you make use of existing code from a base class without having to define it yourself.

#### **LOGICAL STRUCTURES AND GROUPING**

When multiple classes inherit a base class, it creates a logical group. For an example, see figure 6.5. The classes `Astronaut`, `Doctor`, `Programmer`, and `Manager` are all grouped as types of the class `Employee`.



**EXAM TIP** Inheritance enables you to reuse code that has already been defined by a class. Inheritance can be implemented by extending a class.

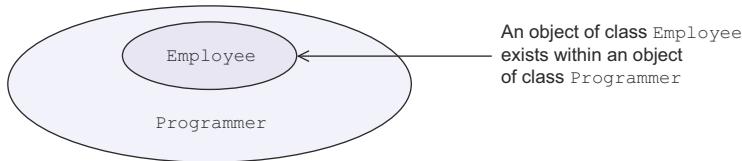
The next section solves the mystery of how you can access the inherited members of a base class directly in a derived class.

### **6.1.2 A derived class contains within it an object of its base class**

The classes `Programmer` and `Manager` inherit the variables and methods defined in the class `Employee` and use them directly, as if they were defined in their own classes. Examine the following code:

```
class Employee {
 String name;
 String address;
 String phoneNumber;
 float experience;
}
class Manager extends Employee {
 int teamSize;
 void reportProjectStatus() {}
}
class Programmer extends Employee {
 String[] programmingLanguages;
 void writeCode() {}
 void accessBaseClassMembers() {
 name = "Programmer";
 }
}
```

Derived class `Programmer`  
can directly access  
members of its base class.



**Figure 6.6** An object of a derived class contains an object of its base class.

How can the class `Programmer` assign a value to a variable that's defined in the class `Employee`? You can think of this arrangement as follows: when a class inherits another class, it encloses within it an object of the inherited class. Hence, all the members (variables and methods) of the inherited class are available to the class, as shown in figure 6.6.

But a derived class can't inherit all the members of its base class. The next two sections discuss which base class members are and aren't inherited by a derived class.

### 6.1.3 Which base class members are inherited by a derived class?

The access modifiers play an important role in determining the inheritance of base class members in derived classes. A derived class inherits all the non-private members of its base class. A derived class inherits base class members with the following accessibility modifiers:

- *Default*—Members with default access can be accessed in a derived class only if base and derived classes reside in the same package.
- *protected*—Members with protected access are accessible to all the derived classes, regardless of the packages in which the base and derived classes are defined.
- *public*—Members with public access are visible to all the other classes.

### 6.1.4 Which base class members aren't inherited by a derived class?

A derived class doesn't inherit the following members:

- *private* members of the base class.
- Base class members with default access, if the base class and derived classes exist in separate packages.
- Constructors of the base class. A derived class can call a base class's constructors, but it doesn't inherit them (section 6.5 discusses how a derived class can call a base class's constructors using the implicit reference `super`).

Apart from inheriting the properties and behavior of its base class, a derived class can also define additional properties and behaviors, as discussed in the next section.

### 6.1.5 Derived classes can define additional properties and behaviors

Though derived classes are similar to their base classes, they generally also have differences. Derived classes can define additional properties and behaviors. You may see explicit questions on the exam about how a derived class can differ from its base class.

Take a quick look back at figure 6.5. All the derived classes—Manager, Programmer, Doctor, and Astronaut—define additional variables, methods, or both. Derived classes can also define their own constructors and static methods and variables. A derived class can also *hide* or *override* its base class's members.

When a derived class defines an instance or class variable with the same name as one defined from its base class, only these new variables and methods are visible to code using the derived class. When a derived class defines different code for a method inherited from a base class by defining the method again, this method is treated as a special method—an *overridden* method.

You can implement inheritance by using either a concrete class or an abstract class as a base class, but there are some important differences that you should be aware of. These are discussed in the next section.

### 6.1.6 Abstract base class versus concrete base class

Figures 6.2 and 6.3 showed how you can pull out the common properties and behavior of a Programmer and Manager and represent these as a new class, Employee. You can define class Employee as an abstract class, if you think that it's only a categorization and no real employee exists in real life—that is, if all employees are really either *Programmers* or *Managers*. That's the essence of an abstract class: it groups the common properties and behavior of its derived classes, but it prevents itself from being instantiated. Also, an abstract class can force all its derived classes to define their own implementations for a behavior by defining it as an abstract method (a method without a body).

It isn't mandatory for an abstract class to define an abstract method. It may or may not define any abstract methods. But if an abstract base class defines one or more abstract methods, the class must be marked as abstract and the abstract methods must be implemented in all its derived classes. If a derived class doesn't implement all the abstract methods defined by its base class, then it also needs to be an abstract class.

For the exam, you need to remember the following important points about implementing inheritance using an abstract base class:

- You can never create objects of an abstract class.
- A base class can be defined as an abstract class, even if it doesn't define any abstract methods.
- A derived class should implement all the abstract methods of its base class. If it doesn't, it must be defined as an abstract derived class.
- You can use variables of an abstract base class to refer to objects of its derived class (discussed in detail in section 6.3).

The first Twist in the Tale exercise for this chapter queries you on the relationship between base and derived classes (answer in the appendix).

**Twist in the Tale 6.1**

Let's modify the code used in the previous example as follows. Which of the options is correct for this modified code?

```
class Employee {
 private String name;
 String address;
 protected String phoneNumber;
 public float experience;
}
class Programmer extends Employee {
 Programmer (String val) {
 name = val;
 }
 String getName() {
 return name;
 }
}
class Office {
 public static void main(String args[]) {
 new Programmer ("Harry").getName();
 }
}
```

- a The class `Office` prints Harry.
- b The derived class `Programmer` can't define a getter method for a variable defined in its base class `Employee`.
- c The derived class `Programmer` can't access variables of its base class in its constructors.
- d `new Programmer ("Harry").getName();` isn't the right way to create an object of class `Programmer`.
- e Compilation error.

**TERMS AND DEFINITIONS TO REMEMBER**

Following is a list of terms and their corresponding definitions that you should remember; they're used throughout the chapter, and you'll come across them while answering questions on inheritance in the OCA Java SE 7 Programmer I exam.

- *Base class*—A class inherited by another class. The class `Employee` is a *base class* for the classes `Programmer` and `Manager` in the previous examples.
- *Superclass*—A base class is also known as a *superclass*.
- *Parent class*—A base class is also known as a *parent class*.
- *Derived class*—A class that inherits from another class. The classes `Programmer` and `Manager` are *derived classes* in the previous example.
- *Subclass*—A derived class is also known as a *subclass*.
- *Extended class*—A derived class is also known as an *extended class*.

- *Child class*—A derived class is also known as a *child class*.
- *IS-A relationship*—A relationship shared by base and derived classes. In the previous examples, a Programmer IS-A Person. A Manager IS-A Person. Because a derived class represents a specialized type of a base class, a derived IS-A class is a kind of base class.
- *extends*—The keyword used by a class to inherit another class and by an interface to inherit another interface.
- *implements*—The keyword used by a class to implement an interface (interfaces are covered in the next section).



**NOTE** The terms *base class*, *superclass*, and *parent class* are used interchangeably. Similarly, the terms *derived class* and *subclass* are also used interchangeably.

In this section, you learned that an abstract class may define abstract methods. Let's take it a step further to interfaces, which can define only abstract methods and constants. In the next section, we'll discuss why you need interfaces and how to use them.

## 6.2 Use interfaces



### [7.6] Use abstract classes and interfaces

Interfaces are abstract classes taken to extremes. An interface can define only abstract methods and constants. All the members of an interface are implicitly public.

Let's go back to the example used in section 6.1 with classes Employee, Programmer, and Manager, where Programmer and Manager inherit the class Employee. Imagine that your boss steps in and commands that Programmer and Manager *must* support additional behaviors, as listed in table 6.1.

**Table 6.1 Additional behaviors that need to be supported by the classes Programmer and Manager**

| Entity     | New expected behavior               |
|------------|-------------------------------------|
| Programmer | Attend training                     |
| Manager    | Attend training, conduct interviews |

How will you accomplish this task? One approach you can take is to define all the relevant methods in class Employee. Because both Programmer and Manager extend the class Employee, they'd be able to access these methods. But wait: Programmer doesn't need the behavior of the conducting interview task; only Manager should support the functionality of conducting interviews.

Another obvious approach would be to define the relevant methods in the desired classes. You could define methods to conduct interviews in Manager and methods to attend training in both Programmer and Manager. Again, this is not an ideal solution. What will happen if your boss later informs you that all the Employees who attend

training should accept a *training schedule*; that is, there is a change in the signature of the method that defines the behavior “attends training”? Can you define separate classes for this behavior and make the classes Programmer and Manager implement them? No, you can’t. Java doesn’t allow a class to inherit multiple classes.

Let’s try interfaces. Create two interfaces to define the specified behavior:

```
interface Trainable {
 public void attendTraining();
}

interface Interviewer {
 public void conductInterview();
}
```

Though Java does not allow a class to inherit from more than one class, it allows a class to implement multiple interfaces. A class uses the keyword `implements` to implement an interface. In the following code, the classes Programmer and Manager implement the relevant interfaces (modified code in bold):

```
class Employee {
 String name;
 String address;
 String phoneNumber;
 float experience;
}

class Manager extends Employee implements Interviewer, Trainable {
 int teamSize;
 void reportProjectStatus() {}
 public void conductInterview() {
 System.out.println("Mgr - conductInterview");
 }
 public void attendTraining() {
 System.out.println("Mgr - attendTraining");
 }
}
class Programmer extends Employee implements Trainable{
 String[] programmingLanguages;
 void writeCode() {}
 public void attendTraining() {
 System.out.println("Prog - attendTraining");
 }
}
```

**Manager implements Interviewer and Trainable**

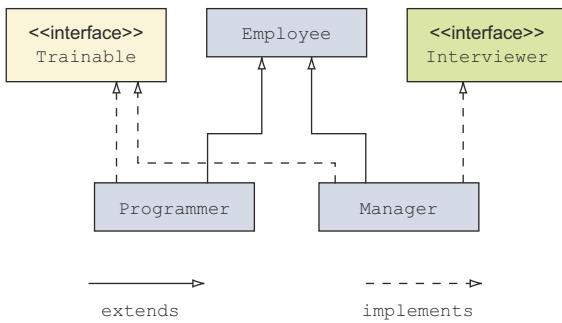
**Programmer implements only Trainable**

The code shows two classes, Manager and Programmer, extending Employee and implementing Trainable. Annotations on the right side of the code indicate that Manager implements both Interviewer and Trainable, while Programmer only implements Trainable.

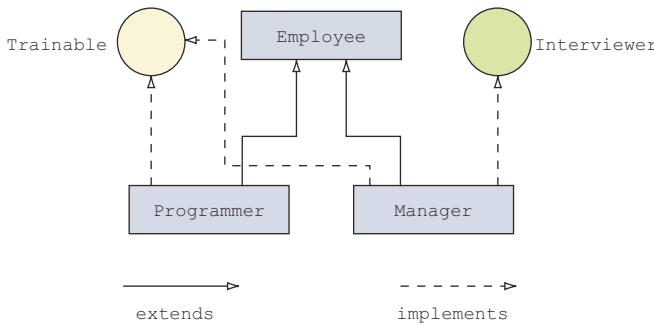
Figure 6.7 displays the relationships between these classes in a UML diagram.

An interface can be represented using either a rectangle with the text `<<interface>>` or a circle. Both these notations are popular; you may see them in various websites or books. The same relationships can also be represented as depicted in figure 6.8, where the interfaces are defined as circles.

Each class can implement these methods in its own particular manner. As mentioned previously, let’s change the method `attendTraining` in the interface `Trainable` so it accepts a `trainingSchedule`, as follows:



**Figure 6.7 Relationships between the classes Employee, Programmer, and Manager and the interfaces Trainable and Interviewer**



**Figure 6.8 Relationships between the classes Employee, Programmer, and Manager and the interfaces Trainable and Interviewer, with interfaces represented using circles**

```

interface Trainable {
 public void attendTraining(String[] trainingSchedule);
}

```

Method attendTraining now accepts a trainingSchedule as an array of String

Does a change in the signature of a method in an interface have any impact on the definition of this method in the classes that implement it? Yes, it does. If the signature of a method is changed in an interface, all classes that implement the interface will fail to compile. Now that the method signature has been modified, the classes Programmer and Manager must be modified so that the signature of the method attendTraining matches in all three: the interface Trainable and the classes Programmer and Manager.

The changes are as follows (in bold):

```

interface Trainable {
 public void attendTraining(String[] trainingSchedule);
}
interface Interviewer {
 public void conductInterview();
}
class Employee {
 String name;
 String address;
 String phoneNumber;
 float experience;
}

```

Signature of method attendTraining should match in interface Trainable, class Manager, and class Programmer

```

class Manager extends Employee implements Interviewer, Trainable {
 int teamSize;
 void reportProjectStatus() {}
 public void conductInterview() {
 System.out.println("Mgr - conductInterview");
 }
 public void attendTraining(String[] trainingSchedule) { ←
 System.out.println("Mgr - attendTraining");
 }
}
class Programmer extends Employee implements Trainable{
 String[] programmingLanguages;
 void writeCode() {}
 public void attendTraining(String[] trainingSchedule) { ←
 System.out.println("Prog - attendTraining");
 }
}

```

**Signature of method attendTraining should match in interface Trainable, class Manager, and class Programmer**



**EXAM TIP** The method signatures of a method defined in an interface and the classes that implement the interface must match, or the classes won't compile.

### 6.2.1 Properties of members of an interface

An interface can only define constants. Once it's assigned, you can't change the value of a constant. The variables of an interface are implicitly public, final, and static.

For example, the following definition of the interface MyInterface,

```
interface MyInterface {
 int age = 10;
}
```

is equivalent to the following definition:

```
interface MyInterface {
 public static final int AGE = 10;
}
```

**public, static, and final modifiers are implicitly added to variables defined in an interface.**

You should initialize all variables in an interface, or your code won't compile:

```
interface MyInterface {
 int AGE;
}
```

**Won't compile. Should assign a value to a final variable.**

The methods of an interface are implicitly public. When you implement an interface, you must implement all its methods by using the access modifier public. A class that implements an interface can't make the interface's methods more restrictive. Although the following class and interface definitions look acceptable, they're not:

```

interface Relocatable {
 void move();
}
class CEO implements Relocatable {
 void move() {}
}

```

**Implicitly public**

**Won't compile. Can't assign weaker access (default access) to public method move in class CEO.**

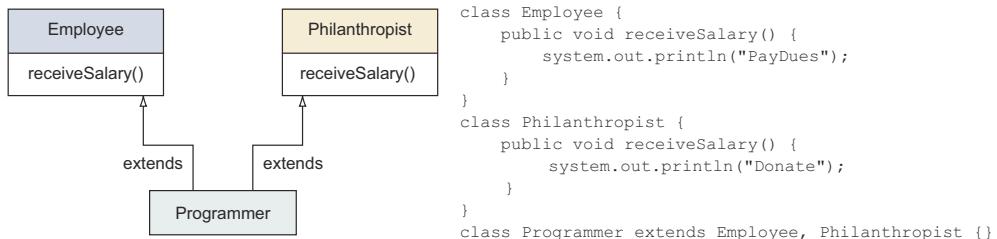
The following code is correct and compiles happily:

```
interface Relocatable {
 void move();
}
class CEO implements Relocatable {
 public void move() {}
}
```

Unlike a class, an interface can't define constructors.

### 6.2.2 Why a class can't extend multiple classes

In Java, a class can't extend multiple classes. Why do you think this is so? Let's examine this issue using an example, in which the class `Programmer` is allowed to inherit two classes: `Employee` and `Philanthropist`. Figure 6.9 shows the relationship between these classes and the corresponding code.



**Figure 6.9 What happens if a class is allowed to extend multiple classes?**

If class `Programmer` inherited the method `receiveSalary`, defined in both `Employee` and `Philanthropist`, what do you think a `Programmer` would do with his or her salary: pay dues (like an `Employee`) or donate it (like a `Philanthropist`)? What do you think would be the output of the following code?

```
class Test {
 public static void main(String args[]) {
 Programmer p = new Programmer();
 p.receiveSalary();
 }
}
```

In this case, class `Programmer` can access two `receiveSalary` methods with identical method signatures but different implementations, so it is impossible to resolve this method call. This is why classes aren't allowed to inherit multiple classes in Java.



**EXAM TIP** Because a derived class may inherit different implementations for the same method signature from multiple base *classes*, multiple inheritance is not allowed in Java.

### 6.2.3 Implementing multiple interfaces

In the previous section, you learned that a class can't inherit multiple classes, but a class can implement multiple interfaces. Also, an interface can extend multiple interfaces.

Why is this allowed, when Java doesn't allow a class to extend multiple classes? What's the catch?

An interface defines barebones methods—methods without any body—and when an interface extends another interface, it inherits the methods defined in the base interface. What happens if the base interface and subinterface define methods with the same signatures? Or when an interface extends more than one interface that defines the same method?

Consider the following code, whose UML representation is shown in figure 6.10.

Which of the `getName` methods will be inherited by the interface `MyInterface`? Will `MyInterface` inherit the `getName` method defined in `BaseInterface1` or the one defined in `BaseInterface2`?

```
interface BaseInterface1 {
 String getName();
}
interface BaseInterface2 {
 String getName();
}
interface MyInterface extends BaseInterface1, BaseInterface2 {}
```

Because neither of the `getName` methods defined in `BaseInterface1` and `BaseInterface2` define a method body (as shown in figure 6.11), the question of which of the methods `MyInterface` inherits is irrelevant. Interface `MyInterface` has access to a single `getName` method, which should be implemented by all the classes that implement `MyInterface`.

Let's make the `Employee` class implement the interface `MyInterface`, as follows:

```
class Employee implements MyInterface {
 String name;
 public String getName() {
 return name;
 }
}
```

**Employee defines a body for method `getName`, inherited from interface `MyInterface`**

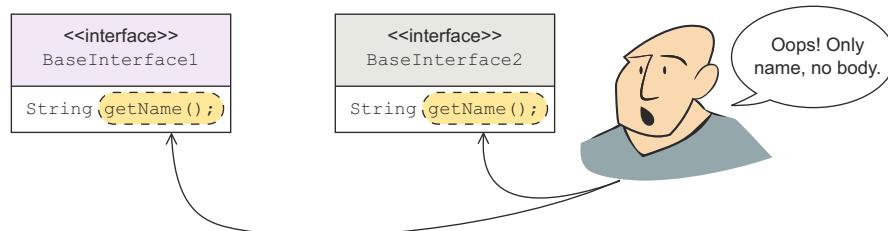


Figure 6.10 The interface `MyInterface` extends the interfaces `BaseInterface1` and `BaseInterface2`.

**POINTS TO NOTE ABOUT CLASS AND INTERFACE INHERITANCE:**

- A class can inherit zero or one class.
- A class uses the keyword `extends` to inherit a class.
- A class can implement multiple interfaces.
- A class uses the keyword `implements` to implement an interface.
- An interface can't implement any class.
- An interface can inherit zero or more interfaces.
- An interface uses the keyword `extends` to inherit interfaces.
- An abstract class can extend a concrete class and vice versa.
- An abstract class can implement interfaces.
- An abstract class can extend another abstract class.
- The first concrete class in the hierarchy must supply actual method implementations for all abstract methods.

You can use a reference variable of a base class to refer to an object of its derived class. Similarly, you can use a reference variable of an interface to refer to an object of a class that implements it. It's interesting to note that these variables can't access all the variables and methods defined in the derived class or the class that implements the interface.

Let's dig into some more details about this in the next section.

### 6.3 Reference variable and object types



[7.3] Differentiate between the type of a reference and the type of an object

For this exam objective, you need to understand that when you refer to an object, the type of the *object reference variable* and the type of the *object* being referred to may be different. But there are rules on *how different* these can be. This concept may take a while to sink in, so don't worry if you don't get it on your first attempt.

In the same way in which you can refer to a person using their first name, last name, or both names, objects of derived classes can be referred to using a reference variable of either of the following types:

- *Its own type*—An object of a class `HRExecutive` can be referred to using an object reference variable of type `HRExecutive`.
- *Its base class*—If the class `HRExecutive` inherits the class `Employee`, an object of the class `HRExecutive` can be referred to using a variable of type `Employee`. If the class `Employee` inherits the class `Person`, an object of the class `HRExecutive` can also be referred to using a variable of type `Person`.
- *Implemented interfaces*—If the class `HRExecutive` implements the interface `Interviewer`, an object of the class `HRExecutive` can be referred using a variable of type `Interviewer`.

There are differences, however, when you try to access an object using a reference variable of its own type, its base class, or an implemented interface. Let's start with accessing an object with a variable of its own type.

### 6.3.1 Using a variable of the derived class to access its own object

Let's start with the code of the class `HRExecutive`, which inherits the class `Employee` and implements the interface `Interviewer`, as follows:

```
class Employee {
 String name;
 String address;
 String phoneNumber;
 float experience;
}
interface Interviewer {
 public void conductInterview();
}
class HRExecutive extends Employee implements Interviewer { ←
 String[] specialization;
 public void conductInterview() {
 System.out.println("HRExecutive - conducting interview");
 }
}
```

**Class HRExecutive inherits class Employee and implements interface Interview**

Here's some code that demonstrates that an object of class `HRExecutive` can be referred to using a variable of type `HRExecutive`:

```
class Office {
 public static void main(String args[]) {
 HRExecutive hr = new HRExecutive();
 }
}
```

**A variable of type HRExecutive can be used to refer to its object.**

You can access variables and methods defined in the class `Employee`, the class `HRExecutive`, and the interface `Interviewer` using the variable `hr` (with the type `HRExecutive`), as follows:

```
class Office {
 public static void main(String args[]) {
 HRExecutive hr = new HRExecutive();
 hr.specialization = new String[] {"Staffing"};
 System.out.println(hr.specialization[0]);
 hr.name = "Pavni Gupta";
 System.out.println(hr.name);
 hr.conductInterview(); ←
 }
}
```

**Access variable defined in class HRExecutive**

**Access variable defined in class Employee**

**Access method defined in interface Interviewer**

When you access an object of the class `HRExecutive` using its own type, you can access all the variables and methods that are defined in its base class and interface—the class

`Employee` and the interface `Interviewer`. Can you do the same if the type of the reference variable is changed to the class `Employee`, as defined in the next section?

### 6.3.2 Using a variable of the base class to access an object of a derived class

Let's access an object of type `HRExecutive` using a reference variable of type `Employee`, as follows:

```
class Office {
 public static void main(String args[]) {
 Employee emp = new HRExecutive();
 }
}
```

Variable of type `Employee` can also be used to refer to an object of class `HRExecutive` because class `HRExecutive` extends `Employee`.

Now let's see whether changing the type of the reference variable makes any difference when accessing the members of the class `Employee`, the class `HRExecutive`, or the interface `Interviewer`. Will the following code compile successfully?

```
Type of variable emp is Employee. →
class Office {
 public static void main(String args[]) {
 Employee emp = new HRExecutive();
 emp.specialization = new String[] {"Staffing"};
 System.out.println(emp.specialization[0]);
 emp.name = "Pavni Gupta";
 System.out.println(emp.name);
 emp.conductInterview(); ←
 }
}
```

1 Variable emp can't access member specialization defined in class `HRExecutive`.

Variable emp can access member name defined in class `Employee`.

Variable emp can't access method conductInterview defined in interface `Interviewer`.

The code at ① fails to compile because the type of the variable `emp` is defined as `Employee`. Picture it like this: the variable `emp` can see only the `Employee` object. Hence, it can access only the variables and methods defined in the class `Employee`, as illustrated in figure 6.12.

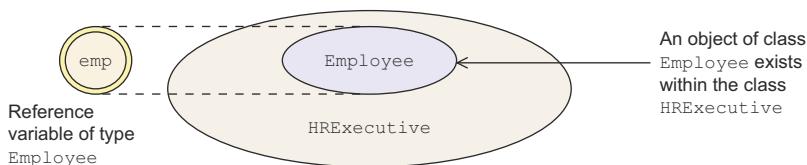


Figure 6.12 A variable of type `Employee` can see only the members defined in the class `Employee`.

### 6.3.3 Using a variable of an implemented interface to access a derived class object

Here's another interesting equation: what happens when you change the type of the reference variable to the interface `Interviewer`? A variable of type `Interviewer` can

also be used to refer to an object of the class `HRExecutive` because the class `HRExecutive` implements `Interviewer`. See the following code:

```
class Office {
 public static void main(String args[]) {
 Interviewer interviewer = new HRExecutive();
 }
}
```

Now try to access the same set of variables and methods using the variable `interviewer`, which refers to an object of the class `HRExecutive`:

```
class Office {
 public static void main(String args[]) {
 Interviewer interviewer = new HRExecutive();
```

**Type of variable  
interviewer is  
Interviewer.**

**Variable  
interviewer can't  
access members  
of class Employee  
or HRExecutive.**

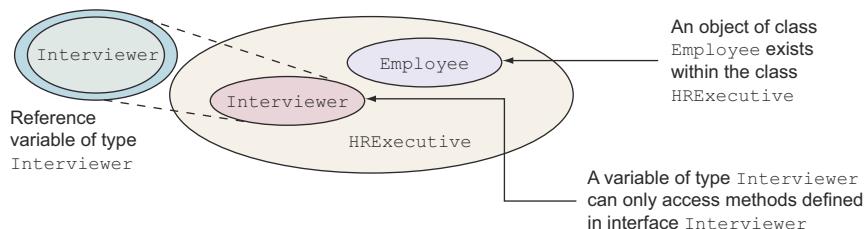
**Variable interviewer can access  
the method conductInterview  
defined in interface Interviewer.**

```
 interviewer.specialization = new String[] {"Staffing"};
 System.out.println(interviewer.specialization[0]);

 interviewer.name = "Pavni Gupta";
 System.out.println(interviewer.name);

 interviewer.conductInterview();
 }
}
```

The code at ① doesn't compile because the type of the variable `interviewer` is defined as `Interviewer`. Picture it like this: the variable `interviewer` can only *access* the methods defined in the interface `Interviewer`, as illustrated in figure 6.13.

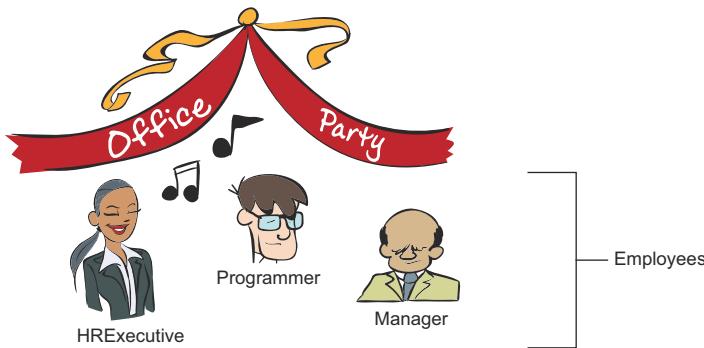


**Figure 6.13 A variable of type Interviewer can see only the members defined in the interface Interviewer.**

#### 6.3.4 The need for accessing an object using the variables of its base class or implemented interfaces

You may be wondering why you need a reference variable of a base class or an implemented interface to access an object of a derived class if a variable can't access all the members that are available to an object of a derived class? The simple answer is that you might not be interested in *all* the members of a derived class.

Confused? Compare it with the following situation. When you enroll in flying classes, do you care whether the instructor can cook Italian cuisine or knows how to swim? No! You don't care about characteristics and behavior that are unrelated to flying. Here is



**Figure 6.14 All types of employees can attend an office party.**

another example. At an office party, all the employees are welcome, whether they are Programmers, HRExecutives, or Managers, as shown in figure 6.14.

The same logic applies when you access an object of the class `HRExecutive` using a reference variable of type `Interviewer`. When you do so, you're only concerned about the behavior of `HRExecutive` that relates to its capability as an `Interviewer`.

This arrangement also makes it possible to create an array (or a list) of the objects that refers to different types of objects grouped by a common base class or an interface. The following code segment defines an array of type `Interviewer` and stores in it objects of the classes `HRExecutive` and `Manager`:

```
class OfficeInheritanceList {
 public static void main(String args[]) {
 Interviewer[] interviewers = new Interviewer[2];
 interviewers[0] = new Manager();
 interviewers[1] = new HRExecutive();
 for (Interviewer interviewer : interviewers) {
 interviewer.conductInterview();
 }
 }
}
```

**Because Manager implements interface Interviewer, it can be stored here.**

**Because HRExecutive implements interface Interviewer, it can be stored here.**

**Array of type Interviewer—an interface**

**Loop through the array and call method conductInterview**

The class `HRExecutive` extends the class `Employee` and implements the interface `Interviewer`. Hence, you can assign an object of `HRExecutive` to any of the following types of variables:

- `HRExecutive`
- `Employee`
- `Interviewer`

Please note that the reverse of these assignments will fail compilation. To start with, you can't refer to an object of a base class by using a reference variable of its derived class. Because *all* members of a derived class can't be accessed using an object of the base class, it isn't allowed. The following statement will not compile:

`HRExecutive hr = new Employee();` ← **Not allowed—won't compile**

Because you can't create an object of an interface, the following line of code will also fail to compile:

```
HRExecutive hr = new Interviewer(); ← Not allowed—won't compile
```

It's now time for you to try to add objects of the previously defined related classes—Employee, Manager, and HRExecutive—to an array in your next Twist in the Tale exercise (answers in the appendix).

### Twist in the Tale 6.2

Given the following definition of the classes and interface Employee, Manager, HRExecutive, and Interviewer, select the correct options for the class TwistInTale2:

```
class Employee {}
interface Interviewer {}
class Manager extends Employee implements Interviewer {}
class HRExecutive extends Employee implements Interviewer {}

class TwistInTale2 {
 public static void main (String args[]) {
 Interviewer[] interviewer = new Interviewer[] {
 new Manager(), // Line 1
 new Employee(), // Line 2
 new HRExecutive(), // Line 3
 new Interviewer() // Line 4
 };
 }
}
```

- a An object of the class Manager can be added to an array of the interface Interviewer. Code on line 1 will compile successfully.
- b An object of the class Employee can be added to an array of the interface Interviewer. Code on line 2 will compile successfully.
- c An object of the class HRExecutive can be added to an array of the interface Interviewer. Code on line 3 will compile successfully.
- d An object of the interface Interviewer can be added to an array of the interface Interviewer. Code on line 4 will compile successfully.



**EXAM TIP** You may see multiple questions in the exam that try to assign an object of a base class to a reference variable of a derived class. Note that a derived class can be referred to using a reference variable of its base class. The reverse is not allowed and won't compile.

In this section, you learned that the variables of a base class or interface are not able to access all the members of the object to which they refer. Don't worry; this can be resolved by *casting* a reference variable of a base class or an interface to the exact type of the object they refer to, as discussed in the next section.

## 6.4 Casting



[7.4] Determine when casting is necessary

*Casting* is the process of forcefully making a variable behave as a variable of another type. If a class shares an IS-A or inheritance relationship with another class or interface, their variables can be cast to each other's type.

In section 6.3, you learned that you can't access all the members of the class `HRExecutive` (derived class) if you refer to it via a variable of type `Interviewer` (implemented interface) or `Employee` (base class). In this section, you'll learn how to cast a variable of type `Interviewer` to access variables defined in the class `HRExecutive`, and why you'd want to.

### 6.4.1 How to cast a variable to another type

We'll start with the definitions of interface `Interviewer` and classes `HRExecutive` and `Manager`:

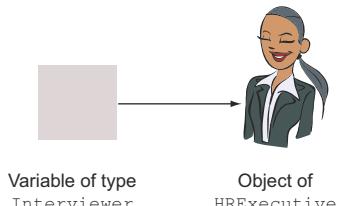
```
class Employee {}
interface Interviewer {
 public void conductInterview();
}
class HRExecutive extends Employee implements Interviewer {
 String[] specialization;
 public void conductInterview() {
 System.out.println("HRExecutive - conducting interview");
 }
}
class Manager implements Interviewer{
 int teamSize;
 public void conductInterview() {
 System.out.println("Manager - conducting interview");
 }
}
```

Create a variable of type `Interviewer` and assign to it an object of type `HRExecutive` (as depicted in figure 6.15).

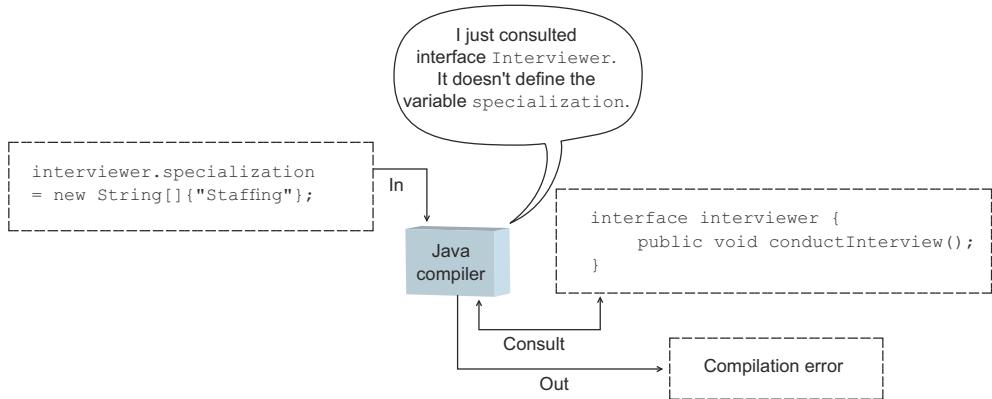
```
Interviewer interviewer = new HRExecutive();
```

Try to access the variable `specialization` defined in the class `HRExecutive` using the previous variable:

```
interviewer.specialization = new String[] {"Staffing"}; ← Won't compile
```



**Figure 6.15** A reference variable of interface `Interviewer` referring to an object of the class `HRExecutive`



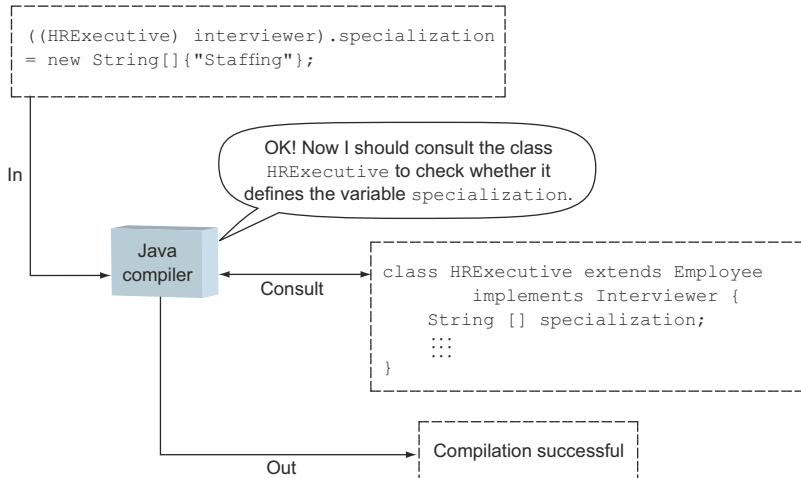
**Figure 6.16** The Java compiler doesn't compile code if you try to access the variable specialization, defined in the class `HRExecutive`, by using a variable of the interface `Interviewer`.

The previous line of code won't compile. The compiler knows that the type of the variable `interviewer` is `Interviewer` and that the interface `Interviewer` doesn't define any variable with the name `specialization` (as shown in figure 6.16).

On the other hand, the JRE knows that the object referred to by the variable `interviewer` is of type `HRExecutive`, so you can use casting to get past the Java compiler and access the members of the object being referred to, as follows (see also figure 6.17):

```
((HRExecutive) interviewer).specialization = new String[] {"Staffing"};
```

In the previous example code, `(HRExecutive)` is placed just before the name of the variable, `interviewer`, to cast it to `HRExecutive`. A pair of parentheses surrounds



**Figure 6.17** Casting can be used to access the variable specialization, defined in the class `HRExecutive`, by using a variable of interface `Interviewer`.

(`HRExecutive`) interviewer, which lets Java know you're sure that the object being referred to is an object of the class `HRExecutive`. Casting is another method of telling Java: "Look, I know that the actual object being referred to is `HRExecutive`, even though I'm using a reference variable of type `Interviewer`."

### 6.4.2 Need for casting

In section 6.3.4, I discussed the need to use a reference variable of an inherited class or an implemented interface to refer to an object of a derived class. I also used an example of enrolling in flying classes, where you don't care about whether the instructor can cook Italian cuisine or knows how to swim. You don't care about characteristics and behavior that are unrelated to flying.

But think about a situation in which you do care about the swimming skills of your instructor. Imagine that when you're attending flying classes, your friend enquires about whether your flying instructor also conducts swimming classes, and if so, whether your friend could enroll. In this case, a *need* arises to enquire about the swimming skills of your flying instructor.

Let's apply this situation to Java. You can't access all the members of an object if you access it using a reference variable of any of its implemented interfaces or of a base class. But if a need arises, you *might* choose to access some of the members of a derived class, which are not explicitly available, by using the reference variable of the base type or the implemented interface. This is where casting comes in!

Time to see this in code. Here's an example that exhibits the need for casting. An application maintains a list of interviewers, and depending on the type of interviewer (`HRExecutive` or `Manager`), it performs a different set of actions. If the interviewer is a `Manager`, the code calls `conductInterview` only if the value for the `Manager`'s `teamSize` is greater than 10. Here's the code that implements this logic:

```
class OfficeWhyCasting {
 public static void main(String args[]) {
 Interviewer[] interviewers = new Interviewer[2];
 interviewers[0] = new Manager();
 interviewers[1] = new HRExecutive();
 for (Interviewer interviewer : interviewers) {
 if (interviewer instanceof Manager) {
 int teamSize = ((Manager)interviewer).teamSize;
 if (teamSize > 10) {
 interviewer.conductInterview();
 }
 else {
 System.out.println("Mgr can't " +
 "interview with team size less than 10");
 }
 }
 }
 }
}
```

**Store object of HRExecutive at array position 1**

**If object referred to by interviewer is of class Manager, use casting to retrieve value for its teamSize**

**Array to store objects of classes that implement interface Interviewer**

**Store object of Manager at array position 0**

**Loop through values of array interviewers**

**If interviewer's teamSize > 10, call conductInterview**

**If interviewer's teamSize <= 10, print message**

```

 else if (interviewer instanceof HRExecutive) {
 interviewer.conductInterview();
 }
 }
}

```

**Otherwise, if object stored is of class HRExecutive, call conductInterview method on the object; no casting is required in this case**

## 6.5 Use this and super to access objects and constructors



[7.5] Use super and this to access objects and constructors

In this section, you'll use the `this` and `super` keywords to access objects and constructors. `this` and `super` are *implicit* object references. These variables are defined and initialized by the JVM for every object in its memory.

Let's examine the capabilities and use of each of these reference variables.

### 6.5.1 Object reference: this

The `this` reference always points to an object's *own instance*. Any object can use the `this` reference to refer to its own instance. Think of the words *me*, *myself*, and *I*: anyone using those words is always referring to themselves, as shown in figure 6.18.

#### USING THIS TO ACCESS VARIABLES AND METHODS

You can use the keyword `this` to refer to all methods and variables that are accessible to a class. For example, here's a modified definition of the class `Employee`:

```
class Employee {
 String name;
}
```

The variable `name` can be accessed in the class `Programmer` (which extends the class `Employee`) as follows:

```
class Programmer extends Employee {
 void accessEmployeeVariables() {
 name = "Programmer";
 }
}
```

Because there exists an object of class `Employee` within the class `Programmer`, the variable `name` is accessible to an object of `Programmer`. The variable `name` can also be accessed in the class `Programmer` as follows:

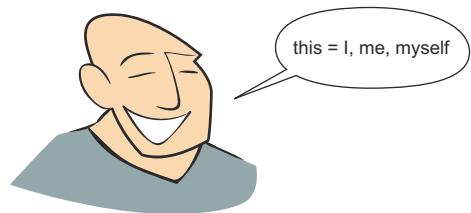


Figure 6.18 The keyword `this` can be compared to the words *me*, *myself*, and *I*.

```
class Programmer extends Employee {
 void accessEmployeeVariables() {
 this.name = "Programmer";
 }
}
```

The `this` reference may be used only when code executing within a method block needs to differentiate between an instance variable and its local variable or method parameters. But some developers use the keyword `this` all over their code, even when it's not required. Some use `this` as a means to differentiate instance variables from local variables or method parameters.

Figure 6.19 shows the constructor of the class `Employee`, which uses the reference variable `this` to differentiate between local and instance variables `name`, which are declared with the same name.

```
class Employee {
 String name;
 Employee(String name) {
 this.name = name;
 }
}
```

Method parameter name  
Instance variable name

**Figure 6.19 Using the keyword `this` to differentiate between method parameter and instance variables**

In the previous example, the class `Employee` defines an instance variable with the name `name`. The `Employee` class constructor also defines a method parameter `name`, which is effectively a local variable defined within the scope of the method block. Hence, within the scope of the previously defined `Employee` constructor, there's a clash of names, and the local variable will take precedence. Using `name` within the scope of the `Employee` class constructor block will implicitly refer to that method's parameter, not the instance variable. In order to refer to the instance variable `name` from within the scope of the `Employee` class constructor, you are obliged to use a `this` reference.

### USING THIS TO ACCESS CONSTRUCTORS

You can also differentiate one constructor from another by using the keyword `this`. Here's an example in which the class `Employee` defines two constructors, with the second constructor calling the first one:

```
class Employee {
 String name;
 String address;
 Employee(String name) {
 this.name = name;
 }
 Employee(String name, String address) {
 this(name);
 this.address = address;
 }
}
```

Instance variables are name and address

Constructor that accepts only name

Calls constructor that accepts only name

Assigns value of method parameter address to instance variable

To call the default constructor (one that doesn't accept any method parameters), call `this()`. Here's an example:

```
class Employee {
 String name;
 String address;

 Employee() {
 name = "NoName";
 address = "NoAddress";
 }

 Employee(String name, String address) {
 this();

 if (name != null) this.name = name;
 if (address != null) this.address = address;
 }
}
```

**Calls constructor that doesn't accept any arguments. Must be the first statement in this method.**

**Instance variables are name and address**

**Constructor that doesn't accept any arguments**

**Constructor that accepts name and address**

**Assigns value of not null method parameters**

If present, a call to a constructor from another constructor must be done on the first line of code of the calling constructor.



**EXAM TIP** `this` refers to the instance of the class in which it's used. `this` can be used to access the inherited members of a base class in the derived class.

## 6.5.2 Object reference: super

In the previous section, I discussed how `this` refers to the object instance itself. Similarly, `super` is also an object reference, but `super` refers to the parent or base class of a class. Think of the words *my parent, my base*: anyone using those terms is always referring to their parent or the base class, as shown in figure 6.20.

### USING SUPER TO ACCESS VARIABLES AND METHODS OF THE BASE CLASS

The variable reference `super` can be used to access a variable or method from the base class if there's a clash between these names. This situation normally occurs when a derived class defines variables and methods with the same name as the base class.

Here's an example:

```
class Employee {
 String name;
}

class Programmer extends Employee {
 String name;

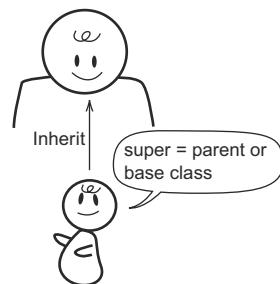
 void setNames() {
 this.name = "Programmer";
 super.name = "Employee";
 }
}
```

**Assign value to instance variable—name, defined in Programmer**

**Instance variable—name, in Employee**

**Instance variable—name, in Programmer**

**Assign value to instance variable—name, defined in Employee**



**Figure 6.20 When a class mentions `super`, it refers to its parent or the base class.**

```

void printNames() {
 System.out.println(super.name);
 System.out.println(this.name);
}
class UsingThisAndSuper {
 public static void main(String[] args) {
 Programmer programmer = new Programmer();
 programmer.setNames();
 programmer.printNames();
 }
}

```

**Print value of instance variable—name, defined in Employee**

**Print value of instance variable—name, defined in Programmer**

**Create an object of class Programmer**

The output of the preceding code is as follows:

```

Employee
Programmer

```

Similarly, you can use the reference variable super to access a method defined with the same name in the base or the parent class.

#### USING SUPER TO ACCESS CONSTRUCTORS OF BASE CLASS

The reference variable super can also be used to refer to the constructors of the base class in a derived class.

Here's an example in which the base class, Employee, defines a constructor that assigns default values to its variables. Its derived class calls the base class constructor in its own constructor.

```

class Employee {
 String name;
 String address;

 Employee(String name, String address) {
 this.name = name;
 this.address = address;
 }
}
class Programmer extends Employee {
 String progLanguage;
}

Programmer(String name, String address, String progLang) {
 super(name, address);
 this.progLanguage = progLang;
}

```

**Constructor that accepts values for superclass variables also**

**Instance variables—name and address**

**Constructor that accepts name and address**

**Instance variable—progLanguage**

**① Calls Employee constructor**

The code at ① calls the superclass constructor by passing it the reference variables, name and address, which it accepts itself.

**EXAM TIP** If present, a call to a superclass's constructor must be the first statement in a derived class's constructor. Otherwise, a call to `super();` (the no-arg constructor) is inserted automatically by the compiler.



### USING SUPER AND THIS IN STATIC METHODS

The keywords `super` and `this` are implicit object references. Because static methods belong to a class, not to objects of a class, you can't use `this` and `super` in static methods. Code that tries to do so won't compile:

```

class Employee {
 String name;
}
class Programmer extends Employee {
 String name;
 static void setNames() {
 this.name = "Programmer";
 super.name = "Employee";
 }
}

Won't compile—can't use this in static method →
Instance variable—name, in Employee ←
Instance variable—name, in Programmer ←
Won't compile—can't use super in static method ←

```

It's time to attempt the next Twist in the Tale exercise, using `this` and `super` keywords (answer in the appendix).

#### Twist in the Tale 6.3

Let's modify the definition of the `Employee` and `Programmer` classes as follows. What is the output of class `TwistInTale3`?

```

class Employee {
 String name = "Emp";
 String address = "EmpAddress";
}
class Programmer extends Employee{
 String name = "Prog";
 void printValues() {
 System.out.print(this.name + ":");
 System.out.print(this.address + ":");
 System.out.print(super.name + ":");
 System.out.print(super.address);
 }
}
class TwistInTale3 {
 public static void main(String args[]) {
 new Programmer().printValues();
 }
}
a Prog:null:Emp:EmpAddress
b Prog:EmpAddress:Emp:EmpAddress
c Prog::Emp:EmpAddress
d Compilation error

```

## 6.6 Polymorphism



[7.6] Use abstract classes and interfaces



[7.2] Develop code that demonstrates the use of polymorphism

The literal meaning of the word “polymorphism” is “many forms.” At the beginning of this chapter, I used a practical example to explain the meaning of polymorphism; the same action may have different meanings for different living beings. The action *eat* has a different meaning for a *fly* and a *lion*. A *fly* may eat *nectar*; whereas a *lion* may eat an antelope. Reacting to the same action in one’s own unique manner in living beings can be compared to polymorphism in Java.

For the exam, you need to know what polymorphism in Java is, why you need it, and how to implement it in code.

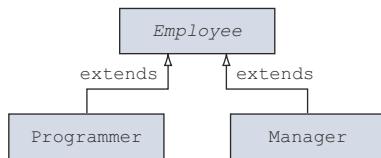
### 6.6.1 Polymorphism with classes

Polymorphism comes into the picture when a class inherits another class and both the base and the derived classes define methods with the same method signature (the same method name and method parameters). As discussed in the previous section, an object can also be referred to using a reference variable of its base class. In this case, depending upon the type of the object used to execute a method, the Java runtime executes the method defined in the base or derived class.

Let’s consider polymorphism using the classes Employee, Programmer, and Manager, where the classes Programmer and Manager inherit the class Employee. Figure 6.21 shows a UML diagram depicting the relationships among these classes.

Let’s start with the Employee class, which is not quite sure about what must be done to start work on a project (execute method startProjectWork). Hence, the method startProjectWork is defined as an abstract method, and the class Employee is defined as an abstract class, as follows:

```
abstract class Employee {
 public void reachOffice() {
 System.out.println("reached office - Gurgaon, India");
 }
 public abstract void startProjectWork();
}
```



**Figure 6.21 Relationships among the classes Employee, Programmer, and Manager**

← Doesn't know how to work on a project

The class Programmer extends the class Employee, which essentially means that it has access to the method reachOffice defined in Employee. Programmer must also implement the abstract method startProjectWork, inherited from Employee. How do you think a programmer will typically start work on a programming project? Most probably, he will define classes and unit test them. This behavior is contained in the

definition of the class `Programmer`, which implements the method `startProjectWork`, as follows:

```
class Programmer extends Employee {
 public void startProjectWork() {
 defineClasses();
 unitTestCode();
 }
 private void defineClasses() { System.out.println("define classes"); }
 private void unitTestCode() { System.out.println("unit test code"); }
}
```

We are fortunate to have another special type of employee, a manager, who knows how to start work on a project. How do you think a manager will typically start work on a programming project? Most probably, she will meet with the customers, define a project schedule, and assign work to the team members. Here's the definition of class `Manager` that extends class `Employee` and implements the method `startProjectWork`:

```
class Manager extends Employee {
 public void startProjectWork() {
 meetingWithCustomer();
 defineProjectSchedule();
 assignRespToTeam();
 }
 private void meetingWithCustomer() {
 System.out.println("meet Customer");
 }
 private void defineProjectSchedule() {
 System.out.println("Project Schedule");
 }
 private void assignRespToTeam() {
 System.out.println("team work starts");
 }
}
```

Let's see how this method behaves with different types of employees. Here's the relevant code:

```
class PolymorphismWithClasses {
 public static void main(String[] args) {
 Employee emp1 = new Programmer();
 Employee emp2 = new Manager();
 emp1.reachOffice();
 emp2.reachOffice();
 emp1.startProjectWork();
 emp2.startProjectWork();
 }
}
```

**emp2 refers to Manager**

**Method from Programmer**

**1 emp1 refers to Programmer**

**No confusion here because reachOffice is defined only in class Employee**

**3 Method from Manager**

Here's the output of the code (blank lines added for clarity):

```
reached office - Gurgaon, India
reached office - Gurgaon, India
```

```
define classes
unit test code

meet Customer
Project Schedule
team work starts
```

The code at ❶ creates an object of the class `Programmer` and assigns it to a variable of type `Employee`. ❷ creates an object of the class `Manager` and assigns it to a variable of type `Employee`. So far, so good!

Now comes the complicated part. ❸ executes the method `reachOffice`. Because this method is defined only in the class `Employee`, there isn't any confusion and the same method executes, printing the following:

```
reached office - Gurgaon, India
reached office - Gurgaon, India
```

The code at ❹ executes the code `emp1.startProjectWork()` and calls the method `startProjectWork` defined in the class `Programmer`, because `emp1` refers to an object of the class `Programmer`. Here's the output of this method call:

```
define classes
unit test code
```

The code at ❺ executes `emp2.startProjectWork()` and calls the method `startProjectWork` defined in the class `Manager`, because `emp2` refers to an object of the class `Manager`. Here's the output of this method call:

```
meet Customer
Project Schedule
team work starts
```

Figure 6.22 illustrates this code.

As discussed in the beginning of this section, the usefulness of polymorphism lies in the ability of an object to behave in its own specific manner when the same action is passed to it. In the previous example, reference variables (`emp1` and `emp2`) of type `Employee` are used to store objects of class `Programmer` and `Manager`. When the same action—that is, method call `startProjectWork`—is invoked on these reference variables (`emp1` and `emp2`), each method call results in the method defined in the respective classes being executed.

#### POLYMORPHIC METHODS ARE ALSO CALLED OVERRIDDEN METHODS

Take a quick look at the method `startProjectWork`, as defined in the following classes `Employee`, `Programmer`, and `Manager` (only the relevant code is shown):

```
abstract class Employee {
 public abstract void startProjectWork();
}

class Programmer extends Employee {
 public void startProjectWork() {
 ...
 }
}

class Manager extends Employee {
```

```

public void startProjectWork() {
 ...
}

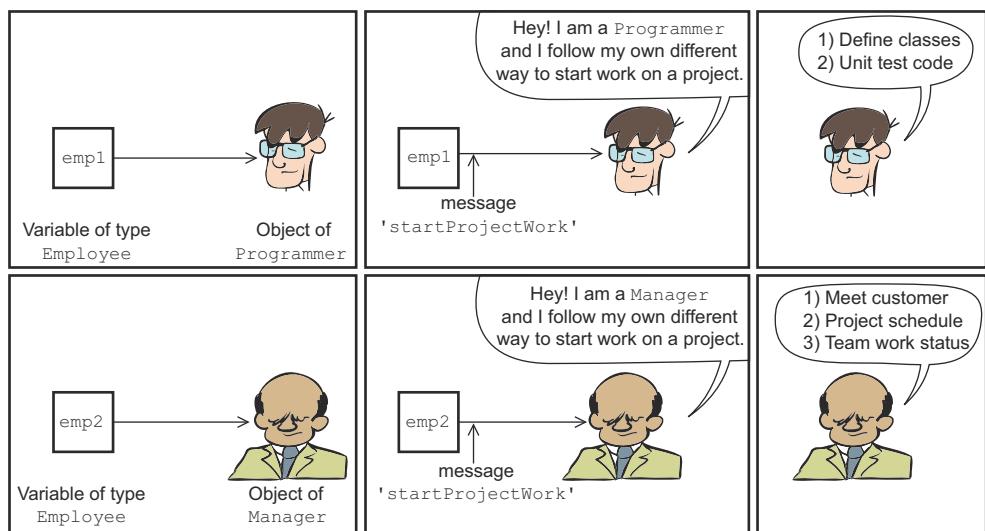
```

Method  
startProjectWork  
in class Manager

Note that the name of method `startProjectWork` is same in all these classes. Also, it accepts the same number of method arguments and defines the same return type in all the three classes: `Employee`, `Programmer`, and `Manager`. This is a contract specified to define overridden methods. Failing to use the same method name, same argument list, or same return type won't mark a method as an overridden method.

#### RULES TO REMEMBER WHEN DEFINING OVERRIDDEN METHODS

- Overridden methods are defined by classes and interfaces that share inheritance relationships.
- The name of the overridden method must be the same in both the base class and the derived class.
- The argument list passed to the overridden method must be the same in both the base class and derived class.
- The return type of an overriding method in the derived class can be the same, or a subclass of the return type of the overridden method in the base class. When the overriding method returns a subclass of the return type of the overridden method, it is known as a *covariant return type*.
- An overridden method defined in the base class can be an abstract method or a non-abstract method.
- Access modifiers for an overriding method can be the same or less restrictive than the method being overridden, but they can't be more restrictive.



**Figure 6.22** The objects are aware of their own type and execute the overridden method defined in their own class, even if a base class variable is used to refer to them.

### DO POLYMORPHIC METHODS ALWAYS HAVE TO BE ABSTRACT?

No, polymorphic methods don't always have to be abstract. You can define the class `Employee` as a concrete class and the method `startProjectWork` as a non-abstract method and still get the same results (changes in bold):

```
class Employee {
 public void reachOffice() {
 System.out.println("reached office - Gurgaon, India");
 }
 public void startProjectWork() {
 System.out.println("procure hardware");
 System.out.println("install software");
 }
}
```

Because there's no change in the definition of the rest of the classes—`Programmer`, `Manager`, and `PolymorphismWithClasses`—I haven't listed them here. If you create an object of the class `Employee` (not of any of its derived classes), you can execute the method `startProjectWork` as follows:

```
Employee emp = new Employee();
emp.startProjectWork();
```

**Object of class Employee,  
not its derived classes**

**Call method  
startProjectWork,  
defined in Employee**



**EXAM TIP** To implement polymorphism with classes, you can define abstract or non-abstract methods in the base class and override them in the derived classes.

### CAN POLYMORPHISM WORK WITH OVERLOADED METHODS?

No, polymorphism works only with overridden methods. Overridden methods have the same number and type of method arguments, whereas overloaded methods define a method argument list with either a different number or type of method parameters.

Overloaded methods only share the same name; the JRE treats them like different methods. In the case of overridden methods, the JRE decides at runtime which method should be called based on the exact type of the object on which it's called.

It's time for the next Twist in the Tale exercise. As usual, you can find the answers in the appendix.

#### Twist in the Tale 6.4

Given the following definition of classes `Employee` and `Programmer`, which of the options when inserted at `//INSERT CODE HERE//` will define the method `run` as a polymorphic method?

```
class Employee {
 //INSERT CODE HERE//
 System.out.println("Emp-run");
 return null;
}
class Programmer extends Employee{
 String run() {
 System.out.println("Programmer-run");
```

```

 return null;
 }
}
class TwistInTale4 {
 public static void main(String args[]) {
 new Programmer().run();
 }
}

a String run()
b void run(int meters)
c void run()
d int run(String race)

```

---

### 6.6.2 Binding of variables and methods at compile time and runtime

You can use reference variables of a base class to refer to an object of a derived class. But there's a major difference in how Java accesses the variables and methods for these objects. With inheritance, the instance variables bind at compile time and the methods bind at runtime.

Examine the following code:

```

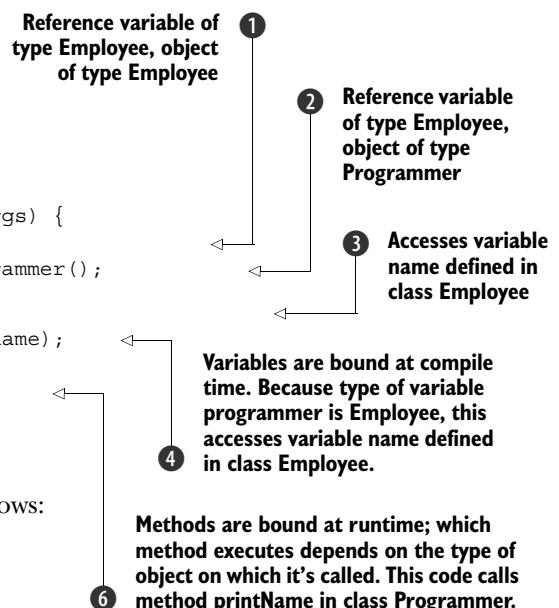
class Employee {
 String name = "Employee";
 void printName() {
 System.out.println(name);
 }
}
class Programmer extends Employee {
 String name = "Programmer";
 void printName() {
 System.out.println(name);
 }
}
class Office1 {
 public static void main(String[] args) {
 Employee emp = new Employee();
 Employee programmer = new Programmer();

 System.out.println(emp.name);
 System.out.println(programmer.name);
 emp.printName();
 programmer.printName();
 }
}

```

**Accesses method in class Employee**

5



The output of the preceding code is as follows:

```

Employee
Employee
Employee
Programmer

```

Let's see what's happening in the code, step by step:

- ① creates an object of class `Employee`, referenced by a variable of its own type—`Employee`.
- ② creates an object of class `Programmer`, referenced by a variable of its base type—`Employee`.
- ③ accesses variable `name` defined in class `Employee` and prints `Employee`.
- ④ also prints `Employee`. The type of the variable `programmer` is `Employee`. Because the variables are bound at compile time, the type of the object that's referenced by the variable `emp` doesn't make a difference. `programmer.name` will access the variable `name` defined in the class `Employee`.
- ⑤ prints `Employee`. Because the type of the reference variable `emp` and the type of object referenced by it are the same (`Employee`), there's no confusion with the method call.
- ⑥ prints `Programmer`. Even though the method `printName` is called using a reference of type `Employee`, the JRE is aware that the method is invoked on a `Programmer` object and hence executes the overridden `printName` method in the class `Programmer`.



**EXAM TIP** Watch out for code in the exam that uses variables of the base class to refer to objects of the derived class and then accesses variables and methods of the referenced object. Remember that variables bind at compile time, whereas methods bind at runtime.

### 6.6.3 Polymorphism with interfaces

Polymorphism can also be implemented using interfaces. Whereas polymorphism with classes has a class as the base class, polymorphism with interfaces requires a class to implement an interface. Polymorphism with interfaces *always* involves abstract methods from the implemented interface because interfaces can define only abstract methods.

Let's start with an example. Here's an interface, `MobileAppExpert`, which defines a method, `deliverMobileApp`:

```
interface MobileAppExpert {
 void deliverMobileApp();
}
```

As you know, all the methods defined in an interface are implicitly abstract and public. Here are the classes `Programmer` and `Manager` that implement this interface and the method `deliverMobileApp`:

```
class Employee {}
class Programmer extends Employee implements MobileAppExpert {
 public void deliverMobileApp() {
 System.out.println("testing complete on real device");
 }
}
```

```
class Manager extends Employee implements MobileAppExpert {
 public void deliverMobileApp() {
 System.out.println("QA complete");
 System.out.println("code delivered with release notes");
 }
}
```



**NOTE** I've deliberately removed the methods previously defined in `Employee`, `Programmer`, and `Manager` because they are not relevant in this section.

The relationships among the two classes and the interface are shown in figure 6.23.

In the real world, the delivery of a mobile application would have different meaning for a programmer and a manager. For a *programmer*, the delivery of a mobile application may require the completion of testing on the real mobile device. However, for a *manager*, the delivery of a mobile application may mean completing the QA process and handing over code to the client along with any release notes. The bottom line is that the same message, `deliverMobileApp`, results in the execution of different sets of steps for a programmer and a manager.

Here's a class `PolymorphismWithInterfaces` that creates objects of the classes `Programmer` and `Manager` and calls the method `deliverMobileApp`:

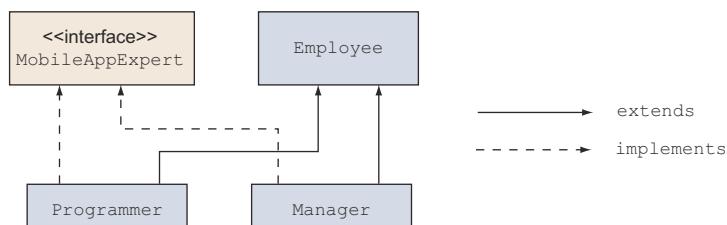
```
class PolymorphismWithInterfaces {
 public static void main(String[] args) {
 MobileAppExpert expert1 = new Programmer();
 MobileAppExpert expert2 = new Manager();
 expert1.deliverMobileApp();
 expert2.deliverMobileApp();
 }
}
```

① Reference type of variables  
expert1 and expert2 is  
MobileAppExpert

The output of the preceding code is as follows:

```
testing complete on real device
QA complete
code delivered with release notes
```

At ①, the type of the variable is `MobileAppExpert`. Because the classes `Manager` and `Programmer` implement the interface `MobileAppExpert`, a reference variable of type



**Figure 6.23 Relationships among classes `Employee`, `Programmer`, and `Manager` and the interface `MobileAppExpert`**

MobileAppExpert can also be used to store objects of the classes Programmer and Manager.

Because both these classes also extend the class Employee, you can use a variable of type Employee to store objects of the classes Programmer and Manager. But in this case you won't be able to call method deliverMobileApp because it isn't visible to the class Employee. Examine the following code:

```
class PolymorphismWithInterfaces {
 public static void main(String[] args) {
 Employee expert1 = new Programmer();
 Employee expert2 = new Manager();

 expert1.deliverMobileApp();
 expert2.deliverMobileApp();
 }
}
```

**Employee can't see  
deliverMobileApp**

**Won't compile**

Let's see what happens if we modify the class Employee to implement the interface MobileAppExpert, as follows:

```
class Employee implements MobileAppExpert {
 // code
}
interface MobileAppExpert {
 // code
}
```

Now the classes Programmer and Manager can just extend the class Employee. They no longer need to implement the interface MobileAppExpert because their base class, Employee, implements it:

```
class Programmer extends Employee {
 // code
}
class Manager extends Employee {
 // code
}
```

With the modified code, the new relationships among the classes Employee, Manager, and Programmer and the interface MobileAppExpert are shown in figure 6.24.

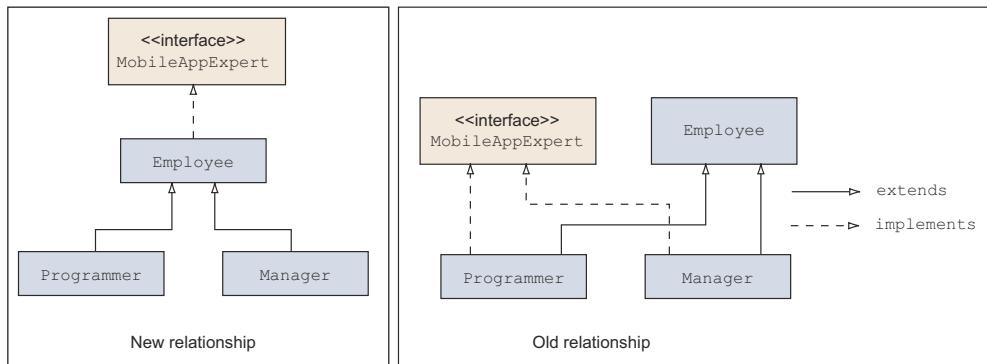
Let's try to access the method deliverMobileApp using a reference variable of type Employee class, as follows:

```
class PolymorphismWithInterfaces {
 public static void main(String[] args) {
 Employee expert1 = new Programmer();
 Employee expert2 = new Manager();

 expert1.deliverMobileApp();
 expert2.deliverMobileApp();
 }
}
```

**Employee can see  
deliverMobileApp**

**Will work!**



**Figure 6.24 Modified relationships among the classes Employee, Manager, and Programmer and the interface MobileAppExpert**

Figure 6.25 shows what's accessible to the variable `expert1`.

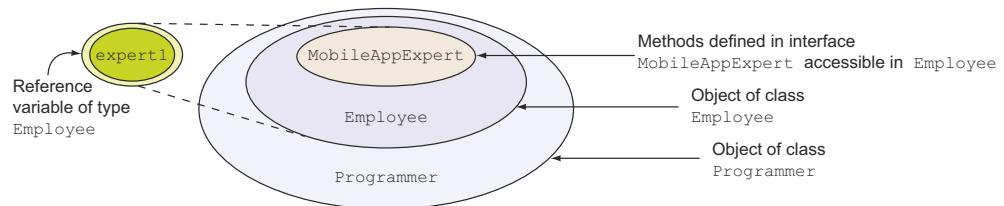


**EXAM TIP** Watch out for overloaded methods that seem to participate in polymorphism—overloaded methods don't participate in polymorphism. Only overridden methods—methods with the same method signatures—participate in polymorphism.

## 6.7 Summary

We started the chapter with a discussion of inheritance and polymorphism, using an example from everyday life: all creatures inherit properties and behavior of their parents, and the same action (such as *reproduce*) may have different meanings for different species. Inheritance enables the reuse of existing code, and it can be implemented using classes and interfaces. A class can't extend more than one class, but it can implement more than one interface. Inheriting a class is also called *subclassing*, and the inherited class is referred to as the *base* or *parent* class. A class that inherits another class or implements an interface is called a *derived class* or *subclass*.

Just as it's common to address someone using a last name or family name, an object of a derived class can be referred to with a variable of a base class or an interface that it implements. But when you refer to an object using a variable of the base class, the variable can access only the members defined in the base class. Similarly, a variable of type interface can access only the members defined in that interface. Even



**Figure 6.25 What's accessible to the variable expert1**

with this limitation, you may wish to refer to objects using variables of their base class to work with multiple objects that have common base classes.

Objects of related classes—the ones that share an inheritance relationship—can be cast to another object. You may wish to cast an object when you wish to access its members that are not available by default using the variable that's used to refer to the object.

The keywords `this` and `super` are object references and are used to access an object and its base class respectively. You can use the keyword `this` to access a class's variables, methods, and constructors. Similarly, the keyword `super` is used to access a base class's variables, methods, and constructors.

Polymorphism is the ability of objects to execute methods defined in a superclass or base class, depending upon their type. Classes that share an inheritance relationship exhibit polymorphism. The polymorphic method should be defined in both the base class and the inherited class.

You can implement polymorphism by using either classes or interfaces. In the case of polymorphism with classes, the base class can be either an abstract class or a concrete class. The method in question here also need not be an abstract method. When you implement polymorphism using interfaces, you must use an abstract method from the interface.

## 6.8 **Review notes**

Inheritance with interfaces and classes:

- A class can inherit the properties and behavior of another class.
- A class can implement multiple interfaces.
- An interface can inherit zero or more interfaces. An interface cannot inherit a class.
- Inheritance enables you to use existing code.
- Inheriting a class is also known as subclassing.
- A class that inherits another class is called a derived class or subclass.
- A class that is inherited is called a parent or base class.
- Private members of a base class cannot be inherited in the derived class.
- A derived class can only inherit members with the default access modifier if both the base class and the derived class are in the same package.
- A class uses the keyword `extends` to inherit a class.
- An interface uses the keyword `extends` to inherit another interface.
- A class uses the keyword `implements` to implement an interface.
- A class can implement multiple interfaces but can inherit only one class.
- An interface can extend multiple interfaces.
- The method signatures of a method defined in an interface and in the class that implements the interface must match; otherwise, the class won't compile.
- An abstract class can inherit a concrete class, and a concrete class can inherit an abstract class.

Reference variable and object types:

- With inheritance, you can also refer to an object of a derived class using a variable of a base class or interface.
- An object of a base class can't be referred to using a reference variable of its derived class.
- When an object is referred to by a reference variable of a base class, the reference variable can only access the variables and members that are defined in the base class.
- When an object is referred to by a reference variable of an interface implemented by a class, the reference variable can access only the variables and methods defined in the interface.
- You may need to access an object of a derived class using a reference variable of the base class to group and use all the classes with common parent classes or interfaces.

The need for casting:

- Casting is the process of forcefully making a variable behave as a variable of another type.
- If the class Manager extends the class Employee, and a reference variable emp of type Employee is used to refer to an object of the class Manager, ((Manager) emp) will cast the variable emp to Manager.

Using super and this to access objects and constructors:

- Keywords super and this are object references. These variables are defined and initialized by the JVM for every object in its memory.
- The this reference always points to an object's *own instance*.
- You can use the keyword this to refer to all methods and variables that are accessible to a class.
- If a method defines a local variable or method parameter with the same name as an instance variable, the keyword this must be used to access the instance variable in the method.
- You can call one constructor from another constructor by using the keyword this.
- super, an object reference, refers to the parent class or the base class of a class.
- The reference variable super can be used to access a variable or method from the base class if there is a clash of these names. This situation normally occurs when a derived class defines variables and methods with the same names as in the base class.
- The reference variable super can also be used to refer to the constructors of the base class in a derived class.

Polymorphism with classes:

- The literal meaning of the word “polymorphism” is “many forms.”
- In Java, polymorphism comes into the picture when there’s an inheritance relationship between classes, and both the base and derived classes define methods with the same name.
- The polymorphic methods are also called *overridden methods*.
- Overridden methods should define methods with the same name, same argument list, same list of method parameters. The return type of the overriding method can be the same, or a subclass of the return type of the overridden method in the base class, which is also known as covariant return type.
- Access modifiers for an overriding method can be the same or less restrictive but can’t be more restrictive than the method being overridden.
- A derived class is said to override a method in the base class if it defines a method with the same name, same parameter list, and same return type as in the derived class.
- If a method defined in a base class is overloaded in the derived classes, then these two methods (in the base class and the derived class) are not called polymorphic methods.
- When implementing polymorphism with classes, a method defined in the base class may or may not be abstract.
- When implementing polymorphism with interfaces, a method defined in the base interface is always abstract.

## 6.9 Sample exam questions

**Q6-1.** What is the output of the following code?

```
class Animal {
 void jump() { System.out.println("Animal"); }
}
class Cat extends Animal {
 void jump(int a) { System.out.println("Cat"); }
}
class Rabbit extends Animal {
 void jump() { System.out.println("Rabbit"); }
}
class Circus {
 public static void main(String args[]) {
 Animal cat = new Cat();
 Rabbit rabbit = new Rabbit();
 cat.jump();
 rabbit.jump();
 }
}

a Animal
Rabbit
```

- b** Cat  
Rabbit
- c** Animal  
Animal
- d** None of the above

**Q6-2.** Given the following code, select the correct statements:

```
class Flower {
 public void fragrance() {System.out.println("Flower"); }
}
class Rose {
 public void fragrance() {System.out.println("Rose"); }
}
class Lily {
 public void fragrance() {System.out.println("Lily"); }
}
class Bouquet {
 public void arrangeFlowers() {
 Flower f1 = new Rose();
 Flower f2 = new Lily();
 f1.fragrance();
 }
}
```

- a** The output of the code is:

Flower

- b** The output of the code is:

Rose

- c** The output of the code is:

Lily

- d** The code fails to compile.

**Q6-3.** Examine the following code and select the correct method declaration to be inserted at // INSERT CODE HERE:

```
interface Movable {
 void move();
}
class Person implements Movable {
 public void move() { System.out.println("Person move"); }
}
class Vehicle implements Movable {
 public void move() { System.out.println("Vehicle move"); }
}
class Test {
 // INSERT CODE HERE
 movable.move();
}
```

```

a void walk(Movable movable) {
b void walk(Person movable) {
c void walk(Vehicle movable) {
d void walk() {

```

**Q6-4.** Select the correct statements:

- a Only an abstract class can be used as a base class to implement polymorphism with classes.
- b Polymorphic methods are also called overridden methods.
- c In polymorphism, depending on the exact type of object, the JVM executes the appropriate method at compile time.
- d None of the above.

**Q6-5.** Given the following code, select the correct statements:

```

class Person {}
class Employee extends Person {}
class Doctor extends Person {}

```

- a The code exhibits polymorphism with classes.
- b The code exhibits polymorphism with interfaces.
- c The code exhibits polymorphism with classes and interfaces.
- d None of the above.

**Q6-6.** Which of the following statements are true?

- a Inheritance enables you to reuse existing code.
- b Inheritance saves you from having to modify common code in multiple classes.
- c Polymorphism passes special instructions to the compiler so that the code can run on multiple platforms.
- d Polymorphic methods cannot throw exceptions.

**Q6-7.** Given the following code, which of the options are true?

```

class Satellite {
 void orbit() {}
}
class Moon extends Satellite {
 void orbit() {}
}
class ArtificialSatellite extends Satellite {
 void orbit() {}
}

```

- a The method orbit defined in the classes Satellite, Moon, and Artificial-Satellite is polymorphic.
- b Only the method orbit defined in the classes Satellite and Artificial-Satellite is polymorphic.

- c Only the method `orbit` defined in the class `ArtificialSatellite` is polymorphic.
- d None of the above.

**Q6-8.** Examine the following code:

```
class Programmer {
 void print() {
 System.out.println("Programmer - Mala Gupta");
 }
}
class Author extends Programmer {
 void print() {
 System.out.println("Author - Mala Gupta");
 }
}
class TestEJava {
 Programmer a = new Programmer();
 // INSERT CODE HERE
 a.print();
 b.print();
}
```

Which of the following lines of code can be individually inserted at `//INSERT CODE HERE` so that the output of the code is as follows:

Programmer - Mala Gupta  
Author - Mala Gupta

- a `Programmer b = new Programmer();`
- b `Programmer b = new Author();`
- c `Author b = new Author();`
- d `Author b = new Programmer();`
- e `Programmer b = ((Author)new Programmer());`
- f `Author b = ((Author)new Programmer());`

**Q6-9.** Given the following code, which of the options, when applied individually, will make it compile successfully?

```
Line1> interface Employee {}
Line2> interface Printable extends Employee {
Line3> String print();
Line4> }
Line5> class Programmer {
Line6> String print() { return("Programmer - Mala Gupta"); }
Line7> }
Line8> class Author extends Programmer implements Printable, Employee {
Line9> String print() { return("Author - Mala Gupta"); }
Line10> }
```

- a Modify code on line 2 to: `interface Printable{`
- b Modify code on line 3 to: `publicStringprint();`

- c Define the accessibility of the print methods to public on lines 6 and 9.
- d Modify code on line 8 so that it implements only the interface Printable.

**Q6-10.** What is the output of the following code?

```
class Base {
 String var = "EJava";
 void printVar() {
 System.out.println(var);
 }
}
class Derived extends Base {
 String var = "Guru";
 void printVar() {
 System.out.println(var);
 }
}
class QReference {
 public static void main(String[] args) {
 Base base = new Base();
 Base derived = new Derived();

 System.out.println(base.var);
 System.out.println(derived.var);
 base.printVar();
 derived.printVar();
 }
}
```

- a EJava  
EJava  
EJava  
Guru
- b EJava  
Guru  
EJava  
Guru
- c EJava  
EJava  
EJava  
EJava
- d EJava  
Guru  
Guru  
Guru

## 6.10 Answers to sample exam questions

**Q6-1.** What is the output of the following code?

```
class Animal {
 void jump() { System.out.println("Animal"); }
}
class Cat extends Animal {
 void jump(int a) { System.out.println("Cat"); }
```

```

}
class Rabbit extends Animal {
 void jump() { System.out.println("Rabbit"); }
}
class Circus {
 public static void main(String args[]) {
 Animal cat = new Cat();
 Rabbit rabbit = new Rabbit();
 cat.jump();
 rabbit.jump();
 }
}

a Animal
Rabbit

b Cat
Rabbit

c Animal
Animal

d None of the above

```

Answer: a

**Explanation:** Although the classes `Cat` and `Rabbit` seem to override the method `jump`, the class `Cat` doesn't override the method `jump()` defined in the class `Animal`. The class `Cat` defines a method parameter with the method `jump`, which makes it an overloaded method, not an overridden method. Because the class `Cat` extends the class `Animal`, it has access to the following two overloaded `jump` methods:

```

void jump() { System.out.println("Animal"); }
void jump(int a) { System.out.println("Cat"); }

```

The following line of code creates an object of class `Cat` and assigns it to a variable of type `Animal`:

```
Animal cat = new Cat();
```

When you call the method `jump` on the previous object, it executes the method `jump`, which doesn't accept any method parameters, printing the following value:

```
Animal
```

The following code will also print `Animal` and not `Cat`:

```
Cat cat = new Cat();
cat.jump();
```

**Q6-2.** Given the following code, select the correct statements:

```

class Flower {
 public void fragrance() {System.out.println("Flower"); }
}
class Rose {
 public void fragrance() {System.out.println("Rose"); }
}

```

```

class Lily {
 public void fragrance() {System.out.println("Lily"); }
}
class Bouquet {
 public void arrangeFlowers() {
 Flower f1 = new Rose();
 Flower f2 = new Lily();
 f1.fragrance();
 }
}

```

- a The output of the code is:

Flower

- b The output of the code is:

Rose

- c The output of the code is:

Lily

- d **The code fails to compile.**

Answer: d

Explanation: Although the code seems to implement polymorphism using classes, note that neither of the classes Rose or Lily *extends* the class Flower. Hence, a variable of type Flower can't be used to store objects of the classes Rose or Lily. The following lines of code will fail to compile:

```

Flower f1 = new Rose();
Flower f2 = new Lily();

```

**Q6-3.** Examine the following code and select the correct method declaration to be inserted at // INSERT CODE HERE:

```

interface Movable {
 void move();
}
class Person implements Movable {
 public void move() { System.out.println("Person move"); }
}
class Vehicle implements Movable {
 public void move() { System.out.println("Vehicle move"); }
}
class Test {
 // INSERT CODE HERE
 movable.move();
}
}

a void walk(Movable movable) {
b void walk(Person movable) {
c void walk(Vehicle movable) {
d void walk() {

```

Answer: a, b, c

Explanation: You need to insert code in the class Test that makes the following line of code work:

```
movable.move();
```

Hence, option (d) is incorrect. Because class Test doesn't define any instance methods, the only way that the question's line of code can execute is when a method parameter movable is passed to the method walk.

Option (a) is correct. Because the interface Movable defines the method move, you can pass a variable of its type to the method move.

Option (b) is correct. Because the class Person implements the interface Movable and defines the method move, you can pass a variable of its type to the method walk. With this version of the method walk, you can pass it an object of the class Person or any of its subclasses.

Option (c) is correct. Because the class Vehicle implements the interface Movable and defines the method move, you can pass a variable of its type to the method walk. With this version of method walk, you can pass it an object of the class Vehicle or any of its subclasses.

**Q6-4.** Select the correct statements:

- a Only an abstract class can be used as a base class to implement polymorphism with classes.
- b **Polymorphic methods are also called overridden methods.**
- c In polymorphism, depending on the exact type of object, the JVM executes the appropriate method at compile time.
- d None of the above.

Answer: b

Option (a) is incorrect. To implement polymorphism with classes, either an abstract class or a concrete class can be used as a base class.

Option (c) is incorrect. First of all, no code execution takes place at compile time. Code can only execute at runtime. In polymorphism, the determination of the exact method to execute is deferred until runtime and is determined by the exact type of the object on which a method needs to be called.

**Q6-5.** Given the following code, select the correct statements:

```
class Person {}
class Employee extends Person {}
class Doctor extends Person {}
```

- a The code exhibits polymorphism with classes.
- b The code exhibits polymorphism with interfaces.
- c The code exhibits polymorphism with classes and interfaces.
- d **None of the above.**

Answer: d

Explanation: The given code does not define any method in the class Person that is redefined or implemented in the classes Employee and Doctor. Though the classes Employee and Doctor extend the class Person, all these three polymorphism concepts or design principles are based on a method, which is missing in these classes.

**Q6-6.** Which of the following statements are true?

- a Inheritance enables you to reuse existing code.
- b Inheritance saves you from having to modify common code in multiple classes.
- c Polymorphism passes special instructions to the compiler so that the code can run on multiple platforms.
- d Polymorphic methods cannot throw exceptions.

Answer: a, b

Explanation: Option (a) is correct. Inheritance can allow you to reuse existing code by extending a class. In this way, the functionality that is already defined in the base class need not be defined in the derived class. The functionality offered by the base class can be accessed in the derived class as if it were defined in the derived class.

Option (b) is correct. Common code can be placed in the base class, which can be extended by all the derived classes. If any changes need to be made to this common code, it can be modified in the base class. The modified code will be accessible to all the derived classes.

Option (c) is incorrect. Polymorphism doesn't pass any special instructions to the compiler to make the Java code execute on multiple platforms. Java code can execute on multiple platforms because the Java compiler compiles to virtual machine code, which is platform-neutral. Different platforms implement this virtual machine.

Option (d) is incorrect. Polymorphic methods can throw exceptions.

**Q6-7.** Given the following code, which of the options are true?

```
class Satellite {
 void orbit() {}
}
class Moon extends Satellite {
 void orbit() {}
}
class ArtificialSatellite extends Satellite {
 void orbit() {}
}
```

- a The method orbit defined in the classes Satellite, Moon, and Artificial-Satellite is polymorphic.
- b Only the method orbit defined in the classes Satellite and Artificial-Satellite is polymorphic.
- c Only the method orbit defined in the class ArtificialSatellite is polymorphic.
- d None of the above.

Answer: a

Explanation: All of these options define classes. When methods with the same method signature are defined in classes that share an inheritance relationship, the methods are considered polymorphic.

**Q6-8.** Examine the following code:

```
class Programmer {
 void print() {
 System.out.println("Programmer - Mala Gupta");
 }
}
class Author extends Programmer {
 void print() {
 System.out.println("Author - Mala Gupta");
 }
}
class TestEJava {
 Programmer a = new Programmer();
 // INSERT CODE HERE
 a.print();
 b.print();
}
```

Which of the following lines of code can be individually inserted at //INSERT CODE HERE so that the output of the code is as follows:

Programmer - Mala Gupta  
Author - Mala Gupta

- a Programmer b = new Programmer();
- b **Programmer b = new Author();**
- c **Author b = new Author();**
- d Author b = new Programmer();
- e Programmer b = ((Author) new Programmer());
- f Author b = ((Author) new Programmer());

Answer: b, c

Explanation: Option (a) is incorrect. This code will compile, but because both the reference variable and object are of type `Programmer`, calling `print` on this object will print `Programmer - Mala Gupta`, not `Author - Mala Gupta`.

Option (d) is incorrect. This code will not compile. You can't assign an object of a base class to a reference variable of a derived class.

Option (e) is incorrect. This line of code will compile successfully, but it will fail at runtime with a `ClassCastException`. An object of a base class can't be cast to an object of its derived class.

Option (f) is incorrect. The expression `((Author) new Programmer())` is evaluated before it can be assigned to a reference variable of type `Author`. This line of code also tries to cast an object of the base class—`Programmer`—to an object of its derived

class—Author. This code will also compile successfully but will fail at runtime with a `ClassCastException`. Using a reference variable of type `Author` won't make a difference here.

**Q6-9.** Given the following code, which of the options, when applied individually, will make it compile successfully?

```

Line1> interface Employee {}
Line2> interface Printable extends Employee {
Line3> String print();
Line4> }
Line5> class Programmer {
Line6> String print() { return("Programmer - Mala Gupta"); }
Line7> }
Line8> class Author extends Programmer implements Printable, Employee {
Line9> String print() { return("Author - Mala Gupta"); }
Line10> }

```

- a Modify code on line 2 to: `interface Printable {`
- b Modify code on line 3 to: `public String print();`
- c **Define the accessibility of the print methods to public on lines 6 and 9.**
- d Modify code on line 8 so that it implements only the interface `Printable`.

Answer: c

Explanation: The methods in an interface are implicitly `public`. A non-abstract class that implements an interface must implement all the methods defined in the interface. While overriding or implementing the methods, the accessibility of the implemented method must be `public`. An overriding method can't be assigned a weaker access privilege than `public`.

Option (a) is incorrect. There are no issues with the interface `Printable` extending the interface `Employee` and the class `Author` implementing both of these interfaces.

Option (b) is incorrect. Adding the access modifier to the method `print` on line 3 will not make any difference to the existing code. The methods defined in an interface are implicitly `public`.

Option (d) is incorrect. There are no issues with a class implementing two interfaces when one of the interfaces extends the other interface.

**Q6-10.** What is the output of the following code?

```

class Base {
 String var = "EJava";
 void printVar() {
 System.out.println(var);
 }
}
class Derived extends Base {
 String var = "Guru";
 void printVar() {

```

```

 System.out.println(var);
 }
}
class QReference {
 public static void main(String[] args) {
 Base base = new Base();
 Base derived = new Derived();

 System.out.println(base.var);
 System.out.println(derived.var);
 base.printVar();
 derived.printVar();
 }
}

a EJava
EJava
EJava
Guru

b EJava
Guru
EJava
Guru

c EJava
EJava
EJava
EJava

d EJava
Guru
Guru
Guru

```

Answer: a

Explanation: With inheritance, the instance variables bind at compile time and the methods bind at runtime. The following line of code refers to an object of the class `Base`, using a reference variable of type `Base`. Hence, both of the following lines of code print `EJava`:

```
System.out.println(base.var);
base.printVar();
```

But the following line of code refers to an object of the class `Derived` using a reference variable of type `Base`:

```
Base derived = new Derived();
```

Because the instance variables bind at compile time, the following line of code accesses and prints the value of the instance variable defined in the class `Base`:

```
System.out.println(derived.var); // prints EJava
```

In `derived.printVar()`, even though the method `printVar` is called using a reference of type `Base`, the JVM is aware that the method is invoked on a `Derived` object and so executes the overridden `printVar` method in the class `Derived`.



# *Exception handling*

| Exam objectives covered in this chapter                                                | What you need to know                                                                                                                                                                                                          |
|----------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [8.3] Describe what exceptions are used for in Java.                                   | Need for the exception handlers; their advantages and disadvantages.                                                                                                                                                           |
| [8.1] Differentiate among checked exceptions, RuntimeExceptions, and Errors.           | Differences and similarities between checked exceptions, RuntimeExceptions, and Errors.                                                                                                                                        |
| [8.2] Create a try-catch block and determine how exceptions alter normal program flow. | Differences and similarities in the way these exceptions and errors are handled in code.                                                                                                                                       |
| [8.4] Invoke a method that throws an exception.                                        | How to create a try-catch-finally block. Understand the flow of code when the enclosed code throws an exception or error.                                                                                                      |
|                                                                                        | How to create nested try-catch-finally blocks.                                                                                                                                                                                 |
| [8.5] Recognize common exception classes and categories.                               | How to determine the flow of control when an invoked method throws an exception. How to apply this to cases when it's thrown without a try block, and from a try block (with appropriate and insufficient exception handlers). |
|                                                                                        | The difference in calling methods that throw or don't throw exceptions.                                                                                                                                                        |
|                                                                                        | Common exception classes and categories, and how to recognize the code that can throw these exceptions and handle them appropriately.                                                                                          |

Imagine you're about to board an airplane to Geneva to attend an important conference. At the last minute, you learn that the flight has been cancelled because the pilot isn't feeling well. Fortunately, the airline quickly arranges for an alternative pilot, allowing the flight to take off at its originally scheduled time. What a relief.

This example illustrates how exceptional conditions can modify the initial flow of an action and demonstrates the need to handle those conditions appropriately. In Java, an exceptional condition (like the illness of a pilot) can affect the normal code flow (airline flight operation). In this context, the arrangement for an alternative pilot can be compared to an exception handler.

Depending on the nature of the exceptional condition, you may or may not be able to recover completely. For example, would airline management have been able to get your flight off the ground if instead an earthquake had damaged much of the airport?

In the exam, you'll be asked similar questions with respect to Java code and exceptions. With that in mind, this chapter covers the following:

- Understanding and identifying exceptions arising in code
- Determining how exceptions alter the normal program flow
- Understanding the need to handle exceptions separately in your code
- Using try-catch-finally blocks to handle exceptions
- Differentiating among checked exceptions, unchecked exceptions, and errors
- Invoking methods that may throw exceptions
- Recognizing common exception categories and classes

You might feel like we're covering a lot in this chapter, but remember that we aren't going to delve into too much background information because we assume you already know the definitions and uses of classes and methods, class inheritance, arrays, and ArrayLists. Our focus in this chapter will be on the exam objectives and what you need to know about exceptions.

In this chapter, I won't discuss a try statement with multiple catch clauses, automatic closing of resources with a try-with-resources statement, or the creation of custom exceptions. These topics are covered in the next level of Java certification (in the OCP Java SE 7 Programmer II exam).

## 7.1 Exceptions in Java



[8.3] Describe what exceptions are used for in Java

In this section, you'll learn what exceptions are in Java, why you need to handle exceptions separately from the main code, and all about their advantages and disadvantages.

### 7.1.1 A taste of exceptions

In figure 7.1, do you think the code in bold in the classes `ArrayAccess`, `OpenFile`, and `MethodAccess` have anything in common?

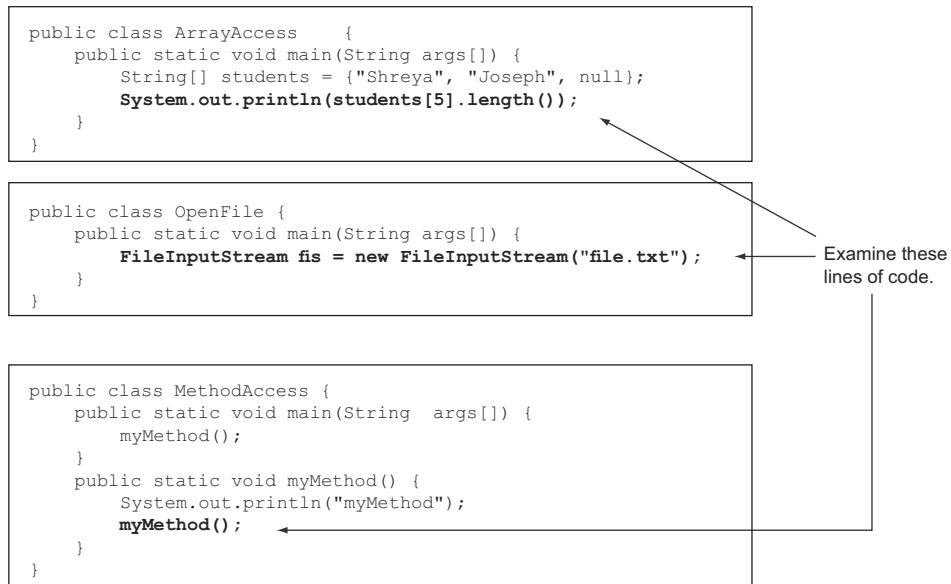


Figure 7.1 Getting a taste of exceptions in Java

I'm sure, given this chapter's title, that this question was easy to answer. Each of these three statements is associated with throwing an exception or an error. Let's look at them individually:

- *Class ArrayAccess*—Because the length of the array `students` is 3, trying to access the element at array position 5 is an exceptional condition, as shown in figure 7.2.
- *Class OpenFile*—The constructor of the class `FileInputStream` throws a checked exception `FileNotFoundException` (as shown in figure 7.3). If you try to compile this code without enclosing it within a `try` block or *catching* this exception, your code will fail to compile. (I'll discuss checked exceptions in detail in section 7.3.2.)
- *Class MethodAccess*—As you can see in figure 7.4, the method `myMethod` calls itself recursively, without specifying an exit condition. These recursive calls result in a `StackOverflowError` at runtime.

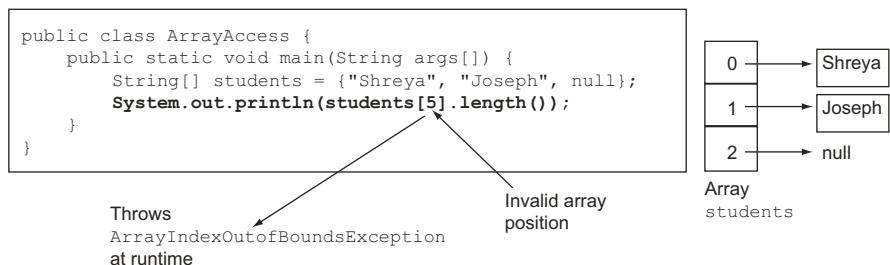
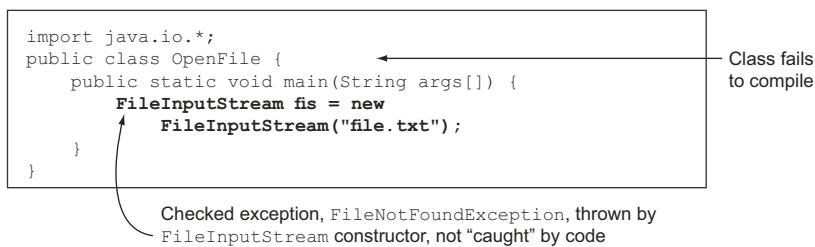
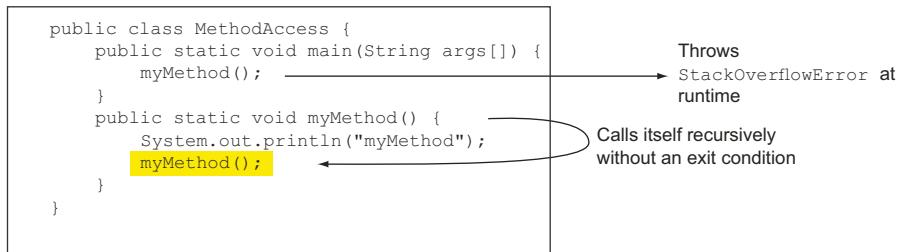


Figure 7.2 An example of `ArrayIndexOutOfBoundsException`



**Figure 7.3 An example of `FileNotFoundException`**



**Figure 7.4 An example of `StackOverflowError`**

These examples of exceptions are typical of what you’ll find on the OCA Java SE 7 Programmer I exam. Let’s move on and explore exceptions and their handling in Java so that you can spot code that throws exceptions and handles them accordingly.

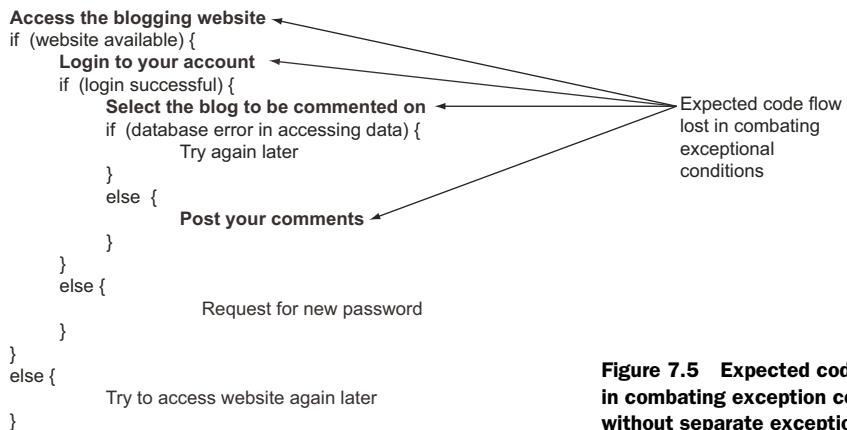
## File I/O in Java

File I/O isn’t covered in the OCA Java SE 7 Programmer I exam, but you may notice it mentioned in questions related to exception handling. I’ll cover it quickly here just to the extent that it’s required for this exam.

File I/O involves multiple classes that enable you to read data from and write it to a source. This data source can be persistent storage, memory, or even network connections. Data can be read and written as streams of binary or character data. Some file I/O classes only read data from a source, some write data to a source, and some do both.

In this chapter, you’ll work with three classes from the file I/O API: `java.io.File`, `java.io.FileInputStream`, and `java.io.FileOutputStream`. `File` is an abstract representation of file and directory pathnames. You can open a `File` and then read from and write to it. A `FileInputStream` obtains input bytes using an object of class `File`. It defines the methods `read` to read bytes and `close` to close this stream. A `FileOutputStream` is an output stream for writing data to a `File`. It defines the methods `write` to write bytes and `close` to close this stream.

Creating an object of class `File` can throw the checked exception `java.io.FileNotFoundException`. The methods `read`, `write`, and `close` defined in classes `FileInputStream` and `FileOutputStream` can throw the checked exception `java.io.IOException`. Note that `FileNotFoundException` subclasses `IOException`.



**Figure 7.5** Expected code flow lost in combating exception conditions, without separate exception handlers

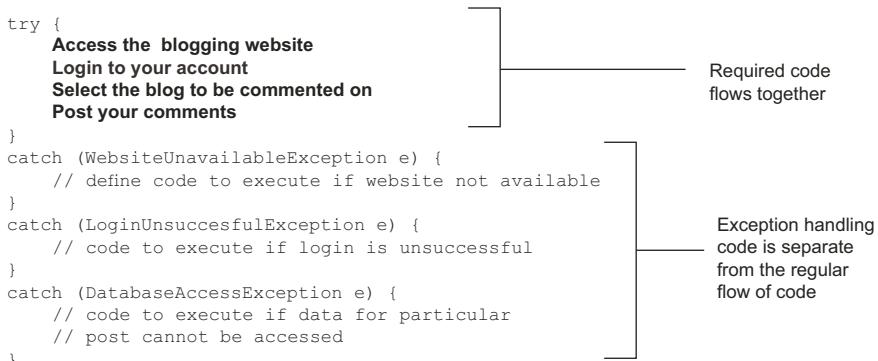
### 7.1.2 Why handle exceptions separately?

Imagine you want to post some comments on a blogging website. To make a comment, you must complete the following steps:

- a Access the blogging website.
- b Log into your account.
- c Select the blog you want to comment on.
- d Post your comments.

The preceding list might seem like an ideal set of steps. In actual conditions, you may have to verify whether you've completed a previous step before you can progress with the next step. Figure 7.5 modifies the previous steps.

The modified logic (figure 7.5) requires the code to check conditions before a user can continue with the next step. This checking of conditions at multiple places introduces new steps for users and also new paths of execution of the original steps. The difficult part of these modified paths is that they may leave users confused about the steps involved in the tasks they're trying to accomplish. Figure 7.6 shows how exception handling can help.



**Figure 7.6** Defining exception-handling code separate from the main code logic

The code in figure 7.6 defines the original steps required to post comments to a blog, along with some exception-handling code. Because the exception handlers are defined separately, any confusion with what steps you need to accomplish to post comments on the website has been clarified. Additionally, this code doesn't compromise on checking the completion of a step before moving on to the next step, courtesy of appropriate exception handlers.

### 7.1.3 Do exceptions offer any other benefits?

Apart from separating concerns between defining the regular program logic and the exception handling code, exceptions also can help pinpoint the offending code (code that throws an exception), together with the method in which it is defined, by providing a stack trace of the exception or error. An example:

```
public class Trace {
 public static void main(String args[]) { // line 1
 method1(); // line 2
 } // line 3
 public static void method1() { // line 4
 method2(); // line 5
 } // line 6
 public static void method2() { // line 7
 String[] students = {"Shreya", "Joseph"}; // line 8
 System.out.println(students[5]); // line 9
 } // line 10
} // line 11
} // line 12
```

`method2()` tries to access the array element of `students` at index 5, which is an invalid index for array `students`, so the code throws the exception `ArrayIndexOutOfBoundsException` at runtime. Figure 7.7 shows the stack trace when this exception is thrown. It includes the runtime exception message and the list of methods that were involved in calling the code that threw the exception, starting from the entry point of this application, the `main` method. You can match the line numbers specified in the stack trace in figure 7.7 to the line numbers in the code.



**NOTE** The stack trace gives you a trace of the methods that were called when the JVM encountered an unhandled exception. Stack traces are read from the bottom. In figure 7.7, the trace starts with the `main` method (last line of the stack trace) and continues up to the method containing the code that threw the exception. Depending on the complexity of your code, a stack trace can

```
Exception in thread "main"
java.lang.ArrayIndexOutOfBoundsException: 5
 at Trace.method2(Trace.java:10) ← Offending code in method2 (line 10)
 at Trace.method1(Trace.java:6) ← method2 called by method1 (line 6)
 at Trace.main(Trace.java:3) ← method1 called by main (line 3)
```

Figure 7.7 Tracing the line of code that threw an exception at runtime

range from a few lines to hundreds of lines of code. A stack trace works with handled and unhandled exceptions.

Let's move on and look at more details of exception propagation and at the creation of try-catch-finally blocks to take care of exceptions in code.

## 7.2 **What happens when an exception is thrown?**



- [8.2] Create a try-catch block and determine how exceptions alter normal program flow



- [8.4] Invoke a method that throws an exception

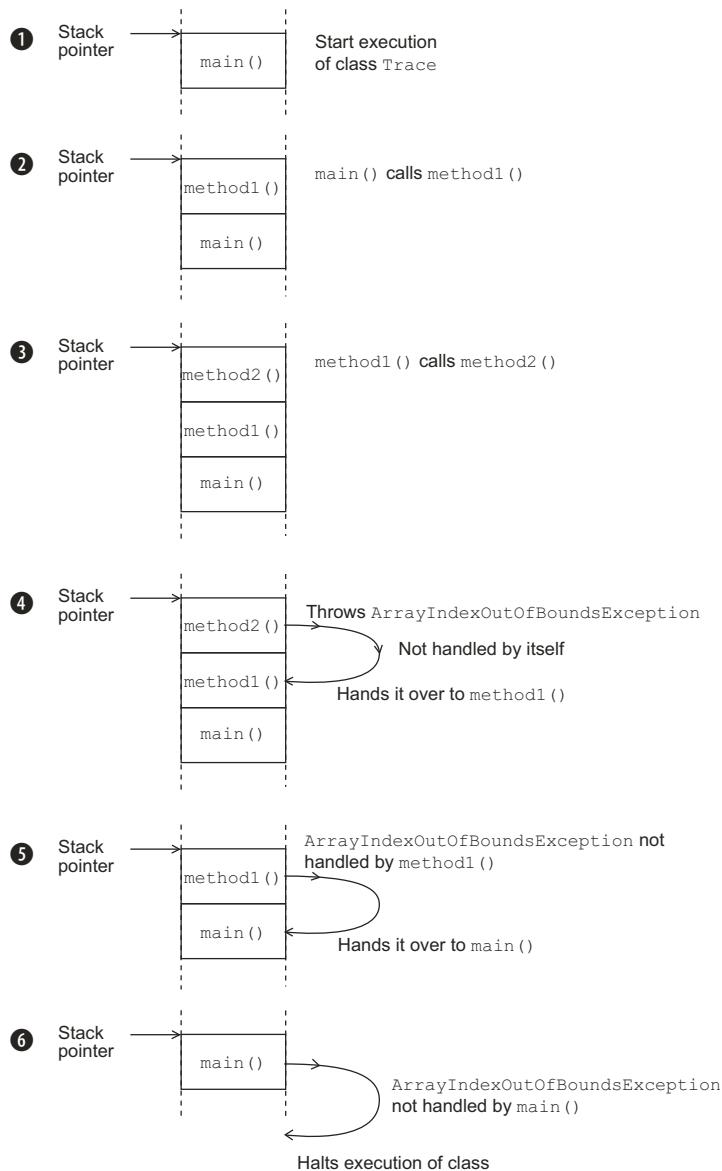
In this section, we'll uncover what happens when an exception is thrown in Java. We'll work through a lot of examples to learn how the normal flow of code is disrupted when an exception is thrown. You'll also define an alternative program flow for code that may throw exceptions.

As with all other Java objects, an exception is an object. All types of exceptions subclass `java.lang.Throwable`. When a piece of code hits an obstacle in the form of an exceptional condition, it creates an object of class `java.lang.Throwable` (at runtime an object of the most appropriate subtype is created), initializes it with the necessary information (such as its type, an optional textual description, and the offending program's state), and hands it over to the JVM. The JVM blows a siren in the form of this exception and looks for an appropriate code block that can "handle" this exception. The JVM keeps an account of all the methods that were called when it hit the offending code, so to find an appropriate exception handler it looks through all of the tracked method calls.

Re-examine the class `Trace` and the `ArrayIndexOutOfBoundsException` thrown by it, as mentioned in the previous section (7.1.3). Figure 7.8 illustrates the propagation of the exception `ArrayIndexOutOfBoundsException` thrown by `method2` through all the methods.

To understand how an exception propagates through method calls, it's important to understand how method calls work. An application starts its execution with the method `main`, and `main` may call other methods. When `main` calls another method, the called method should complete its execution before `main` can complete its own execution.

An operating system (OS) keeps track of the code that it needs to execute using a *stack*. A stack is a type of list in which the items that are added last to it are the first ones to be taken off it—Last In First Out. This stack uses a *stack pointer* to point to the instructions that the OS should execute.



**Figure 7.8 Propagation of an exception through multiple method calls**

Now that you have this basic information under your belt, here's a step-by-step discussion of exception propagation, as shown in figure 7.8:

- 1 When the method `main` starts its execution, its instructions are pushed onto the stack.
- 2 The method `main` calls the method `method1`, and instructions for `method1` are pushed onto the stack.

- 3 method1 calls method2; instructions for method2 are pushed onto the stack.
- 4 method2 throws an exception: `ArrayIndexOutOfBoundsException`. Because method2 doesn't handle this exception itself, it's passed on to the method that called it—method1.
- 5 method1 doesn't define any exception handler for `ArrayIndexOutOfBoundsException`, so it hands this exception over to its calling method—`main`.
- 6 There are no exception handlers for `ArrayIndexOutOfBoundsException` in `main`. Because there are no further methods that handle `ArrayIndexOutOfBoundsException`, execution of the class `Trace` stops.

You can use try-catch-finally blocks to define code that doesn't halt execution when it encounters an exceptional condition.

### 7.2.1 ***Creating try-catch-finally blocks***

When you work with exception handlers, you often hear the terms `try`, `catch`, and `finally`. Before you start to work with these concepts, I'll answer three simple questions:

- ***Try what?***

First you *try* to execute your code. If it doesn't execute as planned, you handle the exceptional conditions using a *catch* block.

- ***Catch what?***

You *catch* the exceptional event arising from the code enclosed within the *try* block and handle the event by defining appropriate exception handlers.

- ***What does finally do?***

*Finally*, you execute a set of code, in all conditions, regardless of whether the code in the *try* block throws any exceptions.

Let's compare a try-catch-finally block with a real-life example. Imagine you're going river rafting on your vacation. Your instructor informs you that while rafting, you *might* fall off the raft into the river while crossing the rapids. In such a condition, you should try to use your oar or the rope thrown toward you to get back into the raft. You *might* also drop your oar into the river while rowing your raft. In such a condition, you should not panic and should stay seated. Whatever happens, you're paying for this adventure sport.

Compare this to Java code:

- You can compare river rafting to a class whose methods *might* throw exceptions.
- Crossing the rapids and rowing a raft are methods that *might* throw exceptions.
- Falling off the raft and dropping your oar are the exceptions.
- The steps for getting back into the raft and not panicking are the exception handlers—code that executes when an exception arises.
- The fact that you pay for the sport, whether you stay in the boat or not, can be compared to the `finally` block.

Let's implement the previous real-life examples by defining appropriate classes and methods. To start with, here are two barebones exception classes—`FallInRiverException` and `DropOarException`—that can be thrown by methods in the class `RiverRafting`:

```
class FallInRiverException extends Exception {}
class DropOarException extends Exception {}
```



**NOTE** You can create an exception of your own—a custom exception—by extending the class `Exception` (or any of its subclasses). Although the creation of custom classes is *not* on this exam, you may see questions in the exam that create and use custom exceptions. Perhaps these are included because hardly any checked exceptions from the Java API are on this exam. Coding questions on the exam may create and use custom exceptions.

Following is a definition of class `RiverRafting`. Its methods `crossRapid` and `rowRaft` may throw exceptions of type `FallInRiverException` and `DropOarException`:

```
class RiverRafting {
 void crossRapid(int degree) throws FallInRiverException { ←
 System.out.println("Cross Rapid");
 if (degree > 10) throw new FallInRiverException(); ①
 }

 void rowRaft(String state) throws DropOarException { ←
 System.out.println("Row Raft");
 if (state.equals("nervous")) throw new DropOarException(); ②
 }
}
```

Method `crossRapid`  
may throw  
`FallInRiverException`

Method `rowRaft`  
may throw  
`DropOarException`

Method `crossRapid` at ① throws the exception `FallInRiverException`. When you call this method, you should define an exception handler for this exception. Similarly, the method `rowRaft` at ② throws the exception `DropOarException`. When you call this method, you should define an exception handler for this exception.

When you execute methods that may throw *checked exceptions* (exceptions that don't extend the class `RuntimeException`), enclose the code within a `try` block. `catch` blocks that follow a `try` block should handle all the checked exceptions thrown by the code enclosed in the `try` block (checked exceptions are covered in detail in section 7.3).

The code shown in figure 7.9 uses the class `RiverRafting` as defined previously and depicts the flow of control when the code on line 3 (`riverRafting.crossRapid(11);`) throws an exception of type `FallInRiverException`.

The example in figure 7.9 shows how exceptions alter the normal program flow. If the code on line 3 throws an exception (`FallInRiverException`), the code on lines 4 and 5 won't execute. In this case, control is transferred to the code block that handles `FallInRiverException`. Then control is transferred to the `finally` block. After the execution of the `finally` block, the code that follows the `try-catch-finally` block is executed. The output of the previous code is:

```

1> RiverRafting riverRafting = new RiverRafting();
2> try {
3> riverRafting.crossRapid(11); ←
4> riverRafting.rowRaft("happy");
5> System.out.println("Enjoy River Rafting");
6> }
7> catch (FallingRiverException e1) { ←
8> System.out.println("Get back in the raft");
9> }
10> catch (DropOarException e2) {
11> System.out.println("Do not panic");
12> }
13> finally {
14> System.out.println("Pay for the sport"); ←
15> }
16> System.out.println("After the try block"); ←

```

1. Execute code on line 3.  
**Code on line 4 and 5 won't execute if line 3 throws an exception.**  
2. Combat exception thrown by code on line 3. Execute exception handler for FallInRiverException.  
3. finally block always executes, whether line 3 throws any exception or not.  
4. Control transfers to the statement following the try-catch-finally block.

Figure 7.9 Modified flow of control when an exception is thrown

Cross Rapid  
Get back in the raft  
Pay for the sport  
After the try block

If you modify the previous example code as follows, no exceptions are thrown by the code on line 3 (modifications in bold):

```

class TestRiverRafting {
 public static void main(String args[]) {
 RiverRafting riverRafting = new RiverRafting();
 try {
 riverRafting.crossRapid(7);
 riverRafting.rowRaft("happy");
 System.out.println("Enjoy River Rafting");
 }
 catch (FallInRiverException e1) {
 System.out.println("Get back in the raft");
 }
 catch (DropOarException e2) {
 System.out.println("Do not panic");
 }
 finally {
 System.out.println("Pay for the sport");
 }
 System.out.println("After the try block");
 }
}

```

No exceptions thrown by this line of code

The output of the previous code is as follows:

Cross Rapid  
Row Raft  
Enjoy River Rafting  
Pay for the sport  
After the try block

What do you think the output of the code would be if the method `rowRaft` threw an exception? Try it for yourself!



**EXAM TIP** The `finally` block executes regardless of whether the `try` block throws an exception.

#### SINGLE TRY BLOCK, MULTIPLE CATCH BLOCKS, AND A FINALLY BLOCK

For a `try` block, you can define multiple catch blocks, but only a single `finally` block. Multiple catch blocks are used to handle different types of exceptions. A `finally` block is used to define *cleanup* code—code that closes and releases resources, such as file handlers and database or network connections.

When it comes to code, it makes sense to verify a concept by watching it in action. Let's work through a simple example so that you can better understand how to use the `try-catch-finally` block.

In listing 7.1, the constructor of the class `FileInputStream` may throw a `FileNotFoundException`, and calling the method `read` on an object of `FileInputStream`, such as `fis`, may throw an `IOException`.

#### Listing 7.1 Code flow with multiple catch statements and a finally block

```
import java.io.*;
public class MultipleExceptions {
 public static void main(String args[]) {
 FileInputStream fis = null;
 try {
 fis = new FileInputStream("file.txt");
 System.out.println("File Opened");
 fis.read();
 System.out.println("Read File ");
 }
 catch (FileNotFoundException fnfe) {
 System.out.println("File not found");
 }
 catch (IOException ioe) {
 System.out.println("File Closing Exception");
 }
 finally {
 System.out.println("finally");
 }
 System.out.println("Next task..");
 }
}
```

May throw  
`FileNotFoundException`

May throw  
`IOException`

Positioning of  
catch and  
finally blocks  
can't be  
interchanged

Table 7.1 compares the code output that occurs depending on whether the system is able or unable to open (and read) `file.txt`.

In either of the cases described in table 7.1, the `finally` block executes, and after its execution, control is transferred to the statement following the `try-catch` block. Here's the output of the class `MultipleExceptions` if none of its code throws an exception:

**Table 7.1 Output of code in listing 7.1 when the system is unable to open file.txt and when the system is able to open file.txt but unable to read it**

| <b>Output if the system is unable to open file.txt</b> | <b>Output if the system is able to open file.txt, but unable to read it</b> |
|--------------------------------------------------------|-----------------------------------------------------------------------------|
| <pre>File not found finally Next task..</pre>          | <pre>File Opened File Closing Exception finally Next task..</pre>           |

```
File Opened
Read File
finally
Next task..
```

It's time now to attempt this chapter's first Twist in the Tale exercise. When you execute the code in this exercise, you'll understand what happens when you change the placement of the exception handlers (answers are in the appendix).

### Twist in the Tale 7.1

Let's modify the placement of the `finally` block in listing 7.1 and see what happens.

Given that `file.txt` doesn't exist on your system, what is the output of the following code?

```
import java.io.*;
public class MultipleExceptions {
 public static void main(String args[]) {
 FileInputStream fis = null;
 try {
 fis = new FileInputStream("file.txt");
 System.out.println("File Opened");
 fis.read();
 System.out.println("Read File");
 }
 finally {
 System.out.println("finally");
 }
 catch (FileNotFoundException fnfe) {
 System.out.println("File not found");
 }
 catch (IOException ioe) {
 System.out.println("File Closing Exception");
 }
 System.out.println("Next task..");
 }
}
```

- a The code prints

```
File not found
finally
Next task..
```

- b The code prints

```
File Opened
File Closing Exception
finally
Next task...
```

- c The code prints File not found
- d The code fails to compile

In the remainder of this section, we'll look at some frequently asked questions on try-catch-finally blocks that often overwhelm certification aspirants.

### **7.2.2 Will a finally block execute even if the catch block defines a return statement?**

Image the following scenario: a guy promises to buy diamonds for his girlfriend and treat her to coffee. The girl inquires about what will happen if he meets with an exceptional condition during the diamond purchase, such as inadequate funds. To the girl's disappointment, the boy replies that he'll still treat her to coffee.

You can compare the try block to the purchase of diamonds and the finally block to the coffee treat. The girl gets the coffee treat regardless of whether the boy successfully purchases the diamonds. Figure 7.10 shows this conversation.

It is interesting to note that a finally block will execute even if the code in the try block or any of the catch blocks defines a return statement. Examine the code in figure 7.11 and its output, and note when the class ReturnFromCatchBlock is unable to open file.txt:

As you can see from figure 7.11's code output, the flow of control doesn't return to the method main when the return statement executes in the catch handler of FileNotFoundException. It continues with the execution of the finally block before the control is transferred back to the main method. Note that the control isn't transferred



**Figure 7.10 A little humor to help you remember that a finally block executes regardless of whether an exception is thrown.**

```

import java.io.*;
public class ReturnFromCatchBlock {
 public static void main(String args[]) {
 openFile();
 }
 private static void openFile() {
 FileInputStream fis = null;
 try {
 fis = new FileInputStream("file.txt");
 }
 catch (FileNotFoundException fnfe) {
 System.out.println("file not found");
 return;
 }
 finally {
 System.out.println("finally");
 }
 System.out.println("Next task..");
 }
}

```

The return statement does not return the control to the main method before execution of the finally block completes.

Code output:  
file not found  
finally

**Figure 7.11** The finally block executes even if an exception handler defines a return statement.

to the `println` statement “`Nexttask...`” that follows the `try` block because the `return` statement is encountered in the `catch` block, as mentioned previously.

Going back to the example of the guy and his girlfriend, a few tragic conditions, such as an earthquake or tornado, can cancel the coffee treat. Similarly, there are a few scenarios in Java in which a `finally` block does not execute:

- *Application termination*—The `try` or the `catch` block executes `System.exit`, which terminates the application
- *Fatal errors*—A crash of the JVM or the OS

In the exam, you may be questioned on the correct order of two or more exception handlers. Does order matter? See for yourself in the next section.

### 7.2.3 What happens if both a catch and a finally block define return statements?

In the previous section, you saw that the `finally` block executes even if a `catch` block defines a `return` statement. For a method that defines a `try-catch-finally` block, what is returned to the calling method if both `catch` and `finally` return a value?

Here's an example:

```

class MultipleReturn {
 int getInt() {
 try {
 String[] students = {"Harry", "Paul"};
 System.out.println(students[5]);
 }
 catch (Exception e) {
 return 10;
 }
 finally {
 return 20;
 }
 }
}

```

Throws  
ArrayIndexOutOfBoundsException

Returns value 10  
from catch block

Returns value 20  
from finally block

```

 }
 }
 public static void main(String args[]) {
 MultipleReturn var = new MultipleReturn();
 System.out.println(var.getInt());
 }
}

```

The output of the preceding code is

20

If both catch and finally blocks define return statements, the calling method will receive a value from the finally block.

#### 7.2.4 What happens if a finally block modifies the value returned from a catch block?

If a catch block returns a primitive data type, the finally block can't modify the value being returned by it. An example:

```

class MultipleReturn {
 int getInt() {
 int returnVal = 10;
 try {
 String[] students = {"Harry", "Paul"};
 System.out.println(students[5]); ↗ Throws
 } ↗ ArrayIndexOutOfBoundsException
 catch (Exception e) {
 System.out.println("About to return :" + returnVal);
 return returnVal; ↗ Returns value 10
 } ↗ from catch block
 finally {
 returnVal += 10;
 System.out.println("Return value is now :" + returnVal);
 }
 return returnVal;
 }
 public static void main(String args[]) {
 MultipleReturn var = new MultipleReturn();
 System.out.println("In Main:" + var.getInt());
 }
}

```

The output of the preceding code is as follows:

```

About to return :10
Return value is now :20
In Main:10

```

Even though the finally block adds 10 to variable `returnVal`, this modified value is not returned to the method `main`. Control in the catch block *copies* the value of `returnVal` to be returned before it executes the finally block, so the returned value is not modified when finally executes.

Will the preceding code behave in a similar manner if the method returns an object? See for yourself:

```
class MultipleReturn {
 StringBuilder getStringBuilder() {
 StringBuilder returnVal = new StringBuilder("10");
 try {
 String[] students = {"Harry", "Paul"};
 System.out.println(students[5]); ← Throws
 ArrayIndexOutOfBoundsException
 }
 catch (Exception e) {
 System.out.println("About to return :" + returnVal);
 return returnVal; ← Returns StringBuilder object
 value from catch block
 }
 finally {
 returnVal.append("10");
 System.out.println("Return value is now :" + returnVal);
 }
 return returnVal;
 }

 public static void main(String args[]) {
 MultipleReturn var = new MultipleReturn();
 System.out.println("In Main:" + var.getStringBuilder());
 }
}
```

This is the output of the preceding code:

```
About to return :10
Return value is now :1010
In Main:1010
```

In this case, the catch block returns an object of the class `StringBuilder`. When the finally block executes, it can access the value of the object referred to by the variable `returnVal` and can modify it. The modified value is returned to the method `main`. Remember that primitives are passed by value and objects are passed by reference.

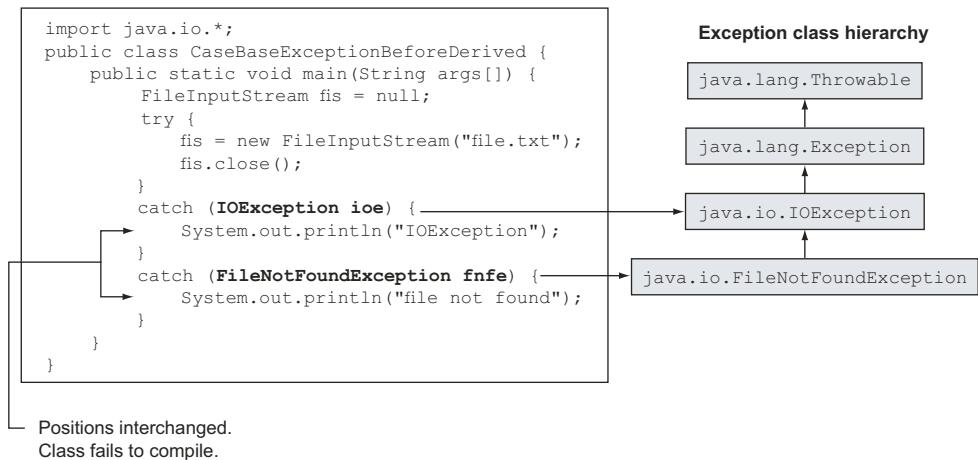


**EXAM TIP** Watch out for code that returns a value from the catch block and modifies it in the finally block. If a catch block returns a primitive data type, the finally block can't modify the value being returned by it. If a catch block returns an object, the finally block can modify the value being returned by it.

## 7.2.5 Does the order of the exceptions caught in the catch blocks matter?

Order doesn't matter for unrelated classes. But it does matter for related classes sharing an IS-A relationship.

In the latter case, if you try to catch an exception of the base class before an exception of the derived class, your code will fail to compile. This behavior may seem bizarre, but there's a valid reason for it. As you know, an object of a derived class can

**Figure 7.12** The order of placement of exception handlers is important.

be assigned to a variable of a base class. Similarly, if you try to catch an exception of a base class before its derived class, the exception handler for the derived class can never be reached, so the code will fail to compile.

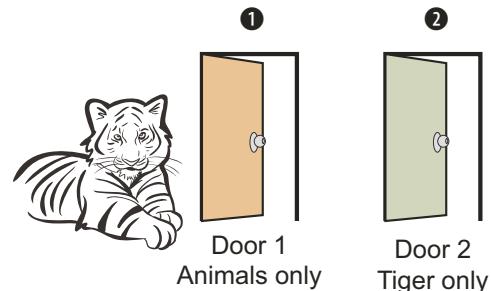
Examine the code in figure 7.12, which has been modified by defining the catch block for `IOException` before the catch block for `FileNotFoundException`.

Figure 7.13 depicts an interesting way to remember that the order matters. As you know, a thrown exception looks for an appropriate exception handler, starting with the first handler and working toward the last. Let's compare a thrown exception to a tiger and the exception handlers to doors that allow certain types of creatures to enter. Like a thrown exception, the tiger should start with the first door and move on to the rest of the doors until a match is found.

The tiger starts with the first door, which allows all animals to enter. Voilà. The tiger enters the first door and never reaches the second door, which is meant specifically for tigers. In Java, when such a condition arises, the Java compiler refuses to compile the code because the later exception handler code will never execute. Java doesn't compile code if it contains unreachable statements.

#### RULES TO REMEMBER

Here are a few more rules you'll need to answer the questions in the OCA Java SE 7 Programmer I exam:

**Figure 7.13** A visual way to remember that the order matters for exceptions caught in the catch blocks

- A try block may be followed by multiple catch blocks, and the catch blocks may be followed by a single finally block.
- A try block may be followed by either a catch or a finally block or both. But a finally block alone wouldn't suffice if code in the try block throws a checked exception. In this case, you need to catch the checked exception or declare it to be thrown by your method. Otherwise your code won't compile.
- The try, catch, and finally blocks can't exist independently.
- The finally block can't appear before a catch block.
- A finally block always executes, regardless of whether the code throws an exception.

### 7.2.6 Can I rethrow an exception or the error I catch?

You can do whatever you want with an exception. Rethrow it, pass it on to a method, assign it to another variable, upload it to a server, send it in an SMS, and so on. Examine the following code:

```
import java.io.*;
public class ReThrowException {
 FileInputStream soccer;
 public void myMethod() {
 try {
 soccer = new FileInputStream("soccer.txt");
 }
 catch (FileNotFoundException fnfe) {
 throw fnfe; ←
 }
 }
}
```

**Use throw keyword to  
throw exception caught  
in exception handler**

Oops. The previous code fails to compile, and you get the following compilation error message:

```
ReThrowException.java:9: unreported exception java.io.FileNotFoundException;
must be caught or declared to be thrown
 throw fnfe;
 ^
```

When you rethrow a checked exception, it's treated like a regular thrown checked exception, meaning that all the rules of handling a checked exception apply to it. In the previous example, the code neither "caught" the rethrown FileNotFoundException exception nor declared that the method `myMethod` would throw it using the `throw` clause. Hence, the code failed to compile.

The following (modified) code declares that the method `myMethod` throws a `FileNotFoundException`, and it compiles successfully:

```
import java.io.*;
public class ReThrowException {
 FileInputStream soccer;
 public void myMethod() throws FileNotFoundException { ←
}
```

**Throws  
FileNotFoundException**

```

try {
 soccer = new FileInputStream("soccer.txt");
}
catch (FileNotFoundException fnfe) {
 throw fnfe;
}
}
}

```



**Exception  
rethrown**

Another interesting point to note is that the previous code doesn't apply to a `RuntimeException`. You can rethrow a runtime exception, but you're not required to catch it, nor must you modify your method signature to include the `throws` clause. The simple reason for this rule is that `RuntimeExceptions` aren't checked exceptions, and they may not be caught or declared to be thrown by your code (exception categories are discussed in detail in section 7.3).

### 7.2.7 Can I declare my methods to throw a checked exception, instead of handling it?

If a method doesn't wish to handle the checked exceptions thrown by a method it calls, it can *throw* these exceptions using the `throws` clause in its own method signature. Examine the following example, in which the method `myMethod` doesn't include an exception handler; instead, it rethrows the `IOException` thrown by a constructor of the class `FileInputStream` using the `throws` clause in its method signature:

```

import java.io.*;
public class ReThrowException2 {
 public void myMethod() throws IOException {
 FileInputStream soccer = new FileInputStream("soccer.txt");
 soccer.close();
 }
}

```



**myMethod throws  
checked exception**

Any method that calls `myMethod` must now either catch the exception `IOException` or declare that it will be rethrown in its method signature.

### 7.2.8 I can create nested loops, so can I create nested try-catch blocks too?

The simple answer is yes, you can define a try-catch-finally block within another try-catch-finally block. Theoretically, the levels of nesting for the try-catch-finally blocks have no limits.

In the following example, another set of try-catch blocks is defined in the `try` and `finally` blocks of the outer `try` block:

```

import java.io.*;
public class NestedTryCatch {
 FileInputStream players, coach;
 public void myMethod() {
 try {
 players = new FileInputStream("players.txt");

```



**Outer try  
block**

```

try {
 coach = new FileInputStream("coach.txt");
 //... rest of the code
}
catch (FileNotFoundException e) {
 System.out.println("coach.txt not found");
}
//... rest of the code
}
catch (FileNotFoundException fnfe) {
 System.out.println("players.txt not found");
}
finally {
 try {
 players.close();
 coach.close();
 }
 catch (IOException ioe) {
 System.out.println(ioe);
 }
}
}
}
}


```

Now comes another Twist in the Tale exercise that'll test your understanding of the exceptions thrown and caught by nested try-catch blocks. In this one, an inner try block defines code that throws a `NullPointerException`. But the inner try block doesn't define an exception handler for this exception. Will the outer try block catch this exception? See for yourself (answer in the appendix).

### Twist in the Tale 7.2

Given that `players.txt` exists on your system and that the assignment of `players`, shown in bold, doesn't throw any exceptions, what is the output of the following code?

```

import java.io.*;
public class TwistInTaleNestedTryCatch {
 static FileInputStream players, coach;
 public static void main(String args[]) {
 try {
 players = new FileInputStream("players.txt");
 System.out.println("players.txt found");
 try {
 coach.close();
 }
 catch (IOException e) {
 System.out.println("coach.txt not found");
 }
 }
 catch (FileNotFoundException fnfe) {
 System.out.println("players.txt not found");
 }
 }
}

```

```

 catch (NullPointerException ne) {
 System.out.println("NullPointerException");
 }
 }
}

```

- a The code prints

```
players.txt found
NullPointerException
```

- b The code prints

```
players.txt found
coach.txt not found
```

- c The code throws a runtime exception.

- d The code fails to compile.

## 7.3 Categories of exceptions



[8.1] Differentiate among checked exceptions, RuntimeExceptions, and Errors

In this section, you'll learn about the categories of exceptions in Java, including checked exceptions, unchecked exceptions, and errors. I'll use code examples to explain the differences between these categories.

### 7.3.1 Identifying exception categories

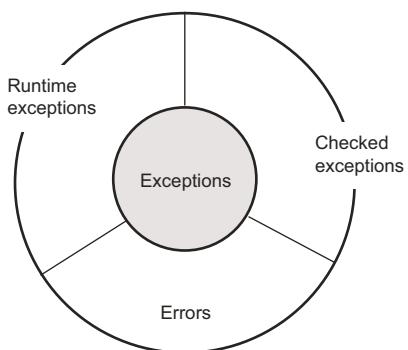
As depicted in figure 7.14, exceptions can be divided into three main categories:

- Checked exceptions
- Runtime exceptions (unchecked exceptions)
- Errors

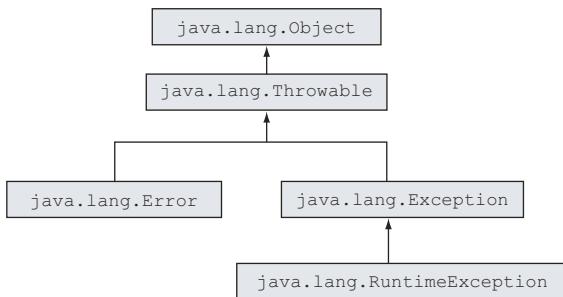
Of these three types, checked exceptions require most of your attention when it comes to coding and using methods. Normally, you shouldn't try to catch runtime exceptions, and there are few options you can use for the errors, because they're thrown by the JVM.

For the OCA Java SE 7 Programmer I exam, it's important to have a crystal-clear understanding of these three categories of exceptions, including their similarities and differences.

These categories are related to each other, and subclasses of the class `java.lang.Exception`



**Figure 7.14 Categories of exceptions: checked exceptions, runtime exceptions, and errors**



**Figure 7.15** Class hierarchy of exception categories

are categorized as checked exceptions if they aren't subclasses of the class `java.lang.RuntimeException`. Subclasses of the class `java.lang.RuntimeException` are categorized as runtime exceptions. Subclasses of the class `java.lang.Error` are categorized as errors. Figure 7.15 illustrates the class hierarchy of these exception categories.

As you can see in figure 7.15, all of the errors and exceptions extend the class `java.lang.Throwable`. Let's examine each of these categories in detail.

### 7.3.2 Checked exceptions

When we talk about handling exceptions, it's *checked* exceptions that take up most of our attention. What is a checked exception?

- A checked exception is an unacceptable condition *foreseen* by the author of a method but outside the immediate control of the code. For example, `FileNotFoundException` is a checked exception. This exception is thrown if the file that the code is trying to access can't be found. When it's thrown, this condition is outside the immediate control of the author of the code but it was *foreseen* by the author.
- A checked exception is a subclass of class `java.lang.Exception`, but it's not a subclass of `java.lang.RuntimeException`. It's interesting to note, however, that the class `java.lang.RuntimeException` itself is a subclass of the class `java.lang.Exception`.



**EXAM TIP** In the OCA Java SE 7 Programmer I exam, you may have to select which type of reference variable to use to store the object of the thrown checked exception in a handler. To answer such questions correctly, remember that a checked exception is a subclass of the `java.lang.Exception` class, but not a subclass of `java.lang.RuntimeException`.

If a method uses another method that may throw a checked exception, one of the two following things should be true:

- The method should be enclosed within a `try-catch` block  
or
- The method should specify this exception to be thrown in its method signature

Let's quickly review the class `OpenFile`, which we discussed in an earlier section:

```
import java.io.*;
public class OpenFile {
 public static void main(String args[]) {
 FileInputStream fis = new FileInputStream("file.txt");
 }
}
```

**Throws checked exception  
FileNotFoundException**

As mentioned earlier, this will fail to compile because the code in bold throws the checked exception `FileNotFoundException`, and the previous class neither enclosed this line of code within a `try` block nor specified that it would be thrown in its method signature.

If a method chooses not to handle the checked exception thrown by its code, it may choose to throw it, and its method signature must specify that. Examine the following definition of the `FileInputStream` constructor (from the source code of the Java API), which is used in the previously mentioned class `OpenFile`:

```
public FileInputStream(String name) throws FileNotFoundException {
 this(name != null ? new File(name) : null);
}
```

Now examine the corresponding description of this constructor in the Java API documentation:

```
public FileInputStream(File file)
 throws FileNotFoundException
```

A checked exception is part of the API and is well documented. Checked exceptions are unacceptable conditions that a programmer *foresees* at the time of writing a method. By declaring these exceptions as checked exceptions, the author of the method makes its users aware of the exceptional conditions that can arise from its use. The user of a method with a checked exception must handle the exceptional condition accordingly.

### 7.3.3 Runtime exceptions (also known as unchecked exceptions)

Although you'll spend most of your time and energy combating checked exceptions, it's the runtime exceptions that'll give you the most headaches. This is particularly true when you're preparing to work on real-life projects. Some examples of runtime exceptions are `NullPointerException` (the most common one), `ArrayIndexOutOfBoundsException`, and `ClassCastException`.

What is a runtime exception?

- A runtime exception is a representation of a programming error. These occur from inappropriate use of another piece of code. For example, `NullPointerException` is a runtime exception that occurs when a piece of code tries to execute some code on a variable that hasn't been assigned an object and points to `null`. Another example is `ArrayIndexOutOfBoundsException`, which is thrown when a piece of code tries to access an array list element at a nonexistent position.
- A runtime exception is a subclass of `java.lang.RuntimeException`.

- A runtime exception may not be a part of the method signature, even if a method may throw it.

How about an example, now that you've read the previous definitions of runtime exceptions? Examine the following code, which throws a runtime exception (`ArrayIndexOutOfBoundsException`):

```
public class InvalidArrayAccess {
 public static void main(String args[]) {
 String[] students = {"Shreya", "Joseph"};
 System.out.println(students[5]);
 System.out.println("All seems to be well");
 }
}
```

**students[5] tries to access nonexistent array position;  
Exception thrown:  
`ArrayIndexOutOfBoundsException`**

The preceding code doesn't print output from `System.out.println()`.

It's possible to create an exception handler for the exception `ArrayIndexOutOfBoundsException` thrown by the previous example code, as follows:

```
public class InvalidArrayAccess {
 public static void main(String args[]) {
 String[] students = {"Shreya", "Joseph"};
 try {
 System.out.println(students[5]);
 }
 catch (ArrayIndexOutOfBoundsException e){
 System.out.println("Exception");
 }
 System.out.println("All seems to be well");
 }
}
```

The output of the previous code is as follows:

```
Exception
All seems to be well
```

In the same way you can *catch* a checked exception, you can also catch a `RuntimeException`. In the previous code, you can prevent `ArrayIndexOutOfBoundsException` from being thrown by using appropriate checks:

```
public class InvalidArrayAccess {
 public static void main(String args[]) {
 String[] students = {"Shreya", "Joseph"};
 int pos = 1;
 if (pos > 0 && pos < students.length)
 System.out.println(students[pos]);
 }
}
```

**This line won't execute because pos is greater than length of array students.**

#### 7.3.4 Errors

Whether you're preparing for the OCA Java SE 7 Programmer I exam or your real-life projects, you need to know when the JVM throws errors. These errors are considered to be *serious* exceptional conditions and they can't be directly controlled by your code.

### What's an error?

- An error is a serious exception thrown by the JVM as a result of an error in the environment state that processes your code. For example, `NoClassDefFoundError` is an error thrown by the JVM when it's unable to locate the `.class` file that it's supposed to run. `StackOverflowError` is another error thrown by the JVM when the size of the memory required by the stack of a Java program is greater than what the JRE has offered for the Java application. This error usually occurs as a result of infinite or highly nested loops.
- An error is a subclass of class `java.lang.Error`.
- An error need not be a part of a method signature.
- An error can be caught by an exception handler, but it shouldn't be.

The following example shows how it's possible to “catch” an error:

```
public class CatchError {
 public static void main(String args[]) {
 try {
 myMethod();
 }
 catch (StackOverflowError s) {
 System.out.println(s);
 }
 }
 public static void myMethod() {
 System.out.println("myMethod");
 myMethod();
 }
}
```

A class can catch and handle an error,  
but it shouldn't—it should instead let  
the JVM handle the error itself.

I agree that you shouldn't handle errors in your code. But if you do, will the exception handler that handles the code be executed? See for yourself by answering the question in the following Twist in the Tale exercise (answer in the appendix).

#### Twist in the Tale 7.3

Will the code in the error-handling block execute? What do you think is the output of the following code?

```
public class TwistInTaleCatchError {
 public static void main(String args[]) {
 try {
 myMethod();
 }
 catch (StackOverflowError s) {
 for (int i=0; i<2; ++i)
 System.out.println(i);
 }
 }
 public static void myMethod() {
 myMethod();
 }
}
```

- a 0  
java.lang.StackOverflowError
  - b 0  
1
  - c 0  
1  
2  
java.lang.StackOverflowError
- 

## 7.4 Common exception classes and categories



[8.5] Recognize common exception classes and categories

In this section, we'll take a look at common exception classes and categories of exceptions. You'll also learn about the scenarios in which these exceptions are thrown and how to handle them.

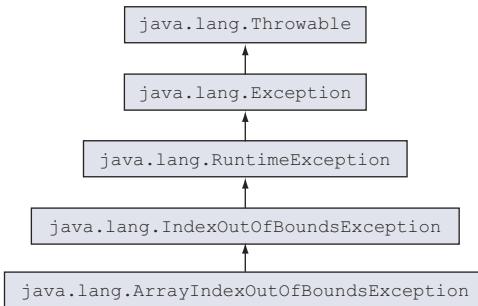
For the OCA Java SE 7 Programmer I exam, you should be familiar with the scenarios that lead to these commonly thrown exception classes and categories, and how to handle them. Table 7.2 lists common errors and exceptions.

**Table 7.2 Common errors and exceptions**

| Runtime exceptions             | Errors                      |
|--------------------------------|-----------------------------|
| ArrayIndexOutOfBoundsException | ExceptionInInitializerError |
| IndexOutOfBoundsException      | StackOverflowError          |
| ClassCastException             | NoClassDefFoundError        |
| IllegalArgumentException       | OutOfMemoryError            |
| IllegalStateException          |                             |
| NullPointerException           |                             |
| NumberFormatException          |                             |

The OCA Java SE 7 Programmer I exam objectives require that you understand which of the previously mentioned errors and exceptions are thrown by the JVM and which should be thrown programmatically. From the discussion of errors earlier in this chapter, you know that the errors represent issues associated with the JRE, such as `OutOfMemoryError`. As a programmer, you *shouldn't* throw or catch these errors—leave them for the JVM. The definition of the runtime exception notes that these are the kind of exceptions that are thrown by the JVM, which shouldn't be thrown by you programmatically.

Let's review each of these in detail.



**Figure 7.16 Class hierarchy of `ArrayIndexOutOfBoundsException`**

#### 7.4.1 `ArrayIndexOutOfBoundsException` and `IndexOutOfBoundsException`

As shown in figure 7.16, `ArrayIndexOutOfBoundsException` and `IndexOutOfBoundsException` are runtime exceptions, which share an IS-A relationship. `IndexOutOfBoundsException` is subclassed by `ArrayIndexOutOfBoundsException`.

`ArrayIndexOutOfBoundsException` is thrown when a piece of code tries to access an array out of its bounds (either an array is accessed at a position less than 0 or at a position greater than or equal to its length). `IndexOutOfBoundsException` is thrown when a piece of code tries to access a list, like an `ArrayList`, using an illegal index.

Assuming that an array and list have been defined as follows,

```

String[] season = {"Spring", "Summer"};
ArrayList<String> exams = new ArrayList<>();
exams.add("SCJP");
exams.add("SCWCD");

```

The following lines of code will throw `ArrayIndexOutOfBoundsException`:

```

System.out.println(season[5]); ← Can't access position
System.out.println(season[-9]); ← >= array length

```

The following lines of code will throw `IndexOutOfBoundsException`:

```

System.out.println(exams.get(-1)); ← Can't access list at
System.out.println(exams.get(4)); ← negative position
 ← Can't access list at
 ← position >= its size

```

Why do you think the JVM has taken the responsibility to throw this exception itself? One of the main reasons is that this exception isn't known until runtime and depends on the array or list position that's being accessed by a piece of code. Most often, a variable is used to specify this array or list position, and its value may not be known until runtime.



**NOTE** When you try to access an invalid array position, `ArrayIndexOutOfBoundsException` is thrown. When you try to access an invalid `ArrayList` position, `IndexOutOfBoundsException` is thrown.

You can avoid these exceptions from being thrown if you check whether the index position you are trying to access is greater than or equal to 0 and less than the size of your array or ArrayList.

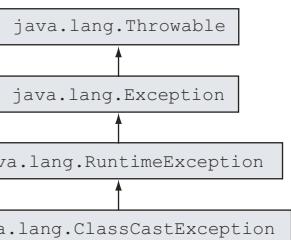
### 7.4.2 ClassCastException

Before I start discussing the example I'll use for this exception, take a quick look at figure 7.17 to review the class hierarchy of this exception.

Examine the code in listing 7.2, where the line of code that throws the ClassCastException is shown in bold.

#### Listing 7.2 An example of code that throws ClassCastException

```
import java.util.ArrayList;
public class ListAccess {
 public static void main(String args[]) {
 ArrayList<Ink> inks = new ArrayList<Ink>();
 inks.add(new ColorInk());
 inks.add(new BlackInk());
 Ink ink = (BlackInk)inks.get(0);
 }
}
class Ink{}
class ColorInk extends Ink{}
class BlackInk extends Ink{}
```



**Figure 7.17 Class hierarchy of ClassCastException**

ClassCastException is thrown when an object fails an IS-A test with the class type to which it's being cast. In the preceding example, class Ink is the base class for classes ColorInk and BlackInk. The JVM throws a ClassCastException in the previous case because the line of code in bold tries to explicitly cast an object of ColorInk to BlackInk.

Note that this line of code avoided the compilation error because the variable inks defines an ArrayList of type Ink, which is capable of storing objects of type Ink and all its subclasses. The code then correctly adds the allowed objects: one each of BlackInk and ColorInk. If the code had defined an ArrayList of type BlackInk or ColorInk, the code would have failed the compilation, as follows:

```
import java.util.ArrayList;
public class Invalid {
 public static void main(String args[]) {
 ArrayList<ColorInk> inks = new ArrayList<ColorInk>();
 inks.add(new ColorInk());
 Ink ink = (BlackInk)inks.get(0);
 }
}
class Ink{}
class ColorInk extends Ink{}
class BlackInk extends Ink{}
```

← **Throws ClassCastException**

← **Compilation issues**

Here's the compilation error thrown by the previously modified piece of code:

```
Invalid.java:6: inconvertible types
found : ColorInk
required: BlackInk
 Ink ink = (BlackInk) inks.get(0);
 ^

```

You can use the `instanceof` operator to verify whether an object can be cast to another class before casting it. Assuming that the definition of classes `Ink`, `ColorInk`, and `BlackInk` are the same as defined in the previous example, the following lines of code will avoid the `ClassCastException`:

```
import java.util.ArrayList;
public class AvoidClassCastException {
 public static void main(String args[]) {
 ArrayList<Ink> inks = new ArrayList<Ink>();
 inks.add(new ColorInk());
 inks.add(new BlackInk());
 if (inks.get(0) instanceof BlackInk) {
 BlackInk ink = (BlackInk) inks.get(0); ← No
 } ClassCastException
 }
}
```

In the previous example, the condition (`inks.get(0) instanceof BlackInk`) evaluates to `false`, so the then part of the `if` statement doesn't execute.

In the following Twist in the Tale exercise, we'll introduce an interface used in the casting example in listing 7.2 (answer in the appendix).

#### Twist in the Tale 7.4

Let's introduce an interface used in listing 7.2 and see how it behaves. Following is the modified code. Examine the code and select the correct options:

```
class Ink{}
interface Printable {}
class ColorInk extends Ink implements Printable {}
class BlackInk extends Ink{}

class TwistInTaleCasting {
 public static void main(String args[]) {
 Printable printable = null;
 BlackInk blackInk = new BlackInk();
 printable = (Printable)blackInk;
 }
}

a printable = (Printable)blackInk will throw compilation error.
b printable = (Printable)blackInk will throw runtime exception.
c printable = (Printable)blackInk will throw checked exception.
d The following line of code will fail to compile:
 printable = blackInk;
```

### 7.4.3 **IllegalArgumentException**

As the name of this exception suggests, `IllegalArgumentException` is thrown to specify that a method has passed illegal or inappropriate arguments. Its class hierarchy is shown in figure 7.18.

Even though it's a runtime exception, programmers usually use this exception to validate the arguments that are passed to a method. The exception constructor is passed a descriptive message, specifying the exception details. Examine the following code:

```
public void login(String username, String pwd, int maxLoginAttempt) {

 if (username == null || username.length() < 6)
 throw new IllegalArgumentException
 ("Login:username can't be shorter than 6 chars");

 if (pwd == null || pwd.length() < 8)
 throw new IllegalArgumentException
 ("Login: pwd cannot be shorter than 8 chars");

 if (maxLoginAttempt < 0)
 throw new IllegalArgumentException
 ("Login: Invalid loginattempt val");

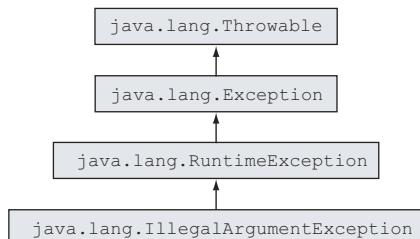
 //.. rest of the method code
}
```

The previous method validates the various method parameters passed to it and throws an appropriate `IllegalArgumentException` if they don't meet the requirements of the method. Each object of the `IllegalArgumentException` is passed a different `String` message that briefly describes it.

### 7.4.4 **IllegalStateException**

According to the Java API documentation, an `IllegalStateException` “signals that a method has been invoked at an illegal or inappropriate time. In other words, the Java environment or Java application is not in an appropriate state for the requested operation.”<sup>1</sup>

The class hierarchy for `IllegalStateException` is shown in figure 7.19.



**Figure 7.18** Class hierarchy of `IllegalArgumentException`



**Figure 7.19** Class hierarchy of `IllegalStateException`

<sup>1</sup> The `IllegalStateException` documentation can be found in the Javadoc: <http://docs.oracle.com/javase/7/docs/api/java/lang/IllegalStateException.html>.

As an author of code, you can throw `IllegalStateException` to signal to the calling method that the method being requested for execution can't be called for the current state of an object.

For example, what happens if an application tries to modify an SMS that is already in transmission? Examine the following code:

```

class SMS {
 private String msg;
 private boolean inTransit = false;

 public void create() {
 msg = "A new Message";
 }

 public void transmit() {

 inTransit = true;
 }

 public void modify() {
 if (!inTransit)
 msg = "new modified message";
 else
 throw new IllegalStateException
 ("Msg in transit. Can't modify it");
 }
}

public class ThrowIllegalStateException {
 public static void main(String[] args) {
 SMS sms = new SMS();
 sms.create();
 sms.transmit();
 sms.modify();
 }
}

```

← **Code to transmit message**

On execution, the class `ThrowIllegalStateException` throws the following exception:

```

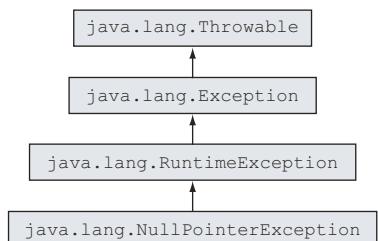
Exception in thread "main" java.lang.IllegalStateException: Msg in transit.
 Can't modify it
 at SMS.modify(ThrowIllegalStateException.java:18)
 at ThrowIllegalStateException.main(ThrowIllegalStateException.java:27)

```

In the example code, the method `modify` in the class `SMS` throws an `IllegalStateException` if another piece of code tries to call it after the method `send` has been executed.

#### 7.4.5 **NullPointerException**

`NullPointerException`, shown in figure 7.20, is the quintessential exception. I imagine that almost all Java programmers have had a taste of this exception, but let's look at an explanation for it.



**Figure 7.20 Class hierarchy of NullPointerException**

This exception is thrown by the JVM if you try to access a method or a variable with a null value. The exam can have interesting code combinations to test you on whether a particular piece of code will throw a `NullPointerException`. The key is to ensure that the reference variable has been assigned a non-null value. In particular, I'll address the following cases:

- Accessing members of a reference variable that is explicitly assigned a null value.
- Accessing members of an uninitialized instance or static reference variable. These are implicitly assigned a null value.
- Using an uninitialized local variable, which may *seem* to throw a `NullPointerException`.
- Attempting to access nonexistent array positions.
- Using members of an array element that are assigned a null value.

Let's get started with the first case, in which a variable is explicitly assigned a null value:

```
import java.util.ArrayList;
class ThrowNullPointerException {
 static ArrayList<String> list = null;
 public static void main(String[] args) {
 list.add("1");
 }
}
```

The diagram shows the Java code above. A callout points to the line `list.add("1");` with the text "list is null". Another callout points to the same line with the text "Attempt to call method add on list throws NullPointerException".

The preceding code tries to access the method `add` on variable `list`, which has been assigned a null value. It throws an exception, as follows:

```
Exception in thread "main" java.lang.NullPointerException
 at ThrowNullPointerException.main(ThrowNullPointerException.java:5)
```

By default, the static and instance variables of a class are assigned a null value. In the previous example, the static variable `list` is assigned an explicit null value. When the method `main` tries to execute the method `add` on variable `list`, it calls a method on a null value. This call causes the JVM to throw a `NullPointerException` (which is a `RuntimeException`). If you define the variable `list` as an instance variable and don't assign an explicit value to it, you'll get the same result (`NullPointerException` being thrown at runtime). Because the static method `main` can't access the instance variable `list`, you'll need to create an object of class `ThrowNullPointerException` to access it:

```
import java.util.ArrayList;
class ThrowNullPointerException {
 ArrayList<String> list;
 public static void main(String[] args) {
 ThrowNullPointerException obj = new ThrowNullPointerException();
 obj.list.add("1");
 }
}
```

The diagram shows the Java code above. A callout points to the line `obj.list.add("1");` with the text "list is implicitly assigned a null value". Another callout points to the same line with the text "Attempt to call method add on list throws NullPointerException".

You can prevent a `NullPointerException` from being thrown by checking whether an object is null before trying to access its member:

```
import java.util.ArrayList;
class ThrowNullPointerException {
 static ArrayList<String> list;
 public static void main(String[] args) {
 if (list!=null)
 list.add("1");
 }
}
```

**Ascertain that list is not null**

What happens if you modify the previous code as follows? Will it still throw a `NullPointerException`?

```
import java.util.ArrayList;
class ThrowNullPointerException {
 public static void main(String[] args) {
 ArrayList<String> list;
 if (list!=null)
 list.add("1");
 }
}
```

**Fails to compile**

Interestingly, the previous code fails to compile. `list` is defined as a local variable inside the method `main`, and by default, local variables aren't assigned a value—not even a null value. If you attempt to use an uninitialized local variable, your code will fail to compile. Watch out for similar questions in the exam.

Another set of conditions when code may throw the `NullPointerException` involves use of arrays:

```
class ThrowAnotherNullPointerException {
 static String[] oldLaptops;
 public static void main(String[] args) {
 System.out.println(oldLaptops[1]); ←———— Throws NullPointerException
 String[] newLaptops = new String[2];
 System.out.println(newLaptops[1].toString()); ←———— Throws NullPointerException
 }
}
```

The variable `oldLaptops` is assigned a null value by default because it's a static variable. Its array elements are neither initialized nor assigned a value. The code that tries to access the array's second element throws a `NullPointerException`.

In the second case, two array elements of the variable `newLaptops` are initialized and assigned a default value of null. If you call method `toString` on the second element of variable `newLaptops`, it results in a `NullPointerException` being thrown.

If you modify that line as shown in the following code, it won't throw an exception—it'll print the value null:

```
System.out.println(newLaptops[1]); ←———— No RuntimeException. Prints "null".
```



**EXAM TIP** In the exam, watch out for code that tries to use an uninitialized local variable. Because such variables aren't initialized with even a null value, you can't print their value using the `System.out.println` method. Such code won't compile.

Let's modify the previous code that uses the variable `oldLaptops` and check your understanding of `NullPointerExceptions`. Here's another Twist in the Tale hands-on exercise for you (answers in the appendix).

#### Twist in the Tale 7.5

Let's check your understanding of the `NullPointerException`. Here's a code snippet. Examine the code and select the correct answers.

```
class TwistInTaleNullPointerException {
 public static void main(String[] args) {
 String[][] oldLaptops =
 { {"Dell", "Toshiba", "Vaio"}, null,
 {"IBM"}, new String[10] };
 System.out.println(oldLaptops[0][0]); // line 1
 System.out.println(oldLaptops[1]); // line 2
 System.out.println(oldLaptops[3][6]); // line 3
 System.out.println(oldLaptops[3][0].length()); // line 4
 System.out.println(oldLaptops); // line 5
 }
}
```

- a Code on line 1 will throw `NullPointerException`
  - b Code on lines 1 and 3 will throw `NullPointerException`
  - c Only code on line 4 will throw `NullPointerException`
  - d Code on lines 3 and 5 will throw `NullPointerException`
- 

#### 7.4.6 `NumberFormatException`

What happens if you try to convert “87” and “9m#” to numeric values? The former value is okay, but you can't convert the latter value to a numeric value unless it's an encoded value, straight from a James Bond movie, that can be converted to anything.

As shown in figure 7.21, `NumberFormatException` is a runtime exception. It's thrown to indicate that the application has tried to convert a string (with an inappropriate format) to one of the numeric types.

Multiple classes in the Java API define parsing methods. One of the most frequently used

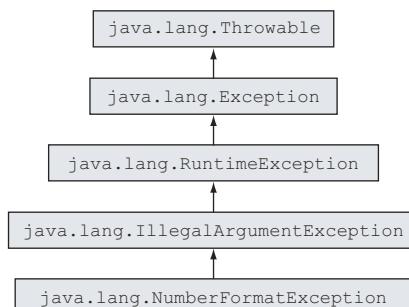


Figure 7.21 Class hierarchy of `NumberFormatException`

methods is `parseInt` from the class `Integer`. It's used to parse a `String` argument as a signed (negative or positive) decimal integer. Here are some examples:

**Valid String values that can be converted to numeric values**

```
System.out.println(Integer.parseInt("-123"));
System.out.println(Integer.parseInt("123"));
System.out.println(Integer.parseInt("+123"));
System.out.println(Integer.parseInt("123_45"));
System.out.println(Integer.parseInt("12ABCD"));
```

**Will throw NumberFormatException.  
Use of underscores in string values isn't allowed.**

**Will throw NumberFormatException.  
Characters ABCD can't be converted to integers in base 10.**

Starting in Java 7, you can use underscores (`_`) in numeric literal values. But you can't use them in `String` values passed to the method `parseInt`. The letters ABCD are not used in the decimal number system, but they can be used in the hexadecimal number system, so you can convert the hexadecimal literal value `"12ABCD"` to the decimal number system by specifying the base of the number system as 16:

```
System.out.println(Integer.parseInt("123ABCD", 16));
```

← Prints 1223629

Note that the argument 16 is passed to the method `parseInt`, not to the method `println`. The following will not compile:

```
System.out.println(Integer.parseInt("123ABCD"), 16);
```

← Won't compile

You may throw `NumberFormatException` from your own method to indicate that there's an issue with the conversion of a `String` value to a specified numeric format (decimal, octal, hexadecimal, binary), and you can add a customized exception message. One of the most common candidates for this exception is methods that are used to convert a command-line argument (accepted as a `String` value) to a numeric value. Please note that all command-line arguments are accepted in a `String` array as `String` values.

The following is an example of code that rethrows `NumberFormatException` programmatically:

```
public class ThrowNumberFormatException {
 public static int convertToNum(String val) {
 int num = 0;
 try {
 num = Integer.parseInt(val, 16);
 }
 catch (NumberFormatException e) {
 throw new NumberFormatException(val +
 " cannot be converted to hexadecimal number");
 }
 return num;
 }
 public static void main(String args[]) {
 System.out.println(convertToNum("16b"));
 System.out.println(convertToNum("65v"));
 }
}
```

**Rethrows  
NumberFormatException thrown by method  
parseInt with modified  
exception message**

The conversion of the hexadecimal literal 16b to the decimal number system is successful. But the conversion of the hexadecimal literal 65v to the decimal number system fails, and the previous code will give the following output:

```
363
Exception in thread "main" java.lang.NumberFormatException: 65v cannot be
 converted to hexadeciml number
at
 ThrowNumberFormatException.convertToNum(ThrowNumberFormatException.java:
 8)
at ThrowNumberFormatException.main(ThrowNumberFormatException.java:14)
```

Now let's take a look at some of the common errors that are covered on this exam.

#### 7.4.7 ***ExceptionInInitializerError***

The `ExceptionInInitializerError` error is typically thrown by the JVM when a static initializer in your code throws any type of `RuntimeException`. Figure 7.22 shows the class hierarchy of `ExceptionInInitializerError`.

A static initializer block is defined using the keyword `static`, followed by curly braces, in a class. This block is defined within a class, but not within a method. It's usually used to execute code when a class loads for the first time. Runtime exceptions arising from any of the following will throw this error:

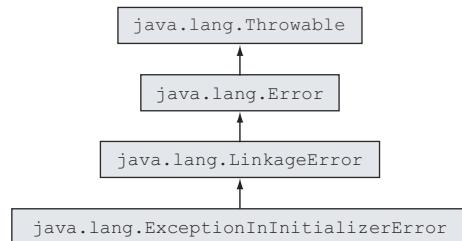
- Execution of an anonymous `static` block
- Initialization of a `static` variable
- Execution of a `static` method (called from either of the previous two items)

The static initializer block of the class defined in the following example will throw a `NumberFormatException`, and when the JVM tries to load this class, it'll throw an `ExceptionInInitializerError`:

```
public class DemoExceptionInInitializerError {
 static {
 int num = Integer.parseInt("sd", 16);
 }
}
```

Following is the error message when JVM tries to load the class `DemoExceptionInInitializerError`:

```
java.lang.ExceptionInInitializerError
Caused by: java.lang.NumberFormatException: For input string: "sd"
at
 java.lang.NumberFormatException.forInputString(NumberFormatException.jav
a:48)
```



**Figure 7.22 Class hierarchy of `ExceptionInInitializerError`**

```

at java.lang.Integer.parseInt(Integer.java:447)
at
DemoExceptionInInitializerError.<clinit>(DemoExceptionInInitializerError
.java:3)

```



**EXAM TIP** Beware of code that seems to be simple in the OCA Java SE 7 Programmer I exam. The class `DemoExceptionInInitializerError` (mentioned previously) seems deceptively simple, but it's a good candidate for an exam question. As you know, this class throws the error `ExceptionInInitializerError` when the JVM tries to load it.

In the following example, initialization of a static variable results in a `NullPointerException` being thrown. When this class is loaded by the JVM, it throws an `ExceptionInInitializerError`:

```

public class DemoExceptionInInitializerError1 {
 static String name = null;
 static int nameLength = name.length();
}

```

The error message when the JVM tries to load the `DemoExceptionInInitializerError1` class is as follows:

```

java.lang.ExceptionInInitializerError
Caused by: java.lang.NullPointerException
 at
 DemoExceptionInInitializerError1.<clinit>(DemoExceptionInInitializerError1.java:3)
Exception in thread "main"

```

Now let's move on to the exception thrown by a `static` method, which may be called by the `static` initializer block or to initialize a `static` variable. Examine the following code, in which `MyException` is a user-defined `RuntimeException`:

```

public class DemoExceptionInInitializerError2 {
 static String name = getName();
 static String getName() {
 throw new MyException();
 }
}
class MyException extends RuntimeException{} ←
 | MyException is a
 | runtime exception

```

This is the error thrown by the class `DemoExceptionInInitializerError2`:

```

java.lang.ExceptionInInitializerError
Caused by: MyException
 at
 DemoExceptionInInitializerError2.getName(DemoExceptionInInitializerError2.java:4)
 at
 DemoExceptionInInitializerError2.<clinit>(DemoExceptionInInitializerError2.java:2)

```

Did you notice that the error `ExceptionInInitializerError` can be caused only by a runtime exception? This happens for valid reasons, of course.

If a static initializer block throws an error, it doesn't recover from it to come back to the code to throw an `ExceptionInInitializerError`. This error can't be thrown if a static initializer block throws an object of a checked exception because the Java compiler is intelligent enough to determine this condition and doesn't allow you to throw an unhandled checked exception from a static initialization block.



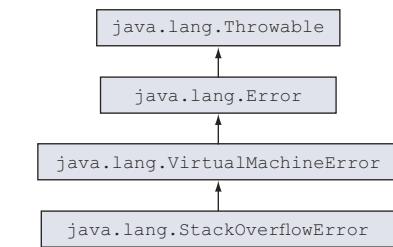
**EXAM TIP** `ExceptionInInitializerError` can be caused by an object of `RuntimeException` only. It can't occur as the result of an error or checked exception thrown by the static initialization block.

#### 7.4.8 StackOverflowError

The `StackOverflowError` error extends `VirtualMachineError` (as shown in figure 7.23). As its name suggests, it should be left to be managed by the JVM.

This error is thrown by the JVM when a Java program calls itself so many times that the memory stack allocated to execute the Java program “overflows.” Examine the following code, in which a method calls itself recursively without an exit condition:

```
public class DemoStackOverflowError{
 static void recursion() {
 recursion();
 }
 public static void main(String args[]) {
 recursion();
 }
}
```



**Figure 7.23 Class hierarchy of `StackOverflowError`**

Calls itself recursively, without exit condition

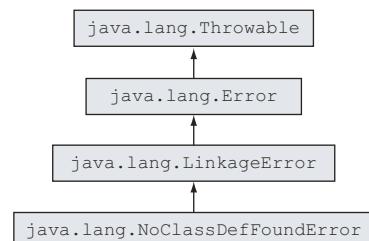
The following error is thrown by the previous code:

```
Exception in thread "main" java.lang.StackOverflowError
at DemoStackOverflowError.recursion(DemoStackOverflowError.java:3)
```

#### 7.4.9 NoClassDefFoundError

What would happen if you failed to set your classpath and, as a result, the JVM was unable to load the class that you wanted to access or execute? Or what happens if you try to run your application before compiling it? In both these conditions, the JVM would throw `NoClassDefFoundError` (class hierarchy shown in figure 7.24).

This is what the Java API documentation says about this error:



**Figure 7.24 Class hierarchy of `NoClassDefFoundError`**

*Thrown if the Java Virtual Machine or a ClassLoader instance tries to load in the definition of a class (as part of a normal method call or as part of creating a new instance using the new expression) and no definition of the class could be found.<sup>2</sup>*

Because this particular error is not a coding issue, I don't have a coding example for you. As you can see from the error hierarchy diagram in figure 7.24, this is a linkage error arising from a missing class file definition at runtime. This error should not be handled by the code and should be left to be handled exclusively by the JVM.



**NOTE** Don't confuse the exception thrown by `Class.forName()`, used to load the class, and `NoClassDefFoundError` thrown by the JVM. `Class.forName()` throws `ClassNotFoundException`.

#### 7.4.10 `OutOfMemoryError`

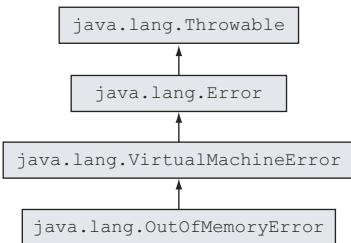
What happens if you create and use a *lot* of objects in your application—for example, if you load a large chunk of persistent data to be processed by your application. In such a case, the JVM may run out of memory *on the heap*, and the garbage collector may not be able to free more memory for the JVM. In this case, the JVM is unable to create any more objects on the heap. An `OutOfMemoryError` will be thrown (class hierarchy shown in figure 7.25).

You'll always work with a finite heap size, no matter what platform you work on, so you can't create and use an unlimited number of objects in your application. To get around this error, you need to either limit the number of resources or objects that your application creates or increase the heap size on the platform you're working with.

A number of tools are available (which are beyond the scope of this book) that can help you monitor the number of objects created in your application.

### 7.5 **Summary**

In this chapter, we discussed the need for exception handling, as well as the advantages of defining the exception-handling code separate from the program logic. You saw how this approach helps separate concerns about defining the regular program logic and exception-handling code. We also looked at the code syntax, specifically the try-catch-finally blocks, for implementing the exception-handling code. Code that throws an exception should be enclosed within a try block that is immediately followed by a catch and/or a finally block. A try block can be followed by multiple catch blocks, but only a single finally block. A finally block can't be placed before



**Figure 7.25** Class hierarchy of `OutOfMemoryError`

<sup>2</sup> The `NoClassDefFoundError` documentation can be found in the Javadoc: <http://docs.oracle.com/javase/7/docs/api/java/lang/NoClassDefFoundError.html>.

a try block. A try block must be followed by at least one catch or finally block. The try, catch, and finally blocks can't exist independently.

Next, we delved into the different categories of exceptions: checked exceptions, runtime or unchecked exceptions, and errors. Checked exceptions are subclasses of the class `java.lang.Exception`. Unchecked exceptions are subclasses of the class `java.lang.RuntimeException`, which itself is a subclass of the class `java.lang.Exception`. Errors are subclasses of `java.lang.Error`. All of these exceptions are subclasses of `java.lang.Throwable`.

A checked exception is an unacceptable condition foreseen by the author of a method but outside the immediate control of the code. A runtime exception represents a programming error—these occur because of inappropriate use of another piece of code. Errors are serious exceptions, thrown by the JVM, as a result of an error in the environment state that processes your code.

In the final sections of this chapter, we covered commonly occurring exceptions and errors, such as `NullPointerException`, `IllegalArgumentException`, `StackOverflowError`, and more. For each of these errors and exceptions, I explained the conditions in which they may be thrown in code and whether they should be explicitly handled in exception handlers.

## 7.6 **Review notes**

This section lists the main points of all the sections covered in this chapter.

A taste of exceptions:

- Trying to access an array element at a position that is greater than or equal to the array's length is considered an exceptional condition.
- Trying to execute a method that throws a checked exception without handling the thrown exception causes a compilation error.
- Trying to call a method recursively without defining an exit condition is considered an exceptional condition.
- Proper handling of exceptions is important in Java. It enables a programmer to define alternative code to execute in case an exceptional condition is met.

Why handle exceptions separately:

- Exception handlers refer to the blocks of code that execute when an exceptional condition arises during code execution.
- Handling exceptions separately enables you to define the main logic of your code together.
- Without the use of separate exception handlers, the main logic of your code would be lost in combating the exceptional conditions. (See figure 7.5 for an example.)
- Separate exception handlers enable you to define alternative code to execute separately from your main code flow when an exceptional condition is met.
- Exception handlers separate the concerns of defining the regular program logic from exception-handling code.

- Exceptions also help pinpoint the offending code, together with the method in which it is defined, by providing a stack trace of the exception or error.
- The stack trace of an exception enables you to get a list of all the exceptions that executed before the exception was reported.
- The stack trace of an exception is available within an exception handler.
- The JVM may send the stack trace of an unhandled exception to the Java console.

An exception is thrown:

- An exception is an object of the class `java.lang.Throwable`.
- When a piece of code hits an obstacle in the form of an exceptional condition, it creates an object of subclass `java.lang.Throwable`, initializes it with the necessary information (such as its type and optionally a textual description and the offending program's state), and hands it over to the JVM.
- The JVM keeps an account of all the methods that were called when it hits the code that throws an exception. To find an appropriate exception handler, it looks through all these method calls.
- Enclose the code that may throw an exception within a `try` block.
- Define `catch` blocks to include alternative code to execute when an exceptional condition arises.
- A `try` block can be followed by one or more `catch` blocks.
- The `catch` blocks must be followed by zero or one `finally` block.
- The `finally` block executes regardless of whether the code in the `try` block throws an exception.
- A `try` block can't define multiple `finally` blocks.
- The order in which the `catch` blocks are placed matters. If the caught exceptions have an inheritance relationship, the base class exceptions can't be caught before the derived class exceptions. An attempt to do this will result in compilation failure.
- A `finally` block will execute even if a `try` or `catch` block defines a `return` statement.
- A `try` block may be followed by either a `catch` or a `finally` block or both.
- If both `catch` and `finally` blocks define `return` statements, the calling method will receive the value from the `finally` block.
- If a `catch` block returns a primitive data type, a `finally` block can't modify the value being returned by it.
- If a `catch` block returns an object, a `finally` block can modify the value being returned by it.
- A `finally` block alone wouldn't suffice with a `try` block if code in the `try` block throws a checked exception. In this case, you need to catch the checked exception or define in the method signature that the exception is thrown, or your code won't compile.

- None of the `try`, `catch`, and `finally` blocks can exist independently.
- The `finally` block can't appear before a `catch` block.
- You can rethrow an error that you *catch* in an exception handler.
- You can either handle an exception or declare it to be thrown by your method. In the latter case, you need not handle the exception in your code. This applies to checked exceptions.
- You can create nested exception handlers.
- A `try`, `catch`, or `finally` block can define another `try-catch-finally` block. Theoretically, there is no limit on the allowed level of nesting of `try-catch-finally` blocks.

Categories of exceptions:

- Exceptions are divided into three categories: checked exceptions, runtime (or unchecked exceptions), and errors. These three categories share IS-A relationships (inheritance).
- Subclasses of the class `java.lang.RuntimeException` are categorized as runtime exceptions.
- Subclasses of the class `java.lang.Error` are categorized as errors.
- Subclasses of the class `java.lang.Exception` are categorized as checked exceptions if they are not subclasses of class `java.lang.Runtime`.
- The class `java.lang.RuntimeException` is a subclass of the class `java.lang.Exception`.
- The class `java.lang.Exception` is a subclass of the class `java.lang.Throwable`.
- The class `java.lang.Error` is also a subclass of the class `java.lang.Throwable`.
- The class `java.lang.Throwable` inherits the class `java.lang.Object`.

Checked exceptions:

- A checked exception is an unacceptable condition foreseen by the author of a method, but outside the immediate control of the code.
- `FileNotFoundException` is a checked exception. This exception is thrown if the file that the code is trying to access can't be found.
- All checked exceptions are a subclass of the `java.lang.Exception` class, not a subclass of `java.lang.RuntimeException`. It's interesting to note, however, that the class `java.lang.RuntimeException` itself is a subclass of the class `java.lang.Exception`.
- If a method calls another method that may throw a checked exception, either it must be enclosed within a `try-catch` block or the method should declare this exception to be thrown in its method signature.

Runtime exceptions:

- Runtime exceptions represent programming errors. These occur from inappropriate use of another piece of code. For example, `NullPointerException` is a

runtime exception that occurs when a piece of code tries to execute some code on a variable that hasn't been assigned an object and points to null. Another example is `ArrayIndexOutOfBoundsException`, which is thrown when a piece of code tries to access an array or list elements at a nonexistent position.

- A runtime exception is a subclass of `java.lang.RuntimeException`.
- A runtime exception isn't a part of the method signature, even if a method may throw it.
- A runtime exception may not necessarily be caught by a try-catch block.

Errors:

- An error is a serious exception, thrown by the JVM as a result of an error in the environment state, which processes your code. For example, `NoClassDefFoundError` is an error thrown by the JVM when it is unable to locate the .class file it is supposed to run.
- `StackOverflowError` is another error, thrown by the JVM when the size of the memory required by the stack of the Java program is greater than what the JRE has offered for the Java application. This error usually occurs as a result of infinite or highly nested loops.
- An error is a subclass of the class `java.lang.Error`.
- An error need not be a part of a method signature.
- Though you can handle the errors syntactically, there is little that you can do when these errors occur. For example, when the JVM throws `OutOfMemoryError`, your code execution will halt, even if you define an exception handler for it.

Commonly occurring exceptions, categories, and classes:

- For the OCA Java SE 7 Programmer I exam, you need to be aware of commonly occurring exception categories and classes, when are they thrown, whether you should handle them, and how to handle them.
- `ArrayIndexOutOfBoundsException` is a runtime exception that's thrown when a piece of code tries to access an array position out of its bounds—when an array is accessed either at a position less than 0 or at a position greater than or equal to its length.
- `IndexOutOfBoundsException` is a runtime exception that's thrown when a piece of code tries to access a list position that's out of its bounds—when the position is either less than 0 or greater than or equal to the list's size.
- The class `ArrayIndexOutOfBoundsException` extends the class `java.lang.IndexOutOfBoundsException`, which extends the class `java.lang.RuntimeException`.
- In typical programming conditions, the `ArrayIndexOutOfBoundsException` shouldn't be thrown programmatically.
- One of the main reasons for the JVM taking the responsibility for throwing this exception itself is that this exception isn't known until runtime and depends on

the array or list position that's being accessed by a piece of code. Most often, a variable is used to specify this array or list position, and its value may not be known until runtime.

- `ClassCastException` is a runtime exception. `java.lang.ClassCastException` extends `java.lang.RuntimeException`.
- `ClassCastException` is thrown when an object fails an IS-A test with the class type it is being cast to.
- You can use the operator `instanceof` to verify whether an object can be cast to another class before casting it.
- `IllegalArgumentException` is a runtime exception. `java.lang.IllegalArgumentException` extends `java.lang.RuntimeException`.
- `IllegalArgumentException` is thrown to specify that a method has been passed illegal or inappropriate arguments.
- Even though `IllegalArgumentException` is a runtime exception, programmers usually use this exception to validate the arguments that are passed to a method, and the exception constructor is passed a descriptive message specifying the exception details.
- `IllegalStateException` is a runtime exception. `java.lang.IllegalStateException` extends `java.lang.RuntimeException`.
- `IllegalStateException` may be thrown programmatically.
- As a programmer, you can throw `IllegalStateException` to signal to the calling method that the method that's being requested for execution isn't ready to start its execution or is in a state in which it can't execute.
- For example, you can throw `IllegalStateException` from your code if an application tries to modify an SMS that has already been sent.
- `NullPointerException` is a runtime exception. The class `java.lang.NullPointerException` extends `java.lang.RuntimeException`.
- `NullPointerException` is thrown by the JVM if you try to access a method or variable of an uninitialized reference variable.
- `NumberFormatException` is a runtime exception. `java.lang.NumberFormatException` extends `java.lang.IllegalArgumentException`. `java.lang.IllegalArgumentException` extends `java.lang.RuntimeException`.
- You can throw `NumberFormatException` from your own method to indicate that there's an issue with the conversion of a `String` value to a specified numeric format (decimal, octal, hexadecimal, or binary).
- Runtime exceptions arising from any of the following may throw `ExceptionInInitializerError`:
  - Execution of an anonymous static block
  - Initialization of a static variable
  - Execution of a static method (called from either of the previous two items)

- The error `ExceptionInInitializerError` can be thrown only by an object of a runtime exception.
- `ExceptionInInitializerError` can't be thrown if a static initializer block throws an object of a checked exception, because the Java compiler is intelligent enough to determine this condition and it doesn't allow you to throw an unhandled checked exception from a static initialization block.
- `StackOverflowError` is an error. `java.lang.StackOverflowError` extends `java.lang.VirtualMachineError`.
- Because `StackOverflowError` extends `VirtualMachineError`, it should be left to be managed by the JVM.
- The `StackOverflowError` error is thrown by the JVM when a Java program calls itself so many times that the memory stack allocated to execute the Java program "overflows."
- `NoClassDefFoundError` is an Error. `java.lang.NoClassDefFoundError` extends `java.lang.LinkageError`. `java.lang.LinkageError` extends `java.lang.Error`.
- `NoClassDefFoundError` is thrown by the JVM or a `ClassLoader` when it is unable to load the definition of a class required to create an object of the class.
- Don't confuse the exception thrown by `Class.forName()`, used to load the class, and `NoClassDefFoundError` thrown by the JVM. `Class.forName()` throws `ClassNotFoundException`.
- `OutOfMemoryError` is thrown by the JVM when it's unable to create objects on the heap and the garbage collector may not be able to free more memory for the JVM.

## 7.7 Sample exam questions

**Q7-1.** What is the output of the following code:

```
class Course {
 String courseName;
 Course() {
 Course c = new Course();
 c.courseName = "Oracle";
 }
}
class EJavaGuruPrivate2 {
 public static void main(String args[]) {
 Course c = new Course();
 c.courseName = "Java";
 System.out.println(c.courseName);
 }
}
```

- a The code will print Java.
- b The code will print Oracle.
- c The code will not compile.
- d The code will throw an exception or an error at runtime.

**Q7-2.** Select the correct option(s):

- a You cannot handle runtime exceptions.
- b You should not handle errors.
- c If a method throws a checked exception, it must be either handled by the method or specified in its throws clause.
- d If a method throws a runtime exception, it may include the exception in its throws clause.
- e Runtime exceptions are checked exceptions.

**Q7-3.** Examine the following code and select the correct option(s):

```
class EJavaGuruExcep2 {
 public static void main(String args[]) {
 EJavaGuruExcep2 var = new EJavaGuruExcep2();
 var.printArrValues(args);
 }
 void printArrValues(String[] arr) {
 try {
 System.out.println(arr[0] + ":" + arr[1]);
 }
 catch (NullPointerException e) {
 System.out.println("NullPointerException");
 }
 catch (IndexOutOfBoundsException e) {
 System.out.println("IndexOutOfBoundsException");
 }
 catch (ArrayIndexOutOfBoundsException e) {
 System.out.println("ArrayIndexOutOfBoundsException");
 }
 }
}
```

- a If the class EJavaGuruExcep2 is executed using the following command, it prints NullPointerException:

javaEJavaGuruExcep2

- b If the class EJavaGuruExcep2 is executed using the following command, it prints IndexOutOfBoundsException:

javaEJavaGuruExcep2

- c If the class EJavaGuruExcep2 is executed using the following command, it prints ArrayIndexOutOfBoundsException:

javaEJavaGuruExcep2one

- d The code will fail to compile.

**Q7-4.** What is the output of the following code?

```
class EJava {
 void method() {
 try {
```

```
 guru();
 return;
 }
 finally {
 System.out.println("finally 1");
 }
}
void guru() {
 System.out.println("guru");
 throw new StackOverflowError();
}
public static void main(String args[]) {
 EJava var = new EJava();
 var.method();
}
}

a guru
finally 1
b guru
finally 1
Exception in thread "main" java.lang.StackOverflowError
c guru
Exception in thread "main" java.lang.StackOverflowError
d guru
e The code fails to compile.
```

**Q7-5.** Select the incorrect statement(s):

- a Exceptions enable a developer to define the programming logic separate from the exception-handling code.
- b Exception handling speeds up execution of the code.
- c Exception handing is used to define code that should execute when a piece of code throws an exception.
- d Code that handles all the checked exceptions can still throw unchecked exceptions.

**Q7-6.** Select the incorrect statement(s):

- a `java.lang.Throwable` is the base class of all types of exceptions.
- b If a class is a subclass of `java.lang.Exception`, it may or may not be a checked exception.
- c `Error` is an unchecked exception.
- d `Error` and checked exceptions need not be part of a method signature.

**Q7-7.** What is the output of the following code?

```
class TryFinally {
 int tryAgain() {
 int a = 10;
```

```

 try {
 ++a;
 }
 finally {
 a++;
 }
 return a;
 }

 public static void main(String args[]) {
 System.out.println(new TryFinally().tryAgain());
 }
}

a 10
b 11
c 12
d Compilation error
e Runtime exception

```

**Q7-8.** What is the output of the following code?

```

class EJavaBase {
 void myMethod() throws ExceptionInInitializerError {
 System.out.println("Base");
 }
}
class EJavaDerived extends EJavaBase {
 void myMethod() throws RuntimeException {
 System.out.println("Derived");
 }
}
class EJava3 {
 public static void main(String args[]) {
 EJavaBase obj = new EJavaDerived();
 obj.myMethod();
 }
}

a Base
b Derived
c Derived
Base
d Base
Derived
e Compilation error

```

**Q7-9.** Which of the following statements are true?

- a A user-defined class may not throw an `IllegalStateException`. It must be thrown only by Java API classes.
- b `System.out.println` will throw `NullPointerException` if an uninitialized instance variable of type `String` is passed to it to print its value.

- c NumberFormatException is thrown by multiple methods from the Java API when invalid numbers are passed on as Strings to be converted to the specified number format.
- d ExceptionInInitializerError may be thrown by the JVM when a static initializer in your code throws a NullPointerException.

**Q7-10.** What is the output of the following code?

```
class EJava4 {
 void foo() {
 try {
 String s = null;
 System.out.println("1");
 try {
 System.out.println(s.length());
 }
 catch (NullPointerException e) {
 System.out.println("inner");
 }
 System.out.println("2");
 }
 catch (NullPointerException e) {
 System.out.println("outer");
 }
 }
 public static void main(String args[]) {
 EJava4 obj = new EJava4();
 obj.foo();
 }
}

a 1
 inner
 2
 outer
b 1
 outer
c 1
 inner
d 1
 inner
 2
```

## 7.8 Answers to sample exam questions

**Q7-1.** What is the output of the following code:

```
class Course {
 String courseName;
 Course() {
 Course c = new Course();
 c.courseName = "Oracle";
 }
}
```

```

 }
 class EJavaGuruPrivate2 {
 public static void main(String args[]) {
 Course c = new Course();
 c.courseName = "Java";
 System.out.println(c.courseName);
 }
 }
}

```

- a** The code will print Java.
- b** The code will print Oracle.
- c** The code will not compile.
- d** **The code will throw an exception or an error at runtime.**

Answer: d

Explanation: This class will throw `StackOverflowError` at runtime. The easiest way to look for a `StackOverflowError` is to locate recursive method calls. In the question's code, the constructor of the class `Course` creates an object of the class `Course`, which will call the constructor again. Hence, this becomes a recursive call and ends up throwing `StackOverflowError` at runtime. (As you know, an exception or an error can be thrown only at runtime, not compile time.)

**Q7-2.** Select the correct option(s):

- a** You cannot handle runtime exceptions.
- b** **You should not handle errors.**
- c** **If a method throws a checked exception, it must be either handled by the method or specified in its throws clause.**
- d** **If a method throws a runtime exception, it may include the exception in its throws clause.**
- e** Runtime exceptions are checked exceptions.

Answer: b, c, d

Explanation: Option (a) is incorrect. You can handle runtime exceptions the way you can handle a checked exception in your code: using a try-catch block.

Option (b) is correct. You shouldn't try to handle errors in your code. Or, to put it another way, you can't do much when an error is thrown by your code. Instead of trying to handle errors in your code, you should resolve the code that results in these errors. For example, `StackOverflowError` is an error that will be thrown by your code if your code executes a method recursively without any exit condition. This repetition will consume all the space on the stack and result in a `StackOverflowError`.

Option (c) is correct. If you fail to implement either of these options, your code won't compile.

Option (d) is correct. It isn't mandatory for runtime exceptions to be included in a method's `throws` clause. Usually this inclusion is unnecessary, but if you do include it, your code will execute without any issues.

Option (e) is incorrect. Runtime exception and all its subclasses are *not* checked exceptions.

**Q7-3.** Examine the following code and select the correct option(s):

```
class EJavaGuruExcep2 {
 public static void main(String args[]) {
 EJavaGuruExcep2 var = new EJavaGuruExcep2();
 var.printArrValues(args);
 }
 void printArrValues(String[] arr) {
 try {
 System.out.println(arr[0] + ":" + arr[1]);
 }
 catch (NullPointerException e) {
 System.out.println("NullPointerException");
 }
 catch (IndexOutOfBoundsException e) {
 System.out.println("IndexOutOfBoundsException");
 }
 catch (ArrayIndexOutOfBoundsException e) {
 System.out.println("ArrayIndexOutOfBoundsException");
 }
 }
}
```

- a If the class `EJavaGuruExcep2` is executed using the following command, it prints `NullPointerException`:

`javaEJavaGuruExcep2`

- b If the class `EJavaGuruExcep2` is executed using the following command, it prints `IndexOutOfBoundsException`:

`javaEJavaGuruExcep2`

- c If the class `EJavaGuruExcep2` is executed using the following command, it prints `ArrayIndexOutOfBoundsException`:

`javaEJavaGuruExcep2one`

- d **The code will fail to compile.**

Answer: d

Explanation: The key to answering this question is to be aware of the following two facts:

- Exceptions are classes. If an exception's base class is used in a catch block, it can catch all the exceptions of its derived class. If you try to catch an exception from its derived class afterward, the code won't compile.
- `ArrayIndexOutOfBoundsException` is a derived class of `IndexOutOfBoundsException`.

The rest of the points try to trick you into believing that the question is based on the arguments passed to a `main` method.

**Q7-4.** What is the output of the following code?

```
class EJava {
 void method() {
 try {
 guru();
 return;
 }
 finally {
 System.out.println("finally 1");
 }
 }
 void guru() {
 System.out.println("guru");
 throw new StackOverflowError();
 }
 public static void main(String args[]) {
 EJava var = new EJava();
 var.method();
 }
}

a guru
finally 1
b guru
finally 1
Exception in thread "main" java.lang.StackOverflowError
c guru
Exception in thread "main" java.lang.StackOverflowError
d guru
e The code fails to compile.
```

Answer: b

Explanation: No compilation errors exist with the code.

The method `guru` throws `StackOverflowError`, which is not a checked exception. Even though your code should not throw an error, it is possible syntactically. Your code will compile successfully.

The call to the method `guru` is immediately followed by the keyword `return`, which is supposed to end the execution of the method `method`. But the call to `guru` is placed within a `try-catch` block, with a `finally` block. Because `guru` doesn't handle the error `StackOverflowError` itself, the control looks for the exception handler in the method `method`. This calling method doesn't handle this error, but defines a `finally` block. The control then executes the `finally` block. Because the code can't find an appropriate handler to handle this error, it propagates to the JVM, which abruptly halts the code.

**Q7-5.** Select the incorrect statement(s):

- a Exceptions enable a developer to define the programming logic separate from the exception-handling code.

- b Exception handling speeds up execution of the code.**
- c Exception handling is used to define code that should execute when a piece of code throws an exception.**
- d Code that handles all the checked exceptions can still throw unchecked exceptions.**

Answer: b

Explanation: No direct relationship exists between exception handling and improved execution of code. Code that handles all the checked exceptions can throw unchecked exceptions and vice versa.

**Q7-6.** Select the incorrect statement(s):

- a java.lang.Throwable is the base class of all type of exceptions.**
- b If a class is a subclass of java.lang.Exception, it may or may not be a checked exception.**
- c Error is an unchecked exception.**
- d Error and checked exceptions need not be part of a method signature.**

Answer: c, d

Explanation:

Option (a) is a true statement. A checked exception is a subclass of `java.lang.Exception`, and a runtime exception is a subclass of `java.lang.RuntimeException`. `java.lang.RuntimeException` is a subclass of `java.lang.Exception`, and `java.lang.Exception` is a subclass of `java.lang.Throwable`. Hence, all the exceptions are subclasses of `java.lang.Throwable`.

Option (b) is also a true statement. Unchecked exceptions are subclasses of class `java.lang.RuntimeException`, which itself is a subclass of `java.lang.Exception`. Hence, a class can be a subclass of class `java.lang.Exception` and either a checked or an unchecked exception.

Option (c) is a false statement. `Error` is *not* an exception. It does not subclass `java.lang.Exception`.

Option (d) is also a false statement. `Error` need not be part of a method signature, but checked exceptions must be a part of the method signatures.

**Q7-7.** What is the output of the following code?

```
class TryFinally {
 int tryAgain() {
 int a = 10;
 try {
 ++a;
 }
 finally {
 a++;
 }
 return a;
 }
}
```

```

 public static void main(String args[]) {
 System.out.println(new TryFinally().tryAgain());
 }
 }

 a 10
 b 11
 c 12
 d Compilation error
 e Runtime exception
}

```

Answer: c

Explanation: The `try` block executes, incrementing the value of variable `a` to 11. This step is followed by execution of the `finally` block, which also increments the value of variable `a` by 1, to 12. The method `tryAgain` returns the value 12, which is printed by the method `main`.

There are no compilation issues with the code. A `try` block can be followed by a `finally` block, without any `catch` blocks. Even though the `try` block doesn't throw any exceptions, it compiles successfully. The following is an example of a `try-catch` block that won't compile because it tries to *catch* a checked exception that's never thrown by the `try` block:

```

try {
 ++a;
}
catch (java.io.FileNotFoundException e) {
}

```

**Q7-8.** What is the output of the following code?

```

class EJavaBase {
 void myMethod() throws ExceptionInInitializerError {
 System.out.println("Base");
 }
}
class EJavaDerived extends EJavaBase {
 void myMethod() throws RuntimeException {
 System.out.println("Derived");
 }
}
class EJava3 {
 public static void main(String args[]) {
 EJavaBase obj = new EJavaDerived();
 obj.myMethod();
 }
}

 a Base
 b Derived
 c Derived
 Base
}

```

- d Base  
Derived
- e Compilation error

Answer: b

Explanation: The rule that if a base class method doesn't throw an exception, an overriding method in the derived class can't throw an exception applies only to checked exceptions. It doesn't apply to runtime (unchecked) exceptions or errors. A base or overridden method is free to throw any Error or runtime exception.

**Q7-9.** Which of the following statements are true?

- a A user-defined class may not throw an `IllegalStateException`. It must be thrown only by Java API classes.
- b `System.out.println` will throw `NullPointerException` if an uninitialized instance variable of type `String` is passed to it to print its value.
- c **NumberFormatException is thrown by multiple methods from the Java API when invalid numbers are passed on as Strings to be converted to the specified number format.**
- d **ExceptionInInitializerError may be thrown by the JVM when a static initializer in your code throws a NullPointerException.**

Answer: c, d

Option (a) is incorrect. A user-defined class can throw any exception from the Java API.

Option (b) is incorrect. An uninitialized instance variable of type `String` will be assigned a default value of `null`. When you pass this variable to `System.out.println` to print it, it will print `null`. If you try to access any member (variable or method) of this `null` object, then `NullPointerException` will be thrown.

**Q7-10.** What is the output of the following code?

```
class EJava4 {
 void foo() {
 try {
 String s = null;
 System.out.println("1");
 try {
 System.out.println(s.length());
 }
 catch (NullPointerException e) {
 System.out.println("inner");
 }
 System.out.println("2");
 }
 catch (NullPointerException e) {
 System.out.println("outer");
 }
 }
 public static void main(String args[]) {
```

```
 EJava4 obj = new EJava4();
 obj.foo();
}
}

a 1
inner
2
outer

b 1
outer

c 1
inner

d 1
inner
2
```

Answer: d

Explanation: First of all, nested try-catch statements don't throw compilation errors.

Because the variable s hasn't been initialized, an attempt to access its method length() will throw a NullPointerException. The inner try-catch block handles this exception and prints inner. The control then moves on to complete the remaining code in the outer try-catch block, printing 2. Because the NullPointerException was already handled in the inner try-catch block, it's not handled in the outer try-catch block.

# *Full mock exam*



## **This chapter covers**

- Complete mock exam with 90 questions
- Answers to all mock exam questions with extensive explanations and the subobjective on which each exam question is based

On the real exam, each question displays the count of correct options that you should select. The exam engine won't allow you to select more answer options than are specified by this number. If you try to do so, a warning will be displayed. The questions in this mock exam also specify the correct number of answer options to align it more closely to the real exam.

## **8.1 Mock exam**

**ME-Q1.** Given the following definition of the classes Animal, Lion, and Jumpable, select the correct combinations of assignments of a variable (select 2 options):

```
interface Jumpable {}
class Animal {}
class Lion extends Animal implements Jumpable {}
```

- a Jumpable var1 = new Jumpable();
- b Animal var2 = new Animal();

- c** Lion var3 = new Animal();
- d** Jumpable var4 = new Animal();
- e** Jumpable var5 = new Lion();

**ME-Q2.** Which of the following statements are true? (Select 3 options.)

- a** A Java class can define multiple methods.
- b** A Java class can define multiple variables.
- c** A Java class can be defined in multiple packages.
- d** A Java class can import multiple packages.
- e** A Java class can't define more than 108 constructors.
- f** End-of-line comments can't follow import or package statements.
- g** Multiline comments can only be defined within a method definition.

**ME-Q3.** Given the following code, which option, if used to replace /\* INSERT CODE HERE \*/, will make the code print 1? (Select 1 option.)

```
try {
 String[][] names = {{ "Andre", "Mike"}, null, {"Pedro"}};
 System.out.println(names[2][1].substring(0, 2));
}
catch /* INSERT CODE HERE */ {
 System.out.println(1);
}

 a IndexPositionException e
 b NullPointerException e
 c ArrayIndexOutOfBoundsException e
 d ArrayOutOfBoundsException e
```

**ME-Q4.** What is the output of the following code? (Select 1 option.)

```
int a = 10; String name = null;
try {
 a = name.length();
 a++;
}
catch (RuntimeException e){
 ++a;
}
System.out.println(a);

 a 5
 b 6
 c 10
 d 11
 e 12
 f Runtime exception
```

**ME-Q5.** Given the following class definition,

```
class Student { int marks = 10; }
```

what is the output of the following code? (Select 1 option.)

```
class Result {
 public static void main(String... args) {
 Student s = new Student();
 switch (s.marks) {
 default: System.out.println("100");
 case 10: System.out.println("10");
 case 98: System.out.println("98");
 }
 }
}
```

- a** 100  
10  
98
- b** 10  
98
- c** 100
- d** 10

**ME-Q6.** Given the following code, which code can be used to create and initialize an object of class ColorPencil? (Select 2 options.)

```
class Pencil {}
class ColorPencil extends Pencil {
 String color;
 ColorPencil(String color) {this.color = color;}
}

 a ColorPencil var1 = new ColorPencil();
 b ColorPencil var2 = new ColorPencil(RED);
 c ColorPencil var3 = new ColorPencil("RED");
 d Pencil var4 = new ColorPencil("BLUE");
```

**ME-Q7.** What is the output of the following code? (Select 1 option.)

```
class Doctor {
 protected int age;
 protected void setAge(int val) { age = val; }
 protected int getAge() { return age; }
}
class Surgeon extends Doctor {
 Surgeon(String val) {
 specialization = val;
 }
 String specialization;
 String getSpecialization() { return specialization; }
}
```

```

class Hospital {
 public static void main(String args[]) {
 Surgeon s1 = new Surgeon("Liver");
 Surgeon s2 = new Surgeon("Heart");
 s1.age = 45;
 System.out.println(s1.age + s2.getSpecialization());
 System.out.println(s2.age + s1.getSpecialization());
 }
}

 a 45Heart
 b 45Liver
 c 45Liver
 d 45Heart
 e Class fails to compile.

```

**ME-Q8.** What is the output of the following code? (Select 1 option.)

```

class RocketScience {
 public static void main(String args[]) {
 int a = 0;
 while (a == a++) {
 a++;
 System.out.println(a);
 }
 }
}

```

- a The while loop won't execute; nothing will be printed.
- b The while loop will execute indefinitely, printing all numbers, starting from 1.
- c The while loop will execute indefinitely, printing all even numbers, starting from 0.
- d The while loop will execute indefinitely, printing all even numbers, starting from 2.
- e The while loop will execute indefinitely, printing all odd numbers, starting from 1.
- f The while loop will execute indefinitely, printing all odd numbers, starting from 3.

**ME-Q9.** Given the following statements,

- com.ejava is a package
- class Person is defined in package com.ejava
- class Course is defined in package com.ejava

which of the following options correctly imports the classes Person and Course in the class MyEJava? (Select 3 options.)

- a** import com.ejava.\*;  
class MyEJava {}
- b** import com.ejava;  
class MyEJava {}
- c** import com.ejava.Person;  
import com.ejava.Course;  
class MyEJava {}
- d** import com.ejava.Person;  
import com.ejava.\*;  
class MyEJava {}

**ME-Q10.** Given that the following classes Animal and Forest are defined in the same package, examine the code and select the correct statements (select 2 options):

```
line1> class Animal {
line2> public void printKing() {
line3> System.out.println("Lion");
line4> }
line5> }

line6> class Forest {
line7> public static void main(String... args) {
line8> Animal anAnimal = new Animal();
line9> anAnimal.printKing();
line10> }
line11> }
```

- a** The class Forest prints Lion.
- b** If the code on line 2 is changed as follows, the class Forest will print Lion:  

```
private void printKing() {
```
- c** If the code on line 2 is changed as follows, the class Forest will print Lion:  

```
void printKing() {
```
- d** If the code on line 2 is changed as follows, the class Forest will print Lion:  

```
default void printKing() {
```

**ME-Q11.** Which of the following statements are true? (Select 2 options.)

- a** Given that you changed the access of a public method B, in class A, to a private method, class C that uses method B will fail to compile.
- b** Given that you changed the access of a private method B, in class A, to a public method, none of the classes that use class A will fail to compile.
- c** Given that you changed the access of a protected method B, in class A, to a method with default access, class C from the same package as class A won't be able to access method B.
- d** A change in the accessibility of the methods in your class never affects any other class that uses your class.

**ME-Q12.** Which of the following statements are correct? (Select 3 options.)

- a** You may not be able to handle all the checked exceptions in your code.
- b** If required, you can handle all the runtime exceptions in your code.
- c** You can handle an exception in your code even if you don't know its exact name.
- d** A single exception handler can be used to handle all types of runtime and checked exceptions.
- e** You must handle all errors that can be thrown by your code.
- f** Runtime exceptions are also known as checked exceptions.

**ME-Q13.** Given the following code,

```
class MainMethod {
 public static void main(String... args) {
 System.out.println(args[0]+":"+ args[2]);
 }
}
```

what's its output if it's executed using the following command? (Select 1 option.)

java MainMethod 1+2 2\*3 4-3 5+1

- a** java:1+2
- b** java:3
- c** MainMethod:2\*3
- d** MainMethod:6
- e** 1+2:2\*3
- f** 3:3
- g** 6
- h** 1+2:4-3
- i** 31
- j** 4

**ME-Q14.** What is the output of the following code? (Select 1 option.)

```
class Person {
 int age;
 float height;
 boolean result;
 String name;
}
public class EJava {
 public static void main(String arguments[]) {
 Person person = new Person();
 System.out.println(person.name + person.height + person.result
 + person.age);
 }
}

 a null0.0false0
 b null0false0
```

- c null0.Offalse0
- d 0.Offalse0
- e 0false0
- f 0.Offalse0
- g null0.0true0
- h 0true0
- i 0.0ftrue0

**ME-Q15.** Given the following code, which option, if used to replace /\* INSERT CODE HERE \*/ , will make the code print the value of the variable pagesPerMin? (Select 1 option.)

```
class Printer {
 int inkLevel;
}
class LaserPrinter extends Printer {
 int pagesPerMin;
 public static void main(String args[]) {
 Printer myPrinter = new LaserPrinter();
 System.out.println(/* INSERT CODE HERE */);
 }
}
```

- a (LaserPrinter)myPrinter.pagesPerMin
- b myPrinter.pagesPerMin
- c LaserPrinter.myPrinter.pagesPerMin
- d ((LaserPrinter)myPrinter).pagesPerMin

**ME-Q16.** Which statements describe the use of exception handling in Java? (Select 2 options.)

- a Exception handling can prevent an application from crashing or producing incorrect outputs or incorrect input values.
- b Exception handlers can't define an alternative flow of action in the event of an exception.
- c Exception handlers enable a programmer to define separate code blocks for handling different types of exceptions.
- d Exception handlers help to define well-encapsulated classes.
- e Exception handlers help with efficient inheritance.

**ME-Q17.** Which statements are true for reference and primitive variables? (Select 3 options.)

- a The names of the reference variables are limited to a length of 256 characters.
- b There is no limit on the length of the names of primitive variables.
- c Multiple reference variables may refer to exactly the same object in memory.
- d Values stored by primitive and reference variables can be compared for equality by using the equals operator (==) or by using the method equals.
- e A primitive variable can't refer to an object and vice versa.

**ME-Q18.** What is the output of the following code? (Select 1 option.)

```
public class Handset {
 public static void main(String... args) {
 double price;
 String model;
 System.out.println(model + price);
 }
}
```

- a** null0
- b** null0.0
- c** 0
- d** 0.0
- e** Compilation error

**ME-Q19.** What is the output of the following code? (Select 1 option.)

```
public class Sales {
 public static void main(String args[]) {
 int salesPhone = 1;
 System.out.println(salesPhone++ + ++salesPhone +
 ++salesPhone);
 }
}
```

- a** 5
- b** 6
- c** 8
- d** 9

**ME-Q20.** Which of the following options defines the correct structure of a Java class? (Select 1 option.)

- a** package com.ejava.guru;
 package com.ejava.oracle;
 class MyClass { }
- b** import com.ejava.guru.\*;
 import com.ejava.oracle.\*;
 package com.ejava;
 class MyClass { }
- c** class MyClass {
 import com.ejava.guru.\*;
 }
- d** class MyClass {
 int abc;
 }

**ME-Q21.** What is the output of the following code? (Select 1 option.)

```
class OpPre {
 public static void main(String... args) {
 int x = 10;
```

```

 int y = 20;
 int z = 30;
 if (x+y%z > (x+(-y)*(-z))) {
 System.out.println(x + y + z);
 }
 }
}

 a 60
 b 59
 c 61
 d No output.
 e The code fails to compile.

```

**ME-Q22.** Select the most appropriate definition of the variable name and the line number on which it should be declared so that the following code compiles successfully (choose 1 option):

```

class EJava {
 // LINE 1
 public EJava() {
 System.out.println(name);
 }
 void calc() {
 // LINE 2
 if (8 > 2) {
 System.out.println(name);
 }
 }
 public static void main(String... args) {
 // LINE 3
 System.out.println(name);
 }
}

```

- a Define static String name; on line 1.
- b Define String name; on line 1.
- c Define String name; on line 2.
- d Define String name; on line 3.

**ME-Q23.** Examine the following code and select the correct statement (choose 1 option):

```

line1> class Emp {
line2> Emp mgr = new Emp();
line3> }
line4> class Office {
line5> public static void main(String args[]) {
line6> Emp e = null;
line7> e = new Emp();
line8> e = null;
line9> }
line10> }

```

- a The object referred to by object e is eligible for garbage collection on line 8.
- b The object referred to by object e is eligible for garbage collection on line 9.
- c The object referred to by object e isn't eligible for garbage collection because its member variable mgr isn't set to null.
- d The code throws a runtime exception and the code execution never reaches line 8 or 9.

**ME-Q24.** Which of the following is the correct declaration of a method that accepts two String arguments and an int argument and doesn't return any value? (Select 2 options.)

- a void myMethod(String str1, int str2, String str3)
- b myMethod(String val1, int val2, String val3)
- c void myMethod(String str1, str2, int a)
- d void myMethod(String val1, val2, int val3)
- e void myMethod(int str2, String str3, String str1)

**ME-Q25.** Which of the following will compile successfully? (Select 3 options.)

- a int eArr1[] = {10, 23, 10, 2};
- b int[] eArr2 = new int[10];
- c int[] eArr3 = new int[] {};
- d int[] eArr4 = new int[10] {};
- e int eArr5[] = new int[2] {10, 20};

**ME-Q26.** Assume that Oracle has asked you to create a method that returns the concatenated value of two String objects. Which of the following methods do you think can accomplish this job? (Select 2 options.)

- a public String add(String 1, String 2) {
   
 return str1 + str2;
 }
- b private String add(String s1, String s2) {
   
 return s1.concat(s2);
 }
- c protected String add(String value1, String value2) {
   
 return value2.append(value2);
 }
- d String subtract(String first, String second) {
   
 return first.concat(second.substring(0));
 }

**ME-Q27.** In Java, the class String is defined in the package java.lang, and this package is automatically imported in all the Java classes. Given this statement, which of the following options represents the correct definition of class EJava, which can define a variable of class String? (Choose 2 options.)

- a** import java.lang;  
    class EJava {  
        String guru;  
    }
- b** import java.lang.String.\*;  
    class EJava {  
        String guru;  
    }
- c** class EJava {  
    String guru;  
}
- d** import java.lang.String;  
    import java.lang.String;  
    class EJava {  
        String guru;  
    }

**ME-Q28.** Given the following definitions of the class ChemistryBook, select the statements that are correct individually (choose 2 options):

```
import java.util.ArrayList;
class ChemistryBook extends Book {
 public void read() {} //METHOD1
 public String read() { return null; } //METHOD2
 ArrayList read(int a) { return null; } //METHOD3
}
```

- a** Methods marked with //METHOD1 and //METHOD2 are correctly overloaded methods.
- b** Methods marked with //METHOD2 and //METHOD3 are correctly overloaded methods.
- c** Methods marked with //METHOD1 and //METHOD3 are correctly overloaded methods.
- d** All the methods—methods marked with //METHOD1, //METHOD2, and //METHOD3—are correctly overloaded methods.

**ME-Q29)** Given the following definition of the class Home, select the correct statements (choose 4 options):

```
class Home {
 String name;
 int rooms;
 Home() {}
}
```

- a** The class Home will be provided a default constructor.
- b** The class Home won't be provided a default constructor.
- c** A default constructor can't coexist with overloaded constructors.
- d** A default constructor doesn't accept any method parameters.
- e** After compilation, the class Home has only a no-argument constructor.

- f** After compilation, the class Home has two constructors: a no-argument constructor and a default constructor.
- g** When an object of class Home is created, its variables name and rooms are not assigned any default values.

**ME-Q30.** Given the following code, which option, if used to replace /\* INSERT CODE HERE \*/, will make the code print numbers that are completely divisible by 14? (Select 1 option.)

```
for (int ctr = 2; ctr <= 30; ++ctr) {
 if (ctr % 7 != 0)
 //INSERT CODE HERE
 if (ctr % 14 == 0)
 System.out.println(ctr);
}
```

- a** continue;
- b** exit;
- c** break;
- d** end;

**ME-Q31.** Ideally, which of the following should never be handled by an exception handler? (Select 2 options.)

- a** StackOverflowError
- b** OutOfMemoryError
- c** ArrayIndexOutOfBoundsException
- d** ClassLoadingException
- e** CompilationError
- f** OutOfStorageError

**ME-Q32.** What is the output of the following code? (Select 1 option.)

```
public class MyCalendar {
 public static void main(String arguments[]) {
 Season season1 = new Season();
 season1.name = "Spring";

 Season season2 = new Season();
 season2.name = "Autumn";

 season1 = season2;
 System.out.println(season1.name);
 System.out.println(season2.name);
 }
}
class Season {
 String name;
}
```

- a String  
Autumn
- b Spring  
String
- c Autumn  
Autumn
- d Autumn  
String

**ME-Q33.** What is true about the following code? (Select 1 option.)

```
class Shoe {}
class Boot extends Shoe {}
class ShoeFactory {
 ShoeFactory(Boot val) {
 System.out.println("boot");
 }
 ShoeFactory(Shoe val) {
 System.out.println("shoe");
 }
}
```

- a The class ShoeFactory has a total of two overloaded constructors.
- b The class ShoeFactory has three overloaded constructors, two user-defined constructors, and one default constructor.
- c The class ShoeFactory will fail to compile.
- d The addition of the following constructor will increment the number of constructors of the class ShoeFactory to 3:

```
private ShoeFactory (Shoe arg) {}
```

**ME-Q34.** Given the following definitions of the classes ColorPencil and TestColor, which option, if used to replace /\* INSERT CODE HERE \*/, will initialize the instance variable color of reference variable myPencil with the String literal value "RED"? (Select 1 option.)

```
class ColorPencil {
 String color;
 ColorPencil(String color) {
 //INSERT CODE HERE
 }
}
class TestColor {
 ColorPencil myPencil = new ColorPencil("RED");
}

 a this.color = color;
 b color = color;
 c color = RED;
 d this.color = RED;
```

**ME-Q35.** What is the output of the following code? (Select 1 option.)

```
class EJavaCourse {
 String courseName = "Java";
}
class University {
 public static void main(String args[]) {
 EJavaCourse courses[] = { new EJavaCourse(), new EJavaCourse() };
 courses[0].courseName = "OCA";
 for (EJavaCourse c : courses) c = new EJavaCourse();
 for (EJavaCourse c : courses) System.out.println(c.courseName);
 }
}
```

- a** Java  
Java
- b** OCA  
Java
- c** OCA  
OCA
- d** None of the above.

**ME-Q36.** Given the following code, which option, if used to replace /\* INSERT CODE HERE \*/ , will make the code print the value of the variable screenSize? (Select 1 option.)

```
class Tablet {
 float screenSize = 7.0f;
 float getScreenSize() {
 return screenSize;
 }
 void setScreenSize(float val) {
 screenSize = val;
 }
}

class DemoTabs {
 public static void main(String args[]) {
 Tablet tab = new Tablet();
 System.out.println(/* INSERT CODE HERE */);
 }
}
```

- a** tab.screenSize
- b** tab->getScreensize()
- c** tab::getScreen()
- d** tab:screenSize

**ME-Q37.** Given the following definitions of the class Person and the interface Movable, the task is to declare a class Emp that inherits from the class Person and implements the interface Movable. Select the correct option to accomplish this task (choose 1 option):

```
class Person {}
interface Movable {}

 a class Emp implements Person extends Movable{}
 b class Emp implements Person, Movable{}
 c class Emp extends Person implements Movable{}
 d class Emp extends Person, Movable{}
```

**ME-Q38.** What is the output of the following code? (Select 1 option.)

```
class Phone {
 static void call() {
 System.out.println("Call-Phone");
 }
}
class SmartPhone extends Phone{
 static void call() {
 System.out.println("Call-SmartPhone");
 }
}
class TestPhones {
 public static void main(String... args) {
 Phone phone = new Phone();
 Phone smartPhone = new SmartPhone();
 phone.call();
 smartPhone.call();
 }
}

 a Call-Phone
 Call-Phone
 b Call-Phone
 Call-SmartPhone
 c Call-Phone
 null
 d null
 Call-SmartPhone
```

**ME-Q39.** Given the following code, which of the following statements are true? (Select 3 options.)

```
class MyExam {
 void question() {
 try {
 question();
 }
 catch (StackOverflowError e) {
 System.out.println("caught");
 }
 }
 public static void main(String args[]) {
 new MyExam().question();
 }
}
```

- a The code will print caught.
- b The code won't print caught.
- c The code would print caught if StackOverflowError were a runtime exception.
- d The code would print caught if StackOverflowError were a checked exception.
- e The code will print caught if question() throws exception NullPointerException.

**ME-Q40.** A class Student is defined as follows:

```
public class Student {
 private String fName;
 private String lName;
 public Student(String first, String last) {
 fName = first; lName = last;
 }
 public String getName() { return fName + lName; }
}
```

The creator of the class later changes the method getName as follows:

```
public String getName() {
 return fName + " " + lName;
}
```

What are the implications of this change? (Select 2 options.)

- a The classes that were using the class Student will fail to compile.
- b The classes that were using the class Student will work without any compilation issues.
- c The class Student is an example of a well-encapsulated class.
- d The class Student exposes its instance variable outside the class.

**ME-Q41.** What is the output of the following code? (Select 1 option.)

```
class ColorPack {
 int shadeCount = 12;
 static int getShadeCount() {
 return shadeCount;
 }
}
class Artist {
 public static void main(String args[]) {
 ColorPack pack1 = new ColorPack();
 System.out.println(pack1.getShadeCount());
 }
}

 a 10
 b 12
 c No output
 d Compilation error
```

**ME-Q42.** Paul defined his Laptop and Workshop classes to upgrade his laptop's memory. Do you think he succeeded? What is the output of this code? (Select 1 option.)

```
class Laptop {
 String memory = "1GB";
}
class Workshop {
 public static void main(String args[]) {
 Laptop life = new Laptop();
 repair(life);
 System.out.println(life.memory);
 }
 public static void repair(Laptop laptop) {
 laptop.memory = "2GB";
 }
}
```

- a** 1 GB
- b** 2 GB
- c** Compilation error
- d** Runtime exception

**ME-Q43.** What is the output of the following code? (Select 1 option.)

```
public class Application {
 public static void main(String... args) {
 double price = 10;
 String model;
 if (price > 10)
 model = "Smartphone";
 else if (price <= 10)
 model = "landline";
 System.out.println(model);
 }
}
```

- a** landline
- b** Smartphone
- c** No output
- d** Compilation error

**ME-Q44.** What is the output of the following code? (Select 1 option.)

```
class EString {
 public static void main(String args[]) {
 String eVal = "123456789";
 System.out.println(eVal.substring(eVal.indexOf("2"), eVal.indexOf("0")).concat
 ("0"));
 }
}
```

- a 234567890
- b 34567890
- c 234456789
- d 3456789
- e Compilation error
- f Runtime exception

**ME-Q45.** Examine the following code and select the correct statements (choose 2 options):

```
class Artist {
 Artist assistant;
}
class Studio {
 public static void main(String... args) {
 Artist a1 = new Artist();
 Artist a2 = new Artist();
 a2.assistant = a1;
 a2 = null; // Line 1
 } // Line 2
}
```

- a At least two objects are garbage collected on line 1.
- b At least one object is garbage collected on line 1.
- c No objects are garbage collected on line 1.
- d The number of objects that are garbage collected on line 1 is unknown.
- e At least two objects are eligible for garbage collection on line 2.

**ME-Q46.** What is the output of the following code? (Select 1 option.)

```
class Book {
 String ISBN;
 Book(String val) {
 ISBN = val;
 }
}
class TestEquals {
 public static void main(String... args) {
 Book b1 = new Book("1234-4657");
 Book b2 = new Book("1234-4657");
 System.out.print(b1.equals(b2) + ":");
 System.out.print(b1 == b2);
 }
}
```

- a true:false
- b true:true
- c false:true
- d false:false
- e Compilation error—there is no equals method in the class Book.

**ME-Q47.** Which of the following statements are correct? (Select 2 options.)

- a** `StringBuilder sb1 = new StringBuilder()` will create a `StringBuilder` object with no characters, but with an initial capacity to store 16 chars.
- b** `StringBuilder sb1 = new StringBuilder(5*10)` will create a `StringBuilder` object with a value 50.
- c** Unlike the class `String`, the `concat` method in `StringBuilder` modifies the value of a `StringBuilder` object.
- d** The `insert` method can be used to insert a character, number, or `String` at the start or end or at a specified position of a `StringBuilder` object.

**ME-Q48.** Given the following definition of the class `Animal` and the interface `Jump`, select the correct array declarations and initialization (choose 3 options):

```
interface Jump {}
class Animal implements Jump {}
```

- a** `Jump eJump1[] = {null, new Animal()}`;
- b** `Jump[] eJump2 = new Animal()[22];`
- c** `Jump[] eJump3 = new Jump[10];`
- d** `Jump[] eJump4 = new Animal[87];`
- e** `Jump[] eJump5 = new Jump()[12];`

**ME-Q49.** What is the output of the following code? (Select 1 option.)

```
import java.util.*;
class EJGArrayL {
 public static void main(String args[]) {
 ArrayList<String> seasons = new ArrayList<String>();
 seasons.add(1, "Spring"); seasons.add(2, "Summer");
 seasons.add(3, "Autumn"); seasons.add(4, "Winter");
 seasons.remove(2);

 for (String s : seasons)
 System.out.print(s + ", ");
 }
}
```

- a** Spring, Summer, Winter,
- b** Spring, Autumn, Winter,
- c** Autumn, Winter,
- d** Compilation error
- e** Runtime exception

**ME-Q50.** What is the output of the following code? (Select 1 option.)

```
class EIF {
 public static void main(String args[]) {
 boolean boolean = false;
 if (boolean = true)
 System.out.println("true");
```

```

 else
 System.out.println("false");
 }
}

```

- a The class will print true.
- b The class will print false.
- c The class will print true if the if condition is changed to boolean == true.
- d The class will print false if the if condition is changed to boolean != true.
- e The class won't compile.

**ME-Q51.** How many Fish did the Whale (defined as follows) manage to eat? Examine the following code and select the correct statements (choose 2 options):

```

class Whale {
 public static void main(String args[]) {
 boolean hungry = false;
 while (hungry=true) {
 ++Fish.count;
 }
 System.out.println(Fish.count);
 }
}
class Fish {
 static byte count;
}

```

- a The code doesn't compile.
- b The code doesn't print a value.
- c The code prints 0.
- d Changing ++Fish.count to Fish.count++ will give the same results.

**ME-Q52.** Given the following code, which option, if used to replace /\* INSERT CODE HERE \*/, will make the code print the name of the phone with the position at which it's stored in the array phone? (Select 1 option.)

```

class Phones {
 public static void main(String args[]) {
 String phones[] = {"BlackBerry", "Android", "iPhone"};
 for (String phone : phones)
 /* REPLACE CODE HERE */
 }
}

```

- a System.out.println(phones.count + ":" + phone);
- b System.out.println(phones.counter + ":" + phone);
- c System.out.println(phones.getPosition() + ":" + phone);
- d System.out.println(phones.getCtr() + ":" + phone);
- e System.out.println(phones.getCount() + ":" + phone);
- f System.out.println(phones.pos + ":" + phone);
- g None of the above

**ME-Q53.** Which of the following classes represent runtime exceptions in Java (select 4 options):

- a RuntimeException
- b CheckedException
- c NullPointerException
- d ArrayIndexOutOfBoundsException
- e CompilationException
- f Throwable
- g StackOverflowException
- h MemoryOutOfBoundsException
- i IllegalArgumentException
- j NumberFormatException

**ME-Q54.** What is the output of the following code? (Select 1 option.)

```
class Book {
 String ISBN;
 Book(String val) {
 ISBN = val;
 }
 public boolean equals(Object b) {
 if (b instanceof Book) {
 return ((Book)b).ISBN.equals(ISBN);
 }
 else
 return false;
 }
}
class TestEquals {
 public static void main(String args[]) {
 Book b1 = new Book("1234-4657");
 Book b2 = new Book("1234-4657");
 System.out.print(b1.equals(b2) +":");
 System.out.print(b1 == b2);
 }
}
 a true:false
 b true:true
 c false:true
 d false:false
```

**ME-Q55.** What is the output of the following code? (Select 1 option.)

```
int a = 10;
for (; a <= 20; ++a) {
 if (a%3 == 0) a++;
 else if (a%2 == 0) a=a*2;
 System.out.println(a);
}
```

- a** 11  
13  
15  
17  
19
- b** 20
- c** 11  
14  
17  
20
- d** 40
- e** Compilation error

**ME-Q56.** Given the following code, which option, if used to replace /\* INSERT CODE HERE \*/, will define an overloaded rideWave method (select 1 option):

```
class Raft {
 public String rideWave() { return null; }
 //INSERT CODE HERE
}
```

- a** public String[] rideWave() { return null; }
- b** protected void riceWave(int a) {}
- c** private void rideWave(int value, String value2) {}
- d** default StringBuilder rideWave(StringBuffer a) { return null; }

**ME-Q57.** Given the following code, which option, if used to replace /\* INSERT CODE HERE \*/, will correctly calculate the sum of all the even numbers in the array num and store it in variable sum? (Select 1 option.)

```
int num[] = {10, 15, 2, 17};
int sum = 0;
for (int number : num) {
 //INSERT CODE HERE
 sum += number;
}
```

- a** if (number % 2 == 0)
 continue;
- b** if (number % 2 == 0)
 break;
- c** if (number % 2 != 0)
 continue;
- d** if (number % 2 != 0)
 break;

**ME-Q58.** What is the output of the following code? (Select 1 option.)

```
class Op {
 public static void main(String... args) {
 int a = 0;
```

```
int b = 100;
if (!b++ > 100 && a++ == 10) {
 System.out.println(a+b);
}
}
```

- a 100
- b 101
- c 102
- d Code fails to compile.
- e No output is produced.

**ME-Q59.** Given the following definitions of the interfaces `Movable` and `Jumpable`, the task is to declare a class `Person` that inherits both of these interfaces. Which of the following code snippets will accomplish this task? (Select 2 options.)

```
interface Movable {}
interface Jumpable {}
```

- a interface Movable {}
 interface Jumpable {}
 class Person implements Movable, Jumpable {}
- b interface Movable {}
 interface Jumpable {}
 class Person extends Movable, Jumpable {}
- c interface Movable {}
 interface Jumpable {}
 class Person implements Movable extends Jumpable {}
- d interface Movable {}
 interface Jumpable implements Movable {}
 class Person implements Jumpable {}
- e interface Movable {}
 interface Jumpable extends Movable {}
 class Person implements Jumpable {}

**ME-Q60.** Choose the option that meets the following specification: Create a well-encapsulated class `Pencil` with one instance variable `model`. The value of `model` should be accessible and modifiable outside `Pencil`. (Select 1 option.)

- a class Pencil {
 public String model;
}
- b class Pencil {
 public String model;
 public String getModel() { return model; }
 public void setModel(String val) { model = val; }
}

**c** class Pencil {  
 private String model;  
 public String getModel() { return model; }  
 public void setModel(String val) { model = val; }  
}  
 **d** class Pencil {  
 public String model;  
 private String getModel() { return model; }  
 private void setModel(String val) { model = val; }  
}

**ME-Q61.** What is the output of the following code? (Select 1 option.)

```
class Phone {
 void call() {
 System.out.println("Call-Phone");
 }
}
class SmartPhone extends Phone{
 void call() {
 System.out.println("Call-SmartPhone");
 }
}
class TestPhones {
 public static void main(String[] args) {
 Phone phone = new Phone();
 Phone smartPhone = new SmartPhone();
 phone.call();
 smartPhone.call();
 }
}
```

- a** Call-Phone  
 Call-Phone
- b** Call-Phone  
 Call-SmartPhone
- c** Call-Phone  
 null
- d** null  
 Call-SmartPhone

**ME-Q62.** Given the following requirements, choose the best looping construct to implement them (choose 1 option):

Step 1: Meet the director of Oracle.

Step 2: Schedule another meeting with the director.

Step 3: Repeat steps 1 and 2, as long as more meetings are required.

- a** for loop
- b** enhanced for loop
- c** do-while loop
- d** while loop

**ME-Q63.** What is the output of the following code? (Select 1 option.)

```
class Phone {
 String keyboard = "in-built";
}
class Tablet extends Phone {
 boolean playMovie = false;
}
class College2 {
 public static void main(String args[]) {
 Phone phone = new Tablet();
 System.out.println(phone.keyboard + ":" + phone.playMovie);
 }
}

 a in-built:false
 b in-built:true
 c null:false
 d null:true
 e Compilation error
```

**ME-Q64.** What is the output of the following code? (Select 1 option.)

```
public class Wall {
 public static void main(String args[]) {
 double area = 10.98;
 String color;
 if (area < 5)
 color = "red";
 else
 color = "blue";
 System.out.println(color);
 }
}

 a red
 b blue
 c No output
 d Compilation error
```

**ME-Q65.** What is the output of the following code? (Select 1 option.)

```
class Diary {
 int pageCount = 100;
 int getPageCount() {
 return pageCount;
 }
 void setPageCount(int val) {
 pageCount = val;
 }
}
class ClassRoom {
 public static void main(String args[]) {
```

```

 System.out.println(new Diary().getPageCount());
 new Diary().setPageCount(200);
 System.out.println(new Diary().getPageCount());
 }
}

 a 100
 b 200
 c 100
 d 200
 d Code fails to compile.

```

**ME-Q66.** How many times do you think you can shop with the following code (that is, what's the output of the following code)? (Select 1 option.)

```

class Shopping {
 public static void main(String args[]) {
 boolean bankrupt = true;
 do System.out.println("enjoying shopping"); bankrupt = false;
 while (!bankrupt);
 }
}

```

- a The code prints enjoying shopping once.
- b The code prints enjoying shopping twice.
- c The code prints enjoying shopping in an infinite loop.
- d The code fails to compile.

**ME-Q67.** Which of the following options are valid for defining multidimensional arrays? (Choose 4 options.)

- a String ejg1[][] = new String[1][2];
- b String ejg2[][] = new String[][] {{}, {}};
- c String ejg3[][] = new String[2][2];
- d String ejg4[][] = new String[][] {{null}, new String[] {"a", "b", "c"}, {new String()}};
- e String ejg5[][] = new String[] [2];
- f String ejg6[][] = new String[] [] {"A", "B"};
- g String ejg7[][] = new String[] [{"A"}, {"B"}];

**ME-Q68.** What is the output of the following code? (Select 1 option.)

```

class Laptop {
 String memory = "1GB";
}
class Workshop {
 public static void main(String args[]) {
 Laptop life = new Laptop();
 }
}

```

```

 repair(life);
 System.out.println(life.memory);
 }
 public static void repair(Laptop laptop) {
 laptop = new Laptop();
 laptop.memory = "2GB";
 }
}

```

- a 1 GB
- b 2 GB
- c Compilation error
- d Runtime exception

**ME-Q69.** Given the following code, which option, if used to replace /\* INSERT CODE HERE \*/, will enable a reference variable of type Roamable to refer to an object of the Phone class? (Select 1 option.)

```

interface Roamable{}
class Phone {}
class Tablet extends Phone implements Roamable {
 //INSERT CODE HERE
}

```

- a Roamable var = new Phone();
- b Roamable var = (Roamable)Phone();
- c Roamable var = (Roamable)new Phone();
- d Because the interface Roamable and the class Phone are unrelated, a reference variable of type Roamable can't refer to an object of class Phone.

**ME-Q70.** Which of the following statements are incorrect about *the main* method used to start a Java application? (Select 2 options.)

- a A class can't define multiple `main` methods.
- b More than one class in an application can define the `main` method.
- c The `main` method may accept a `String`, a `String` array, or varargs (`String... arg`) as a method argument.
- d The `main` method shouldn't define an object of the class in which the `main` method itself is defined.

**ME-Q71.** What is the output of the following code? (Select 1 option.)

```

class Paper {
 Paper() {
 this(10);
 System.out.println("Paper:0");
 }
 Paper(int a) { System.out.println("Paper:1"); }
}

```

```

class PostIt extends Paper {}
class TestPostIt {
 public static void main(String[] args) {
 Paper paper = new PostIt();
 }
}

```

- a Paper:1
- b Paper:0
- c Paper:0  
Paper:1
- d Paper:1  
Paper:0

**ME-Q72.** Examine the following code and select the correct statement (choose 1 option):

```

line1> class StringBuilders {
line2> public static void main(String... args) {
line3> StringBuilder sb1 = new StringBuilder("eLion");
line4> String ejg = null;
line5> ejg = sb1.append("X").substring(sb1.indexOf("L"),
sb1.indexOf("X")));
line6> System.out.println(ejg);
line7> }
line8> }

```

- a The code will print LionX.
- b The code will print Lion.
- c The code will print Lion if line 5 is changed to the following:

```
ejg = sb1.append("X").substring(sb1.indexOf('L'), sb1.indexOf('X'));
```

- d The code will compile correctly if line 4 is changed to the following:

```
StringBuilder ejg = null;
```

**ME-Q73.** When considered individually, which of the options is correct for the following code? (Select 1 option.)

```

interface Jumpable { void jump(); }
class Chair implements Jumpable {
 public void jump() {
 System.out.println("Chair cannot jump");
 }
}

```

- a The class Chair can't implement the interface Jumpable because a Chair can't define a method jump.
- b If the name of the interface is changed to Movable and the definition of class Chair is updated to class Chair implements Movable, class Chair will compile successfully.

- c If the definition of the method `jump` is removed from the definition of the class `Chair`, it will compile successfully.
- d If the name of the method `jump` is changed to run in the interface `Jumpable`, the class `Chair` will compile successfully.

**ME-Q74.** Given the following code, which option, if used to replace `/* INSERT CODE HERE */`, will enable the class `Jungle` to determine whether the reference variable `animal` refers to an object of the class `Lion` and print `1?` (Select 1 option.)

```
class Animal{ float age; }
class Lion extends Animal { int claws; }
class Jungle {
 public static void main(String args[]) {
 Animal animal = new Lion();
 /* INSERT CODE HERE */
 System.out.println(1);
 }
}
```

- a `if (animal instanceof Lion)`
- b `if (animal instanceof Lion)`
- c `if (animal == Lion)`
- d `if (animal = Lion)`

**ME-Q75.** Given that the file `Test.java`, which defines the following code, fails to compile, select the reasons for the compilation failure (choose 2 options):

```
class Person {
 Person(String value) {}
}
class Employee extends Person {}
class Test {
 public static void main(String args[]) {
 Employee e = new Employee();
 }
}
```

- a The class `Person` fails to compile.
- b The class `Employee` fails to compile.
- c The default constructor can call only a no-argument constructor of a base class.
- d Code that creates an object of class `Employee` in class `Test` didn't pass a `String` value to the constructor of class `Employee`.

**ME-Q76.** Select the correct statements. (Choose 4 options.)

- a Checked exceptions are subclasses of `java.lang.Throwable`.
- b Runtime exceptions are subclasses of `java.lang.Exception`.
- c Errors are subclasses of `java.lang.Throwable`.
- d `java.lang.Throwable` is a subclass of `java.lang.Exception`.
- e `java.lang.Exception` is a subclass of `java.lang.Error`.

- f** Errors aren't subclasses of `java.lang.Exception`.
- g** `java.lang.Throwable` is a subclass of `java.lang.Error`.
- h** Checked exceptions are subclasses of `java.lang.CheckedException`.

**ME-Q77.** Examine the following code and select the correct statements (choose 2 options):

```
class Bottle {
 void Bottle() {}
 void Bottle(WaterBottle w) {}
}
class WaterBottle extends Bottle {}
```

- a** A base class can't pass reference variables of its defined class as method parameters in constructors.
- b** The class compiles successfully—a base class can use reference variables of its derived class as method parameters.
- c** The class `Bottle` defines two overloaded constructors.
- d** The class `Bottle` can access only one constructor.

**ME-Q78.** Given the following code, which option, if used to replace `/* INSERT CODE HERE */`, will cause the code to print 110? (Select 1 option.)

```
class Book {
 private int pages = 100;
}
class Magazine extends Book {
 private int interviews = 2;
 private int totalPages() { /* INSERT CODE HERE */ }

 public static void main(String[] args) {
 System.out.println(new Magazine().totalPages());
 }
}

 a return super.pages + this.interviews*5;
 b return this.pages + this.interviews*5;
 c return super.pages + interviews*5;
 d return pages + this.interviews*5;
 e None of the above
```

**ME-Q79.** Given that the method `write` has been defined as follows,

```
class NoInkException extends Exception {}
class Pen{
 void write(String val) throws NoInkException {
 //.. some code
 }
 void article() {
 //INSERT CODE HERE
 }
}
```

which of the following options, when inserted at //INSERT CODE HERE, will define valid use of the method write in the method article? (Select 2 options.)

- a try {
   
     new Pen().write("story");
   
 }
   
 catch (NoInkException e) {}
- b try {
   
     new Pen().write("story");
   
 }
   
 finally {}
- c try {
   
     write("story");
   
 }
   
 catch (Exception e) {}
- d try {
   
     new Pen().write("story");
   
 }
   
 catch (RuntimeException e) {}

**ME-Q80.** What is the output of the following code? (Select 1 option.)

```
class EMyMethods {
 static String name = "m1";
 void riverRafting() {
 String name = "m2";
 if (8 > 2) {
 String name = "m3";
 System.out.println(name);
 }
 }
 public static void main(String[] args) {
 EMyMethods m1 = new EMyMethods();
 m1.riverRafting();
 }
}
```

- a m1
- b m2
- c m3
- d Code fails to compile.

**ME-Q81.** What is the output of the following code? (Select 1 option.)

```
class EBowl {
 public static void main(String args[]) {
 String eFood = "Corn";
 System.out.println(eFood);
 mix(eFood);
 System.out.println(eFood);
 }
}
```

```

 static void mix(String foodIn) {
 foodIn.concat("A");
 foodIn.replace('C', 'B');
 }
 }
}

```

- a Corn  
BornA
- b Corn  
CornA
- c Corn  
Born
- d Corn  
Corn

**ME-Q82.** Which statement is true for the following code? (Select 1 option.)

```

class SwJava {
 public static void main(String args[]) {
 String[] shapes = {"Circle", "Square", "Triangle"};
 switch (shapes) {
 case "Square": System.out.println("Circle"); break;
 case "Triangle": System.out.println("Square"); break;
 case "Circle": System.out.println("Triangle"); break;
 }
 }
}

```

- a The code prints Circle.
- b The code prints Square.
- c The code prints Triangle.
- d The code prints

```

Circle
Square
Triangle

```

- e The code prints

```

Triangle
Circle
Square

```

- f The code fails to compile.

**ME-Q83.** Which of the following options include the ideal conditions for choosing to use a do-while loop over a while loop? (Select 2 options.)

- a Repeatedly display a menu to a user and accept input until the user chooses to exit the application.
- b Repeatedly allow a student to sit in the exam only if she carries her identity card.
- c Repeatedly serve food to a person until he wants no more.
- d Repeatedly allow each passenger to board an airplane if the passengers have their boarding passes.

**ME-Q84.** Given the following definition of the classes Person, Father, and Home, which options, if used to replace /\* INSERT CODE HERE \*/, will cause the code to compile successfully (select 3 options):

```
class Person {}
class Father extends Person {
 public void dance() throws ClassCastException {}
}
class Home {
 public static void main(String args[]) {
 Person p = new Person();
 try {
 ((Father)p).dance();
 }
 //INSERT CODE HERE
 }
}
```

- a** catch (NullPointerException e) {}  
catch (ClassCastException e) {}  
catch (Exception e) {}  
catch (Throwable t) {}
- b** catch (ClassCastException e) {}  
catch (NullPointerException e) {}  
catch (Exception e) {}  
catch (Throwable t) {}
- c** catch (ClassCastException e) {}  
catch (Exception e) {}  
catch (NullPointerException e) {}  
catch (Throwable t) {}
- d** catch (Throwable t) {}  
catch (Exception e) {}  
catch (ClassCastException e) {}  
catch (NullPointerException e) {}
- e** finally {}

**ME-Q85.** What is the output of the following code? (Select 1 option.)

```
class Camera {
 public static void main(String args[]) {
 String settings;
 while (false) {
 settings = "Adjust settings manually";
 }
 System.out.println("Camera:" + settings);
 }
}
```

- a** The code prints Camera:null.
- b** The code prints Camera:Adjust settings manually.
- c** The code will print Camera:..
- d** The code will fail to compile.

**ME-Q86.** The output of the class TestEJavaCourse, defined as follows, is 300:

```
class Course {
 int enrollments;
}
class TestEJavaCourse {
 public static void main(String args[]) {
 Course c1 = new Course();
 Course c2 = new Course();
 c1.enrollments = 100;
 c2.enrollments = 200;
 System.out.println(c1.enrollments + c2.enrollments);
 }
}
```

What will happen if the variable `enrollments` is defined as a `static` variable? (Select 1 option.)

- a No change in output. `TestEJavaCourse` prints 300.
- b Change in output. `TestEJavaCourse` prints 200.
- c Change in output. `TestEJavaCourse` prints 400.
- d The class `TestEJavaCourse` fails to compile.

**ME-Q87.** What is the output of the following code? (Select 1 option.)

```
String ejgStr[] = new String[][] {{null}, new String[] {"a", "b", "c"}, {new
 String()} [0] };
String ejgStr1[] = null;
String ejgStr2[] = {null};

System.out.println(ejgStr[0]);
System.out.println(ejgStr2[0]);
System.out.println(ejgStr1[0]);
```

- a null  
NullPointerException
- b null  
null  
NullPointerException
- c NullPointerException
- d null  
null  
null

**ME-Q88.** Examine the following code and select the correct statement (choose 1 option):

```
import java.util.*;
class Person {}
class Emp extends Person {}

class TestArrayList {
 public static void main(String[] args) {
 ArrayList<Object> list = new ArrayList<Object>();
```

```

 list.add(new String("1234")); //LINE1
 list.add(new Person()); //LINE2
 list.add(new Emp()); //LINE3
 list.add(new String[] {"abcd", "xyz"}); //LINE4
 }
}

```

- a The code on line 1 won't compile.
- b The code on line 2 won't compile.
- c The code on line 3 won't compile.
- d The code on line 4 won't compile.
- e None of the above.

**ME-Q89.** What is the output of the following code? (Select 1 option.)

```

public class If2 {
 public static void main(String args[]) {
 int a = 10; int b = 20; boolean c = false;
 if (b > a) if (++a == 10) if (c!=true) System.out.println(1);
 else System.out.println(2); else System.out.println(3);
 }
}

```

- a 1
- b 2
- c 3
- d No output

**ME-Q90.** Select the incorrect statement (choose 1 option):

- a An enhanced for loop can be used to iterate through the elements of an array and ArrayList.
- b The loop counter of an enhanced for loop can be used to modify the current element of the array being iterated over.
- c do-while and while loops can be used to iterate through the elements of an array and ArrayList.
- d The loop counter of a regular for loop can be used to modify the current element of an ArrayList being iterated over.

## 8.2 Answers to mock exam questions

This section contains answers to all the mock exam questions in section 8.1. Also, each question is preceded by the exam objective that the question is based on.



[7.3] Differentiate between the type of a reference and the type of an object

**ME-Q1.** Given the following definition of the classes Animal, Lion, and Jumpable, select the correct combinations of assignments of a variable (select 2 options):

```
interface Jumpable {}
class Animal {}
class Lion extends Animal implements Jumpable {}

 a Jumpable var1 = new Jumpable();
 b Animal var2 = new Animal();
 c Lion var3 = new Animal();
 d Jumpable var4 = new Animal();
 e Jumpable var5 = new Lion();
```

Answer: b, e

Explanation: Option (a) is incorrect. An interface can't be instantiated.

Option (c) is incorrect. A reference variable of a derived class can't be used to refer to an object of its base class.

Option (d) is incorrect. A reference variable of type Jumpable can't be used to refer to an object of the class Animal because Animal doesn't implement the interface Jumpable.



### [1.2] Define the structure of a Java class

**ME-Q2.** Which of the following statements are true? (Select 3 options.)

- a A Java class can define multiple methods.
- b A Java class can define multiple variables.
- c A Java class can be defined in multiple packages.
- d A Java class can import multiple packages.
- e A Java class can't define more than 108 constructors.
- f End-of-line comments can't follow import or package statements.
- g Multiline comments can only be defined within a method definition.

Answer: a, b, d

Explanation: Option (c) is incorrect. The same class can't be defined in multiple packages. If you try to define the same class—say, the class Person—in the packages com.ejava and com.eoracle, you're defining two classes with the same name but in separate packages. In this case, com.ejava.Person and com.eoracle.Person will refer to two different classes.

Option (e) is incorrect because there is no theoretical limit on the number of constructors that can be defined by a class.

Option (f) is incorrect because end-of-line comments can follow any line of code.

Option (g) is incorrect because multiline comments can also be placed outside a method definition.



[8.2] Create a try-catch block and determine how exceptions alter normal program flow

**ME-Q3.** Given the following code, which option, if used to replace /\* INSERT CODE HERE \*/, will make the code print 1? (Select 1 option.)

```
try {
 String[][] names = {{ "Andre", "Mike"}, null, {"Pedro"}};
 System.out.println (names[2][1].substring(0, 2));
}
catch /*INSERT CODE HERE*/ {
 System.out.println(1);
}
```

a IndexPositionException e  
 b NullPointerException e  
 c ArrayIndexOutOfBoundsException e  
 d ArrayOutOfBoundsException e

Answer: c

Explanation: Options (a) and (d) are incorrect because the Java API doesn't define any exception classes with these names.

Here's a list of the array values that are initialized by the code in this question:

```
names[0][0] = "Andre"
names[0][1] = "Mike"
names[1] = null
names[2][0] = "Pedro"
```

Because the array position [2][1] isn't defined, any attempt to access it will throw `ArrayIndexOutOfBoundsException`.

An attempt to access any position of the second array—that is, `names[1][0]`—will throw `NullPointerException` because `names[1]` is set to `null`.



[8.2] Create a try-catch block and determine how exceptions alter normal program flow

**ME-Q4.** What is the output of the following code? (Select 1 option.)

```
int a = 10; String name = null;
try {
 a = name.length();
 a++;
}
catch (RuntimeException e){
 ++a;
}
System.out.println(a);
```

- a 5
- b 6
- c 10
- d 11
- e 12
- f Runtime exception

Answer: d

Explanation: Because the variable name isn't assigned a value, the following line of code will throw `NullPointerException`:

```
name.length();
```

Hence, the original value of the variable a isn't modified and the control is transferred to the exception handler, which increments the value of the variable a to 11.



### [3.5] Use a switch statement

**ME-Q5.** Given the following class definition,

```
class Student { int marks = 10; }
```

what is the output of the following code? (Select 1 option.)

```
class Result {
 public static void main(String... args) {
 Student s = new Student();
 switch (s.marks) {
 default: System.out.println("100");
 case 10: System.out.println("10");
 case 98: System.out.println("98");
 }
 }
}
```

- a 100  
10  
98
- b 10  
98
- c 100
- d 10

Answer: b

Explanation: The `default` case executes only if no matching values are found. In this case, a matching value of 10 is found and the `case` label prints 10. Because a `break` statement doesn't terminate this `case` label, the code execution continues

and executes the remaining statements within the switch block, until a break statement terminates it or it ends.



### [7.5] Use super and this to access objects and constructors

**ME-Q6.** Given the following code, which code can be used to create and initialize an object of class ColorPencil? (Select 2 options.)

```
class Pencil {}
class ColorPencil extends Pencil {
 String color;
 ColorPencil(String color) {this.color = color;}
}

 a ColorPencil var1 = new ColorPencil();
 b ColorPencil var2 = new ColorPencil(RED);
 c ColorPencil var3 = new ColorPencil("RED");
 d Pencil var4 = new ColorPencil("BLUE");
```

Answer: c, d

Explanation: Option (a) is incorrect because new ColorPencil() tries to invoke the no-argument constructor of class ColorPencil, which isn't defined in class ColorPencil.

Option (b) is incorrect because new ColorPencil(RED) tries to pass a variable RED, which isn't defined in the code.



### [2.3] Read or write to object fields

**ME-Q7.** What is the output of the following code? (Select 1 option.)

```
class Doctor {
 protected int age;
 protected void setAge(int val) { age = val; }
 protected int getAge() { return age; }
}
class Surgeon extends Doctor {
 Surgeon(String val) {
 specialization = val;
 }
 String specialization;
 String getSpecialization() { return specialization; }
}
class Hospital {
 public static void main(String args[]) {
 Surgeon s1 = new Surgeon("Liver");
 Surgeon s2 = new Surgeon("Heart");
 s1.age = 45;
 System.out.println(s1.age + s2.getSpecialization());
```

```

 System.out.println(s2.age + s1.getSpecialization());
 }
}

 a 45Heart
 b 45Liver
 c 45Liver
 d 45Heart
 e Class fails to compile.

```

Answer: a

Explanation: The constructor of the class Surgeon assigns the values "Liver" and "Heart" to the variable specialization of objects s1 and s2. The variable age is protected in the class Doctor. Also, the class Surgeon extends the class Doctor. Hence, the variable age is accessible to reference variables s1 and s2. The code assigns a value of 45 to the member variable age of reference variable s1. The variable age of reference variable s2 is initialized to the default value of an int, which is 0. Hence, the code prints the values mentioned in option (a).



### [3.1] Use Java operators

**ME-Q8.** What is the output of the following code? (Select 1 option.)

```

class RocketScience {
 public static void main(String args[]) {
 int a = 0;
 while (a == a++) {
 a++;
 System.out.println(a);
 }
 }
}

```

- a The while loop won't execute; nothing will be printed.
- b The while loop will execute indefinitely, printing all numbers, starting from 1.
- c The while loop will execute indefinitely, printing all even numbers, starting from 0.
- d **The while loop will execute indefinitely, printing all even numbers, starting from 2.**
- e The while loop will execute indefinitely, printing all odd numbers, starting from 1.
- f The while loop will execute indefinitely, printing all odd numbers, starting from 3.

Answer: d

Explanation: The while loop will execute indefinitely because the condition `a == a++` will always evaluate to true. The postfix unary operator will increment the value of the variable `a` after it's used in the comparison expression. `a++` within the loop body will increment the value of `a` by 1. Hence, the value of `a` increments by 2 in a single loop.



[1.4] Import other Java packages to make them accessible in your code

**ME-Q9.** Given the following statements,

- com.ejava is a package
- class Person is defined in package com.ejava
- class Course is defined in package com.ejava

which of the following options correctly import the classes Person and Course in the class MyEJava? (Select 3 options.)

- a `import com.ejava.*;`  
`class MyEJava {}`
- b `import com.ejava;`  
`class MyEJava {}`
- c `import com.ejava.Person;`  
`import com.ejava.Course;`  
`class MyEJava {}`
- d `import com.ejava.Person;`  
`import com.ejava.*;`  
`class MyEJava {}`

Answer: a, c, d

Explanation: Option (a) is correct. The statement `import com.ejava.*;` imports all the public members of the package com.ejava in class MyEJava.

Option (b) is incorrect. Because com.ejava is a package, to import all the classes defined in this package, the package name should be followed by `.*`:

```
import com.ejava.*;
```

Option (c) is correct. It uses two separate import statements to import each of the classes Person and Course individually, which is correct.

Option (d) is also correct. The first import statement imports only the class Person in MyClass. But the second import statement imports both the Person and Course classes from the package com.ejava. You can import the same class more than once in a Java class with no issues. This code is correct.

In Java, the import statement makes the imported class *visible* to the Java compiler, allowing it to be referred to by the class that's importing it. In Java, the import statement doesn't embed the imported class in the target class.



## [6.6] Apply access modifiers

**ME-Q10.** Given that the following classes Animal and Forest are defined in the same package, examine the code and select the correct statements (select 2 options):

```

line1> class Animal {
line2> public void printKing() {
line3> System.out.println("Lion");
line4> }
line5> }

line6> class Forest {
line7> public static void main(String... args) {
line8> Animal anAnimal = new Animal();
line9> anAnimal.printKing();
line10> }
line11> }

```

- a The class Forest prints Lion.
- b If the code on line 2 is changed as follows, the class Forest will print Lion:  
`private void printKing() {`
- c If the code on line 2 is changed as follows, the class Forest will print Lion:  
`void printKing() {`
- d If the code on line 2 is changed as follows, the class Forest will print Lion:  
`default void printKing() {`

Answer: a, c

Explanation: Option (a) is correct. The code will compile successfully and print Lion.

Option (b) is incorrect. The code won't compile if the access modifier of the method printKing is changed to private. private members of a class can't be accessed outside the class.

Option (c) is correct. The classes Animal and Forest are defined in the same package, so changing the access modifier of the method printKing to default access will still make it accessible in the class Forest. The class will compile successfully and print Lion.

Option (d) is incorrect. "default" isn't a valid access modifier or keyword in Java. In Java, the default accessibility is marked by the absence of any explicit access modifier. This code will fail to compile.



## [6.6] Apply access modifiers

**ME-Q11.** Which of the following statements are true? (Select 2 options.)

- a Given that you changed the access of a public method B, in class A, to a private method, class C that uses method B will fail to compile.

- b Given that you changed the access of a private method B, in class A, to a public method, none of the classes that use class A will fail to compile.
- c Given that you changed the access of a protected method B, in class A, to a method with default access, class C from the same package as class A won't be able to access method B.
- d A change in the accessibility of the methods in your class never affects any other class that uses your class.

Answer: a, b

Explanation: Option (a) is correct. A public method is accessible to other classes. If you change the accessibility of a public method to a private method, it will no longer be accessible outside its class. Any class that uses such a method will fail to compile after this modification.

Option (b) is correct. A private method isn't accessible outside the class in which it's defined. In other words, a private method isn't known to the other classes, so it can't be accessed by other classes. If classes can't even access the private methods of other classes, it won't make a difference to them if their accessibility is changed.

Option (c) is incorrect. A method with default access can be accessed by classes defined in the same package.

Option (d) is incorrect. A change in the accessibility of the methods in your class affects other classes that use your class. If you assign a weaker accessibility to any of your methods, it may no longer be accessible to the other classes. If this happens, the other class will fail to compile.



[8.1] Differentiate among checked exceptions, RuntimeExceptions, and Errors

**ME-Q12. Which of the following statements are correct?** (Select 3 options)

- a You may not be able to handle all the checked exceptions in your code.
- b If required, you can handle all the runtime exceptions in your code.
- c You can handle an exception in your code even if you don't know its exact name.
- d A single exception handler can be used to handle all types of runtime and checked exceptions.
- e You must handle all errors that can be thrown by your code.
- f Runtime exceptions are also known as checked exceptions.

Answer: b, c, d

Explanation: Option (a) is incorrect. If, for example, callingMethod() calls calledMethod(), which throws checked exceptions, callingMethod() can't ignore checked exceptions thrown by calledMethod(). callingMethod() should handle these exceptions itself or declare them to be thrown. callingMethod() can't ignore *any* checked exceptions thrown by calledMethod(). If it tries to do so, the code won't compile.

Option (b) is correct. It is indeed possible to handle all the runtime exceptions in your code.

Options (c) and (d) are correct. The superclass of all types of exceptions (checked and runtime) is class `java.lang.Exception`, so if you define a handler for `java.lang.Exception` in your code, you are able to handle all runtime and checked exceptions, and this will include any exceptions whose names you don't know.

Option (e) is incorrect. Even though errors can be caught by an exception handler, you shouldn't handle them because they're serious exceptions thrown by the JVM as a result of an error in the environment state that processes your code.

Option (f) is incorrect because runtime exceptions are also known as unchecked exceptions.



### [1.3] Create executable Java applications with a main method

**ME-Q13.** Given the following code,

```
class MainMethod {
 public static void main(String... args) {
 System.out.println(args[0]+":"+ args[2]);
 }
}
```

what's its output if it's executed using the following command? (Select 1 option.)

`java MainMethod 1+2 2*3 4-3 5+1`

- a `java:1+2`
- b `java:3`
- c `MainMethod:2*3`
- d `MainMethod:6`
- e `1+2:2*3`
- f `3:3`
- g `6`
- h `1+2:4-3`
- i `31`
- j `4`

Answer: h

Explanation: This question tests you on multiple points:

- *The arguments that are passed on to the main method*—The keyword `java` and the name of the class (`MainMethod`) aren't passed as arguments to the `main` method. The arguments following the class name are passed to the `main` method. In this case, four method arguments are passed to the `main` method, as follows:

```
args[0]: 1+2
args[1]: 2*3
```

```
args[2] : 4-3
args[3] : 5+1
```

- *The type of the arguments that are passed to the main method*—The `main` method accepts arguments of type `String`. All the numeric expressions—`1+2`, `2*3`, `5+1` and `4-3`—are passed as literal `String` values. These won't be evaluated when you try to print their values. Hence, `args[0]` won't be printed as `3`. It will be printed as `1+2`.
- *+ operations with String array elements*—Because the array passed to the `main` method contains all the `String` values, using the `+` operand with its individual values will concatenate its values. It won't add the values, if they are numeric expressions. Hence, `"1+2"+ "4-3"` won't evaluate to `31` or `4`.



[2.2] Differentiate between object reference variables and primitive variables

**ME-Q14.** What is the output of the following code? (Select 1 option.)

```
class Person {
 int age;
 float height;
 boolean result;
 String name;
}
public class EJava {
 public static void main(String arguments[]) {
 Person person = new Person();
 System.out.println(person.name + person.height + person.result
 + person.age);
 }
}

 a null0.0false0
 b null0false0
 c null0.0ffalse0
 d 0.0false0
 e 0false0
 f 0.0ffalse0
 g null0.0true0
 h 0true0
 i 0.0ftrue0
```

Answer: a

Explanation: The instance variables of a class are all assigned default values if no explicit value is assigned to them. Here are the default values of the primitive data types and the objects:

```
char -> \u0000
byte, short, int -> 0
```

```
long -> 0L
float-> 0.0f
double -> 0.0d
boolean -> false
objects -> null
```



[7.4] Determine when casting is necessary

**ME-Q15.** Given the following code, which option, if used to replace /\* INSERT CODE HERE \*/ , will make the code print the value of the variable pagesPerMin? (Select 1 option.)

```
class Printer {
 int inkLevel;
}
class LaserPrinter extends Printer {
 int pagesPerMin;
 public static void main(String args[]) {
 Printer myPrinter = new LaserPrinter();
 System.out.println(/* INSERT CODE HERE */);
 }
}
 a (LaserPrinter)myPrinter.pagesPerMin
 b myPrinter.pagesPerMin
 c LaserPrinter.myPrinter.pagesPerMin
 d ((LaserPrinter)myPrinter).pagesPerMin
```

Answer: d

Explanation: Option (a) is incorrect because (LaserPrinter) tries to cast myPrinter .pagesPerMin to LaserPrinter, which is incorrect. This code won't compile.

Option (b) is incorrect. The type of reference variable myPrinter is Printer. myPrinter refers to an object of the class LaserPrinter, which extends the class Printer. A reference variable of the base class can't access the variables and methods defined in its subclass without an explicit cast.

Option (c) is incorrect. LaserPrinter.myPrinter treats LaserPrinter as a variable, although no variable with this name exists in the question's code. This code fails to compile.



[8.3] Describe what exceptions are used for in Java

**ME-Q16.** Which statements describe the use of exception handling in Java? (Select 2 options.)

- a **Exception handling can prevent an application from crashing or producing incorrect outputs or incorrect input values.**
- b Exception handlers can't define an alternative flow of action in the event of an exception.

- c Exception handlers enable a programmer to define separate code blocks for handling different types of exceptions.
- d Exception handlers help to define well-encapsulated classes.
- e Exception handlers help with efficient inheritance.

Answer: a, c

Explanation: Option (b) is incorrect. One of the main purposes of an exception handler is to define an alternative flow of action.

Options (d) and (e) are incorrect. Definitions of exception handlers, well-encapsulated classes, and efficient inheritance aren't related in behavior as stated by these options.



[2.2] Differentiate between object reference variables and primitive variables

**ME-Q17. Which statements are true for reference and primitive variables? (Select 3 options.)**

- a The names of the reference variables are limited to a length of 256 characters.
- b There is no limit on the length of the names of primitive variables.
- c Multiple reference variables may refer to exactly the same object in memory.
- d Values stored by primitive and reference variables can be compared for equality by using the equals operator (==) or by using the method equals.
- e A primitive variable can't refer to an object and vice versa.

Answer: b, c, e

Explanation: Option (a) is incorrect. Theoretically, there is no limit on the number of characters that can be used to define the name of a primitive variable or object reference.

Option (d) is incorrect. Unlike object references, primitive variables can be compared for equality by using the equals operator (==) only.

Option (e) is correct. A primitive variable can never refer to an object and vice versa.



[2.1] Declare and initialize variables

**ME-Q18. What is the output of the following code? (Select 1 option.)**

```
public class Handset {
 public static void main(String... args) {
 double price;
 String model;
 System.out.println(model + price);
 }
}
```

- a null0
- b null0.0
- c 0

- d 0.0  
 e Compilation error

Answer: e

Explanation: The local variables (variables that are declared within a method) aren't initialized with their default values. If you try to print the value of a local variable before initializing it, the code won't compile.



### [3.1] Use Java operators

**ME-Q19.** What is the output of the following code? (Select 1 option.)

```
public class Sales {
 public static void main(String args[]) {
 int salesPhone = 1;
 System.out.println(salesPhone++ + ++salesPhone +
 ++salesPhone);
 }
}
```

a 5  
 b 6  
 c 8  
 d 9

Answer: c

Explanation: Understanding the following rules will enable you to answer this question correctly:

- An arithmetic expression is evaluated from left to right.
- When an expression uses the unary increment operator (++) in postfix notation, its value increments just *after* its original value is used in an expression.
- When an expression uses the unary increment operator (++) in prefix notation, its value increments just *before* its value is used in an expression.

The initial value of the variable `salesPhone` is 1. Let's evaluate the result of the arithmetic expression `salesPhone++ + ++salesPhone + ++salesPhone` step by step:

- 1 The first occurrence of `salesPhone` uses ++ in postfix notation, so its value is used in the expression *before* it is incremented by 1. This means that the expression evaluates to

`1 + ++salesPhone + ++salesPhone`

- 2 Note that the previous usage of ++ in postfix increments has already incremented the value of `salesPhone` to 2. The second occurrence of `salesPhone` uses ++ in prefix notation, so its value is used in the expression *after* it is incremented by 1, to 3. This means that the expression evaluates to

`1 + 3 + ++salesPhone`

- 3 The third occurrence of salesPhone again uses `++` in prefix notation, so its value is used in the expression *after* it is incremented by 1, to 4. This means that the expression evaluates to

`1 + 3 + 4`

The previous expression evaluates to 8.



[1.2] Define the structure of a Java class

**ME-Q20.** Which of the following options defines the correct structure of a Java class? (Select 1 option.)

- a package com.ejava.guru;  
package com.ejava.oracle;  
class MyClass { }
- b import com.ejava.guru.\*;  
import com.ejava.oracle.\*;  
package com.ejava;  
class MyClass { }
- c class MyClass {  
    import com.ejava.guru.\*;  
}
- d class MyClass {  
    int abc;  
}

Answer: d

Explanation: Option (a) is incorrect. A class can't define more than one package statement.

Option (b) is incorrect. Though a class can import multiple packages in a class, the package statement must be placed before the `import` statement.

Option (c) is incorrect. A class can't define an `import` statement within its class body. The `import` statement appears before the class body.

Option (d) is correct. In the absence of any package information, this class becomes part of the default package.



[3.2] Use parentheses to override operator precedence

**ME-Q21.** What is the output of the following code? (Select 1 option.)

```
class OpPre {
 public static void main(String... args) {
 int x = 10;
 int y = 20;
 int z = 30;
```

```

 if (x+y%z > (x+(-y)*(-z))) {
 System.out.println(x + y + z);
 }
 }
}

```

- a 60
- b 59
- c 61
- d No output.
- e The code fails to compile.

Answer: d

Explanation:  $x+y\%z$  evaluates to 30;  $(x+(y\%z))$  and  $(x+(-y)*(-z))$  evaluate to 610. The if condition returns false and the line of code that prints the sum of x, y, and z doesn't execute. Hence, the code doesn't provide any output.



### [1.1] Define the scope of variables

**ME-Q22.** Select the most appropriate definition of the variable name and the line number on which it should be declared so that the following code compiles successfully (choose 1 option):

```

class EJava {
 // LINE 1
 public EJava() {
 System.out.println(name);
 }
 void calc() {
 // LINE 2
 if (8 > 2) {
 System.out.println(name);
 }
 }
 public static void main(String... args) {
 // LINE 3
 System.out.println(name);
 }
}

```

- a Define static String name; on line 1.
- b Define String name; on line 1.
- c Define String name; on line 2.
- d Define string name; on line 3.

Answer: a

Explanation: The variable name must be accessible in the instance method calc, the class constructor, and the static method main. A non-static variable can't be

accessed by a static method. Hence, the only appropriate option is to define a static variable name that can be accessed by all—the constructor of class EJava, and methods calc and main.



#### [2.4] Explain an object's life cycle

**ME-Q23.** Examine the following code and select the correct statement (choose 1 option):

```

line1> class Emp {
line2> Emp mgr = new Emp();
line3> }
line4> class Office {
line5> public static void main(String args[]) {
line6> Emp e = null;
line7> e = new Emp();
line8> e = null;
line9> }
line10> }
```

- a The object referred to by object e is eligible for garbage collection on line 8.
- b The object referred to by object e is eligible for garbage collection on line 9.
- c The object referred to by object e isn't eligible for garbage collection because its member variable mgr isn't set to null.
- d **The code throws a runtime exception and the code execution never reaches line 8 or 9.**

Answer: d

Explanation: The code throws `java.lang.StackOverflowError` at runtime. Line 7 creates an instance of class `Emp`. Creation of an object of the class `Emp` requires the creation of an instance variable `mgr` and its initialization with an object of the same class. As you see, the `Emp` object creation calls itself recursively, resulting in `java.lang.StackOverflowError`.



#### [6.1] Create methods with arguments and return values

**ME-Q24.** Which of the following is the correct declaration of a method that accepts two `String` arguments and an `int` argument and doesn't return any value? (Select 2 options.)

- a `void myMethod(String str1, int str2, String str3)`
- b `myMethod(String val1, int val2, String val3)`
- c `void myMethod(String str1, str2, int a)`
- d `void myMethod(String val1, val2, int val3)`
- e `void myMethod(int str2, String str3, String str1)`

Answer: a, e

Explanation: The placement of the type of method parameters and the name of the method parameters doesn't matter. You can accept two `String` variables and then an `int` variable or a `String` variable followed by `int` and again a `String`. The name of an `int` variable can be `str2`. As long as the names are valid identifiers, any name is acceptable. The return type of the method should be `void` to specify that the method doesn't return any value.

Option (b) is incorrect. It won't compile because the method signature doesn't include a return type.

Options (c) and (d) are incorrect. The method signatures of these methods don't define data types for all their method parameters.



#### [4.1] Declare, instantiate, initialize, and use a one-dimensional array

**ME-Q25.** Which of the following will compile successfully? (Select 3 options.)

- a `int eArr1[] = {10, 23, 10, 2};`
- b `int[] eArr2 = new int[10];`
- c `int[] eArr3 = new int[] {};`
- d `int[] eArr4 = new int[10] {};`
- e `int eArr5[] = new int[2] {10, 20};`

Answer: a, b, c

Explanation: Option (d) is incorrect because it defines the size of the array while using `{}`, which isn't allowed. Both of the following lines of code are correct:

```
int[] eArr4 = new int[10];
int[] eArr4 = new int[]{};
```

Option (e) is incorrect because it's invalid to specify the size of the array within the square brackets when you're declaring, instantiating, and initializing an array in a single line of code.



#### [6.1] Create methods with arguments and return values

**ME-Q26.** Assume that Oracle has asked you to create a method that returns the concatenated value of two `String` objects. Which of the following methods do you think can accomplish this job? (Select 2 options.)

- a `public String add(String 1, String 2) {
 return str1 + str2;
 }`
- b `private String add(String s1, String s2) {
 return s1.concat(s2);
 }`

- c** protected String add(String value1, String value2) {
 return value2.append(value2);
 }
- d** String subtract(String first, String second) {
 return first.concat(second.substring(0));
 }

Answer: b, d

Explanation: Option (a) is incorrect. This method defines method parameters with invalid identifier names. Identifiers can't start with a digit.

Option (b) is correct. The method requirements don't talk about the access modifier of the required method. It can have any accessibility.

Option (c) is incorrect because the class String doesn't define any append method.

Option (d) is correct. Even though the name of the method—subtract—isn't an appropriate name for a method that tries to concatenate two values, it does accomplish the required job.



#### [1.4] Import other Java packages to make them accessible in your code

**ME-Q27.** In Java, the class String is defined in the package java.lang, and this package is automatically imported in all the Java classes. Given this statement, which of the following options represents the correct definition of class EJava, which can define a variable of class String? (Choose 2 options.)

- a** import java.lang;
 class EJava {
 String guru;
 }
- b** import java.lang.String.\*;
 class EJava {
 String guru;
 }
- c** class EJava {
 String guru;
 }
- d** import java.lang.String;
 import java.lang.String;
 class EJava {
 String guru;
 }

Answer: c, d

Explanation: Options (a) and (b) are incorrect. The code in both these options won't compile because they use incorrect import statement. The following line of code will import all the classes from package java.lang (including class String):

```
import java.lang.*;
```

You can use the following import statement to import just the class String:

```
import java.lang.String;
```

Option (c) is correct. The class EJava can create variables of the class String because the class java.lang.String is automatically imported in all the Java classes. Hence, it's available to EJava, even if this class doesn't import it explicitly.

Option (d) is correct. It doesn't make a difference if you import the same class more than once in your code.



[6.3] Create an overloaded method

**ME-Q28.** Given the following definitions of the class ChemistryBook, select the statements that are correct individually (choose 2 options):

```
import java.util.ArrayList;
class ChemistryBook {
 public void read() {} //METHOD1
 public String read() { return null; } //METHOD2
 ArrayList read(int a) { return null; } //METHOD3
}
```

- a Methods marked with //METHOD1 and //METHOD2 are correctly overloaded methods.
- b **Methods marked with //METHOD2 and //METHOD3 are correctly overloaded methods.**
- c **Methods marked with //METHOD1 and //METHOD3 are correctly overloaded methods.**
- d All the methods—methods marked with //METHOD1, //METHOD2, and //METHOD3—are correctly overloaded methods.

Answer: b, c

Explanation: Options (a) and (d) are incorrect because the methods read marked with //METHOD1 and //METHOD2 only differ in their return types, void and String. Overloaded methods can't be defined with only a change in their return types; hence, these methods don't qualify as correctly overloaded methods.

Note that the presence of methods marked with //METHOD1 and //METHOD2 together will cause a compilation error.



[6.4] Differentiate between default and user-defined constructors

**ME-Q29.** Given the following definition of the class Home, select the correct statements (choose 4 options):

```
class Home {
 String name;
```

```

 int rooms;
 Home() { }
}

```

- a The class Home will be provided a default constructor.
- b The class Home won't be provided a default constructor.
- c A default constructor can't coexist with overloaded constructors.
- d A default constructor doesn't accept any method parameters.
- e After compilation, the class Home has only a no-argument constructor.
- f After compilation, the class Home has two constructors: a no-argument constructor and a default constructor.
- g When an object of class Home is created, its variables name and rooms are not assigned any default values.

Answer: b, c, d, e

Explanation: Option (b) is correct. The class Home doesn't contain a default constructor. A default constructor is generated by Java when the user doesn't define any constructor. In this case, the class Home does define a constructor.

Option (c) is correct. A default constructor is generated only in the absence of a constructor. Hence, it can't coexist with other constructors.

Option (d) is correct. The default constructor doesn't accept any method parameters. It initializes the instance variables of a class to their default values.

Option (e) is correct and (f) is incorrect. No default constructor will be generated for class Home because Home already defines a no-argument constructor. A no-argument constructor is a constructor that defines no method parameters. After compilation, class Home has only one constructor that doesn't accept any method parameters.

Option (g) is incorrect. If you don't assign explicit values to instance variables of a class, they are initialized to their default values.



### [5.5] Use break and continue

**ME-Q30.** Given the following code, which option, if used to replace /\* INSERT CODE HERE \*/, will make the code print numbers that are completely divisible by 14? (Select 1 option.)

```

for (int ctr = 2; ctr <= 30; ++ctr) {
 if (ctr % 7 != 0)
 //INSERT CODE HERE
 if (ctr % 14 == 0)
 System.out.println(ctr);
}

```

- a continue;
- b exit;
- c break;
- d end;

Answer: a

Explanation: Options (b) and (d) are incorrect because `exit` and `end` aren't valid statements in Java.

Option (c) is incorrect. Using `break` will terminate the `for` loop during the first iteration of the `for` loop so that no output is printed.



### [8.5] Recognize common exception classes and categories

**ME-Q31.** Ideally, which of the following should never be handled by an exception handler? (Select 2 options.)

- a `StackOverflowError`
- b `OutOfMemoryError`
- c `ArrayIndexOutOfBoundsException`
- d `ClassNotFoundException`
- e `CompilationError`
- f `OutOfStorageError`

Answer: a, b

Explanation: Options (c), (d), (e), and (f) are incorrect because the Java API doesn't define these exception or error classes.

Options (a) and (b) are correct. You should never try to handle these errors in your code because `StackOverflowError` and `OutOfMemoryError` are serious errors.



### [2.1] Declare and initialize variables

**ME-Q32.** What is the output of the following code? (Select 1 option.)

```
public class MyCalendar {
 public static void main(String arguments[]) {
 Season season1 = new Season();
 season1.name = "Spring";

 Season season2 = new Season();
 season2.name = "Autumn";

 season1 = season2;
 System.out.println(season1.name);
 System.out.println(season2.name);
 }
}
class Season {
 String name;
}
```

- a String  
Autumn

- b Spring  
String
- c Autumn  
Autumn
- d Autumn  
String

Answer: c

Explanation: Multiple variable references can point to the same object. The following lines of code define a reference variable `season1`, which refers to an object that has the value of its instance variable (`name`) set to `Spring`:

```
Season season1 = new Season();
season1.name = "Spring";
```

The following lines of code define a reference variable `season2`, which refers to an object that has the value of its instance variable (`name`) set to `Autumn`:

```
Season season2 = new Season();
season2.name = "Autumn";
```

The following line of code reinitializes the reference variable `season1` and assigns it to the object referred to by the variable `season2`:

```
season1 = season2;
```

Now the variable `season1` refers to the object that is also referred to by the variable `season2`. Both of these variables refer to the same object—the one that has the value of the instance variable set to `Autumn`. Hence, the output of the previous code is as follows:

```
Autumn
Autumn
```



### [6.5] Create and overload constructors

**ME-Q33.** What is true about the following code? (Select 1 option.)

```
class Shoe {}
class Boot extends Shoe {}
class ShoeFactory {
 ShoeFactory(Boot val) {
 System.out.println("boot");
 }
 ShoeFactory(Shoe val) {
 System.out.println("shoe");
 }
}
```

- a The class `ShoeFactory` has a total of two overloaded constructors.
- b The class `ShoeFactory` has three overloaded constructors, two user-defined constructors, and one default constructor.

- c The class ShoeFactory will fail to compile.
- d The addition of the following constructor will increment the number of constructors of the class ShoeFactory to 3:

```
private ShoeFactory (Shoe arg) {}
```

Answer: a

Explanation: Java accepts changes in the objects of base-derived classes as the sole criterion to define overloaded constructors and methods.

Option (b) is incorrect because Java doesn't generate a default constructor for a class that has already defined a constructor.

Option (c) is incorrect. All classes defined for this example compile successfully.

Option (d) is incorrect. The class ShoeFactory already defines a constructor that accepts a method argument of type Shoe. You can't overload a constructor with a mere change in its access modifier.



#### [7.5] Use super and this to access objects and constructors

**ME-Q34.** Given the following definitions of the classes ColorPencil and TestColor, which option, if used to replace /\* INSERT CODE HERE \*/, will initialize the instance variable color of reference variable myPencil with the String literal value "RED"? (Select 1 option.)

```
class ColorPencil {
 String color;
 ColorPencil(String color) {
 //INSERT CODE HERE
 }
}
class TestColor {
 ColorPencil myPencil = new ColorPencil("RED");
}

 a this.color = color;
 b color = color;
 c color = RED;
 d this.color = RED;
```

Answer: a

Explanation: Option (b) is incorrect. This line of code will assign the value of the method parameter to itself. The constructor of the class ColorPencil defines a method parameter with the same name as its instance variable, color. To access an instance variable in the constructor, it must be prefixed with the keyword this, or it will refer to the method parameter color.

Options (c) and (d) are incorrect. They try to access the value of variable RED, which isn't defined in the code.



## [2.3] Read or write to object fields

**ME-Q35.** What is the output of the following code? (Select 1 option.)

```
class EJavaCourse {
 String courseName = "Java";
}
class University {
 public static void main(String args[]) {
 EJavaCourse courses[] = { new EJavaCourse(), new EJavaCourse() };
 courses[0].courseName = "OCA";
 for (EJavaCourse c : courses) c = new EJavaCourse();
 for (EJavaCourse c : courses) System.out.println(c.courseName);
 }
}

 a Java
Java
 b OCA
Java
 c OCA
OCA
 d None of the above.
```

Answer: b

Explanation: This question tests you on multiple concepts: how to read from and write to object fields, how to use arrays, the enhanced for loop, and assigning a value to a loop variable.

The code defines an array of the class EJavaCourse with two elements. The default value of the variable courseName—Java—is assigned to each of these two elements. courses[0].courseName = "OCA" changes the value courseName, for the object stored at array position 0. c = new EJavaCourse() assigns a new object to the loop variable c. This assignment doesn't reassign new objects to the array reference variables. System.out.println(c.courseName) prints the name of the courseName of the objects initially stored by the array, using the loop variable c.

The loop variable in the enhanced for loop refers to a copy of the array or list element. If you modify the state of the loop variable, the modified object state will be reflected in the array. But if you assign a new object to the loop variable, it won't be reflected in the list or the array that's being iterated. You can compare this behavior of the enhanced for loop variable with the behavior of object references passed as arguments to a method.



## [2.5] Call methods on objects

**ME-Q36.** Given the following code, which option, if used to replace /\* INSERT CODE HERE \*/ , will make the code print the value of the variable screenSize? (Select 1 option.)

```

class Tablet {
 float screenSize = 7.0f;
 float getScreenSize() {
 return screenSize;
 }
 void setScreenSize(float val) {
 screenSize = val;
 }
}

class DemoTabs {
 public static void main(String args[]) {
 Tablet tab = new Tablet();
 System.out.println(/* INSERT CODE HERE */);

 }
}

 a tab.screenSize
 b tab->getScreensize()
 c tab::getScreen()
 d tab:screenSize

```

Answer: a

Explanation: Only the dot operator (.) can be used to access an instance variable or a method of an object in Java. The rest of the operators (->, ::, and :) used in options (b), (c), and (d), respectively, aren't valid operators in Java.



### [7.1] Implement inheritance

**ME-Q37.** Given the following definitions of the class Person and the interface Movable, the task is to declare a class Emp that inherits from the class Person and implements the interface Movable. Select the correct option to accomplish this task (choose 1 option):

```

class Person {}
interface Movable {}

 a class Emp implements Person extends Movable{}
 b class Emp implements Person, Movable{}
 c class Emp extends Person implements Movable{}
 d class Emp extends Person, Movable{}

```

Answer: c

Explanation: Options (a) and (b) are incorrect because a class can't use the keyword implements to inherit a class.

Option (d) is incorrect because a class can't use the keyword extends to inherit an interface.



## [7.2] Develop code that demonstrates the use of polymorphism

**ME-Q38.** What is the output of the following code? (Select 1 option.)

```
class Phone {
 static void call() {
 System.out.println("Call-Phone");
 }
}
class SmartPhone extends Phone{
 static void call() {
 System.out.println("Call-SmartPhone");
 }
}
class TestPhones {
 public static void main(String... args) {
 Phone phone = new Phone();
 Phone smartPhone = new SmartPhone();
 phone.call();
 smartPhone.call();
 }
}
```

- a Call-Phone  
Call-Phone
- b Call-Phone  
Call-SmartPhone
- c Call-Phone  
null
- d null  
Call-SmartPhone

Answer: a

Explanation: Invocation of a `static` method is tied to the type of the reference variable and doesn't depend on the type of the object that's assigned to the reference variable. The `static` method belongs to a class, not to its objects. Re-examine the following code:

```
Phone smartPhone = new SmartPhone();
smartPhone.call();
```

In the preceding code, the type of the reference variable `smartPhone` is `Phone`. Because `call` is a `static` method, `smartPhone.call()` calls the method `call` defined in the class `Phone`.



## [8.1] Differentiate among checked exceptions, RuntimeExceptions, and Errors

**ME-Q39.** Given the following code, which of the following statements are true? (Select 3 options.)

```

class MyExam {
 void question() {
 try {
 question();
 }
 catch (StackOverflowError e) {
 System.out.println("caught");
 }
 }
 public static void main(String args[]) {
 new MyExam().question();
 }
}

```

- a The code will print caught.
- b The code won't print caught.
- c The code would print caught if StackOverflowError were a runtime exception.
- d The code would print caught if StackOverflowError were a checked exception.
- e The code will print caught if question() throws exception NullPointerException.

Answer: a, c, d

Explanation: Option (a) is correct. The control will be transferred to the exception handler for StackOverflowError when it's encountered. Hence it will print caught.

Options (c) and (d) are correct. Exception handlers execute when the corresponding checked or runtime exceptions are thrown.

Option (e) is incorrect. An exception handler for class StackOverflow can't handle exceptions of class NullPointerException because NullPointerException is not a superclass of StackOverflowError.



### [6.7] Apply encapsulation principles to a class

**ME-Q40.** A class Student is defined as follows:

```

public class Student {
 private String fName;
 private String lName;
 public Student(String first, String last) {
 fName = first; lName = last;
 }
 public String getName() { return fName + lName; }
}

```

The creator of the class later changes the method getName as follows:

```

public String getName() {
 return fName + " " + lName;
}

```

What are the implications of this change? (Select 2 options.)

- a The classes that were using the class Student will fail to compile.
- b The classes that were using the class Student will work without any compilation issues.
- c The class Student is an example of a well-encapsulated class.
- d The class Student exposes its instance variable outside the class.

Answer: b, c

Explanation: This is an example of a well-encapsulated class. There is no change in the method signature of method `getName` after it's modified. Hence, none of the code that uses this class and method will face any compilation issues. Its instance variables (`fName` and `lName`) aren't exposed outside the class. They are available only via a public method: `getName`.



### [6.2] Apply the static keyword to methods and fields

**ME-Q41.** What is the output of the following code? (Select 1 option.)

```
class ColorPack {
 int shadeCount = 12;
 static int getShadeCount() {
 return shadeCount;
 }
}
class Artist {
 public static void main(String args[]) {
 ColorPack pack1 = new ColorPack();
 System.out.println(pack1.getShadeCount());
 }
}

 a 10
 b 12
 c No output
 d Compilation error
```

Answer: d

Explanation: A static method can't access non-static instance variables of a class. Hence, the class `ColorPack` fails to compile.



### [6.8] Determine the effect upon object references and primitive values when they are passed into methods that change the values

**ME-Q42.** Paul defined his `Laptop` and `Workshop` classes to upgrade his laptop's memory. Do you think he succeeded? What is the output of this code? (Select 1 option.)

```

class Laptop {
 String memory = "1GB";
}
class Workshop {
 public static void main(String args[]) {
 Laptop life = new Laptop();
 repair(life);
 System.out.println(life.memory);
 }
 public static void repair(Laptop laptop) {
 laptop.memory = "2GB";
 }
}
 a 1 GB
 b 2 GB
 c Compilation error
 d Runtime exception

```

Answer: b

Explanation: The method `repair` defined in this example modifies the state of the method parameter `laptop` that is passed to it. It does so by modifying the value of the instance variable `memory`.

When a method modifies the state of an object reference variable that is passed to it, the changes made are visible in the calling method. The method `repair` makes changes to the state of the method parameter `laptop`; these changes are visible in the method `main`. Hence, the method `main` prints the value of `life.memory` as 2 GB.



### [2.1] Declare and initialize variables

**ME-Q43.** What is the output of the following code? (Select 1 option.)

```

public class Application {
 public static void main(String... args) {
 double price = 10;
 String model;
 if (price > 10)
 model = "Smartphone";
 else if (price <= 10)
 model = "landline";
 System.out.println(model);
 }
}

```

- a landline
- b Smartphone
- c No output
- d Compilation error

Answer: d

Explanation: The local variables aren't initialized with default values. Code that tries to print the value of an uninitialized local variable fails to compile.

In this code, the local variable `model` is only declared, not initialized. The initialization of the variable `model` is placed within the `if` and `else-if` constructs. If you initialize a variable within an `if` or `else-if` construct, the compiler can't be sure whether these conditions will evaluate to `true`, resulting in no initialization of the local variable. Because there is no `else` at the bottom and the compiler can't tell whether the `if` and `else-if` are mutually exclusive, the code won't compile.

If you remove the condition `if (price <= 10)` from the preceding code, the code will compile successfully:

```
public class Application {
 public static void main(String... args) {
 double price = 10;
 String model;
 if (price > 10)
 model = "Smartphone";
 else
 model = "landline";
 System.out.println(model);
 }
}
```

In this code, the compiler can be sure about the initialization of the local variable `model`.



### [2.7] Create and manipulate strings

**ME-Q44.** What is the output of the following code? (Select 1 option.)

```
class EString {
 public static void main(String args[]) {
 String eVal = "123456789";

 System.out.println(eVal.substring(eVal.indexOf("2"),eVal.indexOf("0")).concat("0"));
 }
}

 a 234567890
 b 34567890
 c 234456789
 d 3456789
 e Compilation error
 f Runtime exception
```

Answer: f

Explanation: When multiple methods are chained on a single code statement, the methods execute from left to right, not from right to left. `eVal.indexOf("0")`

returns a negative value because, as you can see, the String eVal doesn't contain the digit 0. Hence, eVal.substring is passed a negative end value, which results in a RuntimeException.



[2.4] Explain an object's life cycle

**ME-Q45.** Examine the following code and select the correct statements (choose 2 options):

```
class Artist {
 Artist assistant;
}
class Studio {
 public static void main(String... args) {
 Artist a1 = new Artist();
 Artist a2 = new Artist();
 a2.assistant = a1;
 a2 = null; // Line 1
 }
 // Line 2
}
```

- a At least two objects are garbage collected on line 1.
- b At least one object is garbage collected on line 1.
- c No objects are garbage collected on line 1
- d The number of objects that are garbage collected on line 1 is unknown.
- e At least two objects are eligible for garbage collection on line 2.

Answer: d, e

Explanation: Options (a), (b), and (c) are incorrect.

When an object reference is marked as null, the object is marked for garbage collection. But you can't be sure exactly when a garbage collector will kick in to garbage collect the objects. A garbage collector is a low-priority thread, and its exact execution time will depend on the OS. The OS will start this thread to claim unused space if it needs to claim unused space. You can be sure only about the number of objects that are eligible for garbage collection. You can never be sure about which objects have been garbage collected, so any statement that asserts that a particular number of objects *have* been garbage collected is incorrect.

Option (d) is correct. As mentioned previously, the exact number of objects garbage collected at any point in time can't be determined.

Option (e) is correct. If you marked this option incorrect, think again. The question wants you to select the correct statements, and this is a correct statement. You may argue that at least two objects were already made eligible for garbage collection at line 1, and you are correct. But because nothing changes on line 2, at least two objects are still eligible for garbage collection.



[3.3] Test equality between strings and other objects using == and equals()

**ME-Q46.** What is the output of the following code? (Select 1 option.)

```
class Book {
 String ISBN;
 Book(String val) {
 ISBN = val;
 }
}
class TestEquals {
 public static void main(String... args) {
 Book b1 = new Book("1234-4657");
 Book b2 = new Book("1234-4657");
 System.out.print(b1.equals(b2) + ":");
 System.out.print(b1 == b2);
 }
}

 a true:false
 b true:true
 c false:true
 d false:false
 e Compilation error—there is no equals method in the class Book.
```

Answer: d

Explanation: The comparison operator determines whether the reference variables refer to the same object. Because the reference variables b1 and b2 refer to different objects, b1==b2 prints false.

The method equals is a public method defined in the class java.lang.Object. Because the class Object is the superclass for all the classes in Java, the method equals is inherited by all classes. Hence, the code compiles successfully. The default implementation of method equals in the base class compares the object references and returns true if both the reference variables refer to the same object and false otherwise.

Because the class Book doesn't override this method, the method equals in the base class Object is called for b1.equals(b2), which returns false. Hence, the code prints:

false:false



[2.6] Manipulate data using the StringBuilder class and its methods

**ME-Q47.** Which of the following statements are correct? (Select 2 options.)

- a `StringBuilder sb1 = new StringBuilder()` will create a `StringBuilder` object with no characters, but with an initial capacity to store 16 chars.

- b `StringBuilder sb1 = new StringBuilder(5*10)` will create a `StringBuilder` object with a value 50.
- c Unlike the class `String`, the `concat` method in `StringBuilder` modifies the value of a `StringBuilder` object.
- d **The `insert` method can be used to insert a character, number, or String at the start or end or a specified position of a `StringBuilder`.**

Answer: a, d

Explanation: There is no `concat` method in the `StringBuilder` class. It defines a whole army of `append` methods (overloaded methods) to add data at the end to a `StringBuilder` object.

`new StringBuilder(50)` creates a `StringBuilder` object with no characters, but with an initial capacity to store 50 chars.



#### [4.1] Declare, instantiate, initialize, and use a one-dimensional array

**ME-Q48.** Given the following definition of the class `Animal` and the interface `Jump`, select the correct array declarations and initialization (choose 3 options):

```
interface Jump {}
class Animal implements Jump {}

 a Jump eJump1[] = {null, new Animal();};
 b Jump [] eJump2 = new Animal() [22];
 c Jump [] eJump3 = new Jump [10];
 d Jump [] eJump4 = new Animal [87];
 e Jump [] eJump5 = new Jump () [12];
```

Answer: a, c, d

Explanation: Option (b) is incorrect because the right side of the expression is trying to create a single object of the class `Animal` by using round brackets, `()`. At the same time, it's also using the square brackets, `[]`, to define an array. This combination is invalid.

Option (e) is incorrect. Apart from using an invalid syntax to initialize an array (as mentioned previously), it also tries to create objects of the interface `Jump`. Objects of interfaces can't be created.



#### [4.3] Declare and use an ArrayList

**ME-Q49.** What is the output of the following code? (Select 1 option.)

```
import java.util.*;
class EJGArrayL {
 public static void main(String args[]) {
```

```

ArrayList<String> seasons = new ArrayList<>();
seasons.add(1, "Spring"); seasons.add(2, "Summer");
seasons.add(3, "Autumn"); seasons.add(4, "Winter");
seasons.remove(2);

for (String s : seasons)
 System.out.print(s + ", ");
}
}

 a Spring, Summer, Winter,
 b Spring, Autumn, Winter,
 c Autumn, Winter,
 d Compilation error
 e Runtime exception

```

Answer: e

Explanation: The code throws a runtime exception, `IndexOutOfBoundsException`, because the `ArrayList` is trying to insert its first element at position 0. Before the first call to the method `add`, the size of the `ArrayList` `seasons` is 0. Because `seasons`'s first element is stored at position 0, a call to store its first element at position 1 will throw a `RuntimeException`. The elements of an `ArrayList` can't be added to a higher position if lower positions are available.



### [3.4] Create if and if-else constructs

**ME-Q50.** What is the output of the following code? (Select 1 option.)

```

class EIF {
 public static void main(String args[]) {
 bool boolean = false;
 if (boolean = true)
 System.out.println("true");
 else
 System.out.println("false");
 }
}

```

- a The class will print true.
- b The class will print false.
- c The class will print true if the if condition is changed to `boolean == true`.
- d The class will print false if the if condition is changed to `boolean != true`.
- e **The class won't compile.**

Answer: e

Explanation: This question tries to trick you on two points. First, there is no data type `bool` in Java. Second, the name of an identifier can't be the same as a reserved word. The code tries to define an identifier of type `bool` with the name `boolean`.



## [5.1] Create and use while loops

**ME-Q51.** How many Fish did the Whale (defined as follows) manage to eat? Examine the following code and select the correct statements (choose 2 options):

```
class Whale {
 public static void main(String args[]) {
 boolean hungry = false;
 while (hungry=true) {
 ++Fish.count;
 }
 System.out.println(Fish.count);
 }
}
class Fish {
 static byte count;
}
```

- a The code doesn't compile.
- b The code doesn't print a value.
- c The code prints 0.
- d Changing `++Fish.count` to `Fish.count++` will give the same results.

Answer: b, d

Explanation: Option (a) is incorrect because the code compiles successfully.

Option (c) is incorrect. This question tries to trick you by comparing a boolean value when it's assigning a boolean value in the while construct. Because the while loop assigns a value true to the variable hungry, it will always return true, incrementing the value of the variable count, and thus getting stuck in an infinite loop.

Option (d) is correct because when the unary increment operator (++) is not part of an expression, postfix and prefix notation behave in exactly the same manner.



## [5.2] Create and use for loops including the enhanced for loop

**ME-Q52.** Given the following code, which option, if used to replace /\* INSERT CODE HERE \*/, will make the code print the name of the phone with the position at which it's stored in the array phone? (Select 1 option.)

```
class Phones {
 public static void main(String args[]) {
 String phones[] = {"BlackBerry", "Android", "iPhone"};
 for (String phone : phones)
 /* REPLACE CODE HERE */
 }
}
```

- a `System.out.println(phones.count + ":" + phone);`
- b `System.out.println(phones.counter + ":" + phone);`

- c System.out.println(phones.getPosition() + ":" + phone);
- d System.out.println(phones.getCtr() + ":" + phone);
- e System.out.println(phones.getCount() + ":" + phone);
- f System.out.println(phones.pos + ":" + phone);
- g **None of the above**

Answer: g

Explanation: The enhanced for loop doesn't provide you with a variable to access the position of the array that it's being used to iterate over. This facility comes with the regular for loop.



#### [8.5] Recognize common exception classes and categories

**ME-Q53. Which of the following** classes represent runtime exceptions in Java (select 4 options):

- a **RuntimeException**
- b **CheckedException**
- c **NullPointerException**
- d **ArrayIndexOutOfBoundsException**
- e **CompilationException**
- f **Throwable**
- g **StackOverflowException**
- h **MemoryOutOfBoundsException**
- i **IllegalArgumentException**
- j **NumberFormatException**

Answer: a, c, d, i

Explanation: Options (b), (e), (g), (h), and (j) are incorrect because there are no exception classes by these names in the Java API.

Option (f) is incorrect because Throwable is the base class of all the exceptions—checked and runtime—and errors in Java. RuntimeExceptions is a subset of this class.



#### [3.3] Test equality between strings and other objects using == and equals()

**ME-Q54. What is the output of the following code? (Select 1 option.)**

```
class Book {
 String ISBN;
 Book(String val) {
 ISBN = val;
 }
}
```

```

public boolean equals(Object b) {
 if (b instanceof Book) {
 return ((Book)b).ISBN.equals(ISBN);
 }
 else
 return false;
}
}

class TestEquals {
 public static void main(String args[]) {
 Book b1 = new Book("1234-4657");
 Book b2 = new Book("1234-4657");
 System.out.print(b1.equals(b2) +":");
 System.out.print(b1 == b2);
 }
}

 a true:false
 b true:true
 c false:true
 d false:false

```

Answer: a

Explanation: The comparison operator determines whether the reference variables refer to the same object. Because the reference variables b1 and b2 refer to different objects, b1==b2 prints false.

The method equals is a public method defined in the class java.lang.Object. Because the class Object is the superclass for all the classes in Java, equals is inherited by all classes. The default implementation of equals in the base class compares the object references and returns true if both the reference variables refer to the same object, and false otherwise. If a class has overridden this method, it returns a boolean value depending on the logic defined in this class. The class Book overrides the equals method and returns true if the Book object defines the same ISBN value as the Book object being compared to. Because the ISBN object value of both the variables b1 and b2 is the same, b1.equals(b2) returns true.



[5.2] Create and use for loops including the enhanced for loop

**ME-Q55.** What is the output of the following code? (Select 1 option.)

```

int a = 10;
for (; a <= 20; ++a) {
 if (a%3 == 0) a++; else if (a%2 == 0) a=a*2;
 System.out.println(a);
}

```

- a 11  
13  
15  
17  
19
- b 20
- c 11  
14  
17  
20
- d 40
- e Compilation error

Answer: b

Explanation: This question requires multiple skills: understanding the declaration of a `for` loop, use of operators, and use of the `if-else` construct.

The `for` loop is correctly defined in the code. The `for` loop in this code doesn't use its variable initialization block; it starts with ; to mark the absence of its variable initialization block. The code for the `if` construct is deliberately incorrect, because you may encounter similar code in the exam.

For the first iteration of the `for` loop, the value of the variable `a` is 10. Because `a <= 20` evaluates to `true`, control moves on to the execution of the `if` construct. This `if` construct can be indented properly as follows:

```
if (a%3 == 0)
 a++;
else if (a%2 == 0)
 a=a*2;
```

(`a%3 == 0`) evaluates to `false` and (`a%2 == 0`) evaluates to `true`, so a value of 20 (`a*2`) is assigned to `a`. The subsequent line prints the value of `a` as 20.

The increment part of the loop statement, (`++a`), increments the value of variable `a` to 21. For the next loop iteration, its condition evaluates to `false` (`a <= 20`), and the loop terminates.



### [6.3] Create an overloaded method

**ME-Q56.** Given the following code, which option, if used to replace `/* INSERT CODE HERE */`, will define an overloaded `rideWave` method (select 1 option):

- ```
class Raft {
    public String rideWave() { return null; }
    /*INSERT CODE HERE*/
}


  - a public String[] rideWave() { return null; }
  - b protected void riceWave(int a) {}
```

- c **private void rideWave(int value, String value2) {}**
- d **default StringBuilder rideWave (StringBuffer a) { return null; }**

Answer: c

Explanation: Option (a) is incorrect. Making a change in the return value of a method doesn't define a valid overloaded method.

Option (b) is incorrect. The name of the method in this option is **riceWave** and not **rideWave**. Overloaded methods should have the same method name.

Option (d) is incorrect. **default** isn't a valid access modifier. The default modifier is marked by the absence of an access modifier.



[5.5] Use break and continue

ME-Q57. Given the following code, which option, if used to replace /* INSERT CODE HERE */, will correctly calculate the sum of all the even numbers in the array num and store it in variable sum? (Select 1 option.)

```
int num[] = {10, 15, 2, 17};
int sum = 0;
for (int number : num) {
    //INSERT CODE HERE
    sum += number;
}
```

- a **if (number % 2 == 0)
continue;**
- b **if (number % 2 == 0)
break;**
- c **if (number % 2 != 0)
continue;**
- d **if (number % 2 != 0)
break;**

Answer: c

Explanation: To find the sum of the even numbers, you first need to determine whether a number is an even number. Then you need to add the even numbers to the variable **sum**.

Option (c) determines whether the array element is completely divisible by 2. If it isn't, it skips the remaining statements in the **for** loop by using the **continue** statement, which starts execution of the **for** loop with the next array element. If the array element is completely divisible by 2, **continue** doesn't execute, and the array number is added to the variable **sum**.



[3.1] Use Java operators

ME-Q58. What is the output of the following code? (Select 1 option.)

```
class Op {  
    public static void main(String... args) {  
        int a = 0;  
        int b = 100;  
        if (!b++ > 100 && a++ == 10) {  
            System.out.println(a+b);  
        }  
    }  
}
```

- a 100
- b 101
- c 102
- d **Code fails to compile.**
- e No output is produced.

Answer: d

Explanation: Although it may seem that the negation unary operator (!) is being applied to the expression `b++ > 100`, it's actually being applied to the variable `b` of type `int`. Because a unary negation operator (!) can't be applied to a variable of type `int`, the code fails to compile. The correct `if` condition would be as follows:

```
if (!(b++ > 100) && a++ == 10) {
```



[7.1] Implement inheritance

ME-Q59. Given the following definitions of the interfaces `Movable` and `Jumpable`, the task is to declare a class `Person` that inherits both of these interfaces. Which of the following code snippets will accomplish this task? (Select 2 options.)

```
interface Movable {}  
interface Jumpable {}
```

- a `interface Movable {}`
`interface Jumpable {}`
`class Person implements Movable, Jumpable {}`
- b `interface Movable {}`
`interface Jumpable {}`
`class Person extends Movable, Jumpable {}`
- c `interface Movable {}`
`interface Jumpable {}`
`class Person implements Movable extends Jumpable {}`

- d interface Movable {}
interface Jumpable implements Movable {}
class Person implements Jumpable {}
- e interface Movable {}
interface Jumpable extends Movable {}
class Person implements Jumpable {}

Answer: a, e

Explanation: Option (b) is incorrect because the right keyword for a class to inherit interfaces is `implements` and not `extends`.

Option (c) is incorrect because a class can't use the keyword `extends` to inherit interfaces.

Option (d) is incorrect because an interface should use the keyword `extends` to inherit another interface.



[6.7] Apply encapsulation principles to a class

ME-Q60. Choose the options that meets the following specification: Create a well-encapsulated class `Pencil` with one instance variable `model`. The value of `model` should be accessible and modifiable outside `Pencil`. (Select 1 option.)

- a class Pencil {
 public String model;
}
- b class Pencil {
 public String model;
 public String getModel() { return model; }
 public void setModel(String val) { model = val; }
}
- c class Pencil {
 private String model;
 public String getModel() { return model; }
 public void setModel(String val) { model = val; }
}
- d class Pencil {
 public String model;
 private String getModel() { return model; }
 private void setModel(String val) { model = val; }
}

Answer: c

Explanation: A well-encapsulated class's instance variables shouldn't be directly accessible outside the class. It should be accessible via non-private getter and setter methods.



[7.2] Develop code that demonstrates the use of polymorphism

ME-Q61. What is the output of the following code? (Select 1 option.)

```
class Phone {
    void call() {
        System.out.println("Call-Phone");
    }
}
class SmartPhone extends Phone{
    void call() {
        System.out.println("Call-SmartPhone");
    }
}
class TestPhones {
    public static void main(String[] args) {
        Phone phone = new Phone();
        Phone smartPhone = new SmartPhone();
        phone.call();
        smartPhone.call();
    }
}
```

- a Call-Phone
Call-Phone
- b Call-Phone
Call-SmartPhone
- c Call-Phone
null
- d null
Call-SmartPhone

Answer: b

Explanation: The method `call` is defined in the base class `Phone`. This method `call` is inherited and overridden by the derived class `SmartPhone`. The type of both reference variables, `phone` and `smartPhone`, is `Phone`. But the reference variable `phone` refers to an object of the class `Phone`, and the variable `smartPhone` refers to an object of the class `SmartPhone`. When the method `call` is called on the reference variable `smartPhone`, it calls the method `call` defined in the class `SmartPhone`, because a call to an overridden method is resolved at runtime and is based on the type of the object on which a method is called.



[5.4] Compare loop constructs

ME-Q62. Given the following requirements, choose the best looping construct to implement them (choose 1 option):

- Step 1: Meet the director of Oracle.
 Step 2: Schedule another meeting with the director.
 Step 3: Repeat 1 and 2, as long as more meetings are required.

- a for loop
- b enhanced for loop
- c do-while loop
- d while loop

Answer: c

Explanation: The question asks you to choose the best looping construct. The condition requires meeting the director at least once, without checking any other condition. This requirement is best implemented using a do-while loop.

A regular for loop and while loop will check the condition of whether a meeting is required before the first meeting. This condition doesn't match with the requirements. An enhanced for loop is normally used to iterate through elements of a collection. We don't have any collection to iterate through here.



[7.3] Differentiate between the type of a reference and the type of an object

ME-Q63. What is the output of the following code? (Select 1 option.)

```
class Phone {
    String keyboard = "in-built";
}
class Tablet extends Phone {
    boolean playMovie = false;
}
class College2 {
    public static void main(String args[]) {
        Phone phone = new Tablet();
        System.out.println(phone.keyboard + ":" + phone.playMovie);
    }
}

 a in-built:false
 b in-built:true
 c null:false
 d null:true
 e Compilation error
```

Answer: e

Explanation: This code won't compile. The object reference variable, phone, of type Phone, can be used to refer to an object of its derived type—Tablet. But variables of a base class can't access variables and methods of its derived classes without an explicit cast to the object of the derived class. So phone can access keyboard, but not playMovie.



[2.1] Declare and initialize variables

ME-Q64. What is the output of the following code? (Select 1 option.)

```
public class Wall {  
    public static void main(String args[]) {  
        double area = 10.98;  
        String color;  
        if (area < 5)  
            color = "red";  
        else  
            color = "blue";  
        System.out.println(color);  
    }  
}
```

- a red
- b blue
- c No output
- d Compilation error

Answer: b

Explanation: In this piece of code, the local variable will always be initialized. It's initialized using the `if-else` construct. One of these constructs (`if` or `else`) is sure to execute, initializing the local variable `color` with a value. Hence, there are no issues with the initialization of the variable `color`. The code will execute successfully, printing `blue`.



[2.5] Call methods on objects

ME-Q65. What is the output of the following code? (Select 1 option.)

```
class Diary {  
    int pageCount = 100;  
    int getPageCount() {  
        return pageCount;  
    }  
    void setPageCount(int val) {  
        pageCount = val;  
    }  
}  
class ClassRoom {  
    public static void main(String args[]) {  
        System.out.println(new Diary().getPageCount());  
        new Diary().setPageCount(200);  
        System.out.println(new Diary().getPageCount());  
    }  
}
```

- a 100
200
- b 100
100
- c 200
200
- d Code fails to compile.

Answer: b

Explanation: The constructor of a class creates an object of the class in which it's defined and returns the created object. This returned object can be assigned to a reference variable. In case the returned object isn't assigned to any reference variable, none of the variables or methods of this object can be accessed again. This is what happens in class ClassRoom. All calls to the methods getPageCount and setPageCount in the example operate on unrelated objects.



[5.3] Create and use do-while loops

ME-Q66. How many times do you think you can shop with the following code (that is, what's the output of the following code)? (Select 1 option.)

```
class Shopping {
    public static void main(String args[]) {
        boolean bankrupt = true;
        do System.out.println("enjoying shopping"); bankrupt = false;
        while (!bankrupt);
    }
}
```

- a The code prints enjoying shopping once.
- b The code prints enjoying shopping twice.
- c The code prints enjoying shopping in an infinite loop.
- d The code fails to compile.

Answer: d

Explanation: The code fails to compile because it's trying to stuff two lines of code between the do and while statements without using curly braces.



[4.2] Declare, instantiate, initialize, and use a multidimensional array

ME-Q67. Which of the following options are valid for defining multidimensional arrays? (Choose 4 options.)

- a String ejg1[][] = new String[1][2];
- b String ejg2[][] = new String[][] {{}, {}};
- c String ejg3[][] = new String[2][2];

- d** String ejg4[][] = new String[][]{{null},new String[]{"a","b","c"}},
 {new String()};
- e** String ejg5[][] = new String[] [2];
- f** String ejg6[][] = new String[] [] {"A", "B"};
- g** String ejg7[][] = new String[] {{"A"}, {"B"}};

Answer: a, b, c, d

Explanation: Options (a), (b), (c), and (d) define multidimensional arrays correctly.

Option (e) is incorrect because the size in the first pair of square brackets is missing.

Option (f) is incorrect. The correct code must use an additional pair of {} on the right side, as follows:

```
String ejg6[][] = new String[][]{{"A"}, {"B"}};
```

Option (g) is incorrect. The correct code must use an additional pair of [] on the right side as follows:

```
String ejg7[][] = new String[] [] {"A", "B"};
```



[6.8] Determine the effect upon object references and primitive values when they are passed into methods that change the values

ME-Q68. What is the output of the following code? (Select 1 option.)

```
class Laptop {
    String memory = "1GB";
}
class Workshop {
    public static void main(String args[]) {
        Laptop life = new Laptop();
        repair(life);
        System.out.println(life.memory);
    }
    public static void repair(Laptop laptop) {
        laptop = new Laptop();
        laptop.memory = "2GB";
    }
}
```

- a** 1 GB
- b** 2 GB
- c** Compilation error
- d** Runtime exception

Answer: a

Explanation: The method `repair` defined in this example assigns a new object to the method parameter `laptop` that is passed to it. Then it modifies the state of this new assigned object by assigning 1 GB to its instance variable, `memory`.

When a method reassigns an object reference variable that is passed to it, the changes made to its state aren't visible in the calling method. This is because the changes are made to a new object and not to the one that was initially passed to this method. The method `repair` assigns a new object to the reference variable `laptop` that is passed to it and then modifies its state. Hence, the changes made to the state of the method parameter `laptop` aren't visible in method `main`, and it prints the value of `life.memory` as 1 GB.



[7.4] Determine when casting is necessary

ME-Q69. Given the following code, which option, if used to replace `/* INSERT CODE HERE */`, will enable a reference variable of type `Roamable` to refer to an object of the `Phone` class? (Select 1 option.)

```
interface Roamable{}
class Phone {}
class Tablet extends Phone implements Roamable {
    //INSERT CODE HERE
}
```

- a `Roamable var = new Phone();`
- b `Roamable var = (Roamable)Phone();`
- c `Roamable var = (Roamable)new Phone();`
- d Because interface `Roamable` and class `Phone` are unrelated, a reference variable of type `Roamable` can't refer to an object of class `Phone`.

Answer: c

Explanation: Option (a) is incorrect. Without explicit casting, a reference variable of type `Roamable` can't refer to an object of the class `Phone`.

Option (b) is incorrect because this is an invalid line of code that will fail to compile.

Option (d) is incorrect because a reference variable of type `Roamable` can refer to an object of the class `Phone` with an explicit cast.

Note that although option (c) will compile, it will throw a `ClassCastException` if it is executed.



[1.3] Create executable Java applications with a main method

ME-Q70. Which of the following statements is incorrect about *the main* method used to start a Java application? (Select 2 options.)

- a A class can't define multiple `main` methods.
- b More than one class in an application can define the `main` method.
- c The `main` method may accept a `String`, a `String array`, or `varargs (String... arg)` as a method argument.
- d The `main` method shouldn't define an object of the class in which the `main` method itself is defined.

Answer: c, d

Explanation: Option (a) is a true statement. Even though you can define multiple methods with the name `main` in a class, you can define only one `main` method to start a Java application. This question specifically asks you about the `main` method used to start a Java application.

Option (b) is a true statement. Multiple classes in an application may define the `main` method.

Option (c) is a false statement. The `main` method must accept either a `String` array or varargs (`String... arg`) as a method argument. It can't accept a `String` object.

Option (d) is a false statement. There are no limitations on the types of the objects that this method can create. This includes the object of the class in which the `main` method is defined.



[7.5] Use super and this to access objects and constructors

ME Q71. What is the output of the following code? (Select 1 option.)

```
class Paper {
    Paper() {
        this(10);
        System.out.println("Paper:0");
    }
    Paper(int a) { System.out.println("Paper:1"); }
}
class PostIt extends Paper {}
class TestPostIt {
    public static void main(String[] args) {
        Paper paper = new PostIt();
    }
}

 a Paper:1
 b Paper:0
 c Paper:0
    Paper:1
 d Paper:1
    Paper:0
```

Answer: d

Explanation: `new PostIt()` creates an object of the class `PostIt` by calling its compiler-provided no-argument constructor. The no-argument constructor of class `PostIt` calls its base class no-argument constructor, which calls the other constructor that accepts one `int` method argument. The constructor that accepts an `int` argument prints `Paper:1` and then returns the control to the no-argument constructor. The no-argument constructor then prints `Paper:0`.



[2.6] Manipulate data using the StringBuilder class and its methods

ME-Q72. Examine the following code and select the correct statement (choose 1 option):

```
line1> class StringBuilders {
line2>     public static void main(String... args) {
line3>         StringBuilder sb1 = new StringBuilder("eLion");
line4>         String ejg = null;
line5>         ejg = sb1.append("X").substring(sb1.indexOf("L"),
    sb1.indexOf("X")));
line6>         System.out.println(ejg);
line7>     }
line8> }
```

- a The code will print LionX.
- b The code will print Lion.
- c The code will print Lion if line 5 is changed to the following:

```
ejg = sb1.append("X").substring(sb1.indexOf('L'), sb1.indexOf('X'));
```

- d The code will compile correctly if line 4 is changed to the following:

```
StringBuilder ejg = null;
```

Answer: b

Explanation: Option (a) is incorrect and option (b) is correct. The `substring` method doesn't include the character at the end position in the result that it returns. Hence, the code prints Lion.

Option (c) is incorrect. If line 5 is changed as suggested in this option, the code won't compile. You can't pass a char to `StringBuilder`'s method `indexOf`; it accepts `String`.

Option (d) is incorrect because there are no compilation issues with the code.



[7.6] Use abstract classes and interfaces

ME-Q73. When considered individually, which of the options is correct for the following code? (Select 1 option.)

```
interface Jumpable { void jump(); }
class Chair implements Jumpable {
    public void jump() {
        System.out.println("Chair cannot jump");
    }
}
```

- a The class `Chair` can't implement the interface `Jumpable` because a `Chair` can't define a method `jump`.
- b If the name of the interface is changed to `Movable` and definition of class `Chair` is updated to class `Chair implements Movable`, class `Chair` will compile successfully.

- c If the definition of the method `jump` is removed from the definition of the class `Chair`, it will compile successfully.
- d If the name of the method `jump` is changed to run in the interface `Jumpable`, the class `Chair` will compile successfully.

Answer: b

Explanation: Option (a) is incorrect. The name of the interface or class doesn't matter when it comes to whether a class can implement an interface. If a class implements an interface, it should implement all of the methods defined by the interface.

Option (c) is incorrect. If the definition of the method `jump` is removed from the class `Chair`, it will no longer compile. Because `Chair` implements the interface `Jumpable`, it should implement all of the methods defined in the interface `Jumpable`.

Option (d) is incorrect. If the name of the method `jump` is changed to run in the interface `Jumpable`, the class `Chair` should implement this method to compile successfully.



[7.4] Determine when casting is necessary

ME-Q74. Given the following code, which option, if used to replace `/* INSERT CODE HERE */`, will enable the class `Jungle` to determine whether the reference variable `animal` refers to an object of the class `Lion` and print 1? (Select 1 option.)

```
class Animal{ float age; }
class Lion extends Animal { int claws; }
class Jungle {
    public static void main(String args[]) {
        Animal animal = new Lion();
        /* INSERT CODE HERE */
        System.out.println(1);
    }
}
```

- a `if (animal instanceof Lion)`
- b `if (animal instanceOf Lion)`
- c `if (animal == Lion)`
- d `if (animal = Lion)`

Answer: a

Explanation: Option (b) is incorrect because the correct operator name is `instanceof` and not `instanceOf` (note the capitalized O).

Options (c) and (d) are incorrect. Neither of these lines of code will compile because they are trying to compare and assign a class name to a variable, which isn't allowed.



[6.4] Differentiate between default and user-defined constructors

ME-Q75. Given that the file Test.java, which defines the following code, fails to compile, select the reasons for the compilation failure (choose 2 options):

```
class Person {
    Person(String value) {}
}
class Employee extends Person {}
class Test {
    public static void main(String args[]) {
        Employee e = new Employee();
    }
}
```

- a The class Person fails to compile.
- b The class Employee fails to compile.
- c The default constructor can call only no-argument constructor of a base class.
- d Code that creates an object of class Employee in class Test didn't pass a String value to the constructor of class Employee.

Answer: b, c

Explanation: The class Employee doesn't compile, so class Test can't use a variable of type Employee, and it fails to compile.

While trying to compile the class Employee, the Java compiler generates a default constructor for it, which looks like the following:

```
Employee() {
    super();
}
```

Note that a derived class constructor must always call a base class constructor. When Java generates the previous default constructor for the class Employee, it fails to compile because the base class doesn't have a no-argument constructor. The default constructor that's generated by Java can only define a call to a no-argument constructor in the base class. It can't call any other base class constructor.



[8.1] Differentiate among checked exceptions, RuntimeExceptions, and Errors

ME-Q76. Select the correct statements. (Choose 4 options.)

- a Checked exceptions are subclasses of java.lang.Throwable.
- b Runtime exceptions are subclasses of java.lang.Exception.
- c Errors are subclasses of java.lang.Throwable.
- d java.lang.Throwable is a subclass of java.lang.Exception.
- e java.lang.Exception is a subclass of java.lang.Error.

- f Errors aren't subclasses of `java.lang.Exception`.
- g `java.lang.Throwable` is a subclass of `java.lang.Error`.
- h Checked exceptions are subclasses of `java.lang.CheckedException`.

Answer: a, b, c, f

Explanation: Option (d) is incorrect because `java.lang.Exception` is a subclass of `java.lang.Throwable`.

Option (e) is incorrect because the class `java.lang.Exception` isn't a subclass of `java.lang.Error`. Both of these classes subclass `java.lang.Throwable`.

Option (g) is incorrect because `java.lang.Error` is a subclass of `java.lang.Throwable`.

Option (h) is incorrect because the Java API doesn't define any class `CheckedException` in package `java.lang`.



[6.5] Create and overload constructors

ME-Q77. Examine the following code and select the correct statements (choose 2 options):

```
class Bottle {
    void Bottle() {}
    void Bottle(WaterBottle w) {}
}
class WaterBottle extends Bottle {}
```

- a A base class can't pass reference variables of its defined class, as method parameters in constructors.
- b The class compiles successfully—a base class can use reference variables of its derived class as method parameters.
- c The class `Bottle` defines two overloaded constructors.
- d The class `Bottle` can access only one constructor.

Answer: b, d

Explanation: A base class can use reference variables and objects of its derived classes. Note that the methods defined in the class `Bottle` aren't constructors but regular methods with the name `Bottle`. The return type of a constructor isn't `void`.



[7.5] Use super and this to access objects and constructors

ME-Q78. Given the following code, which option, if used to replace /* INSERT CODE HERE */, will cause the code to print 110? (Select 1 option.)

```
class Book {
    private int pages = 100;
}
```

```

class Magazine extends Book {
    private int interviews = 2;
    private int totalPages() { /* INSERT CODE HERE */ }

    public static void main(String[] args) {
        System.out.println(new Magazine().totalPages());
    }
}

 a return super.pages + this.interviews*5;
 b return this.pages + this.interviews*5;
 c return super.pages + interviews*5;
 d return pages + this.interviews*5;
 e None of the above

```

Answer: e

Explanation: The variable pages has private access in the class Book, and it can't be accessed from outside this class.



[8.4] Invoke a method that throws an exception

ME-Q79. Given that the method write has been defined as follows,

```

class NoInkException extends Exception {}
class Pen{
    void write(String val) throws NoInkException {
        //.. some code
    }
    void article() {
        //INSERT CODE HERE
    }
}

```

which of the following options, when inserted at //INSERT CODE HERE, will define valid use of the method write in the method article? (Select 2 options.)

- a try {
 new Pen().write("story");
 }
 catch (NoInkException e) {}
- b try {
 new Pen().write("story");
 }
 finally {}
- c try {
 write("story");
 }
 catch (Exception e) {}

```
 d try {
    new Pen().write("story");
}
catch (RuntimeException e) {}
```

Answer: a, c

Explanation: Because `NoInkException` extends the class `Exception` and not `Runtime-Exception`, `NoInkException` is a checked exception. When you call a method that throws a checked exception, you can either handle it using a `try-catch` block or declare it to be thrown in your method signature.

Option (a) is correct because a call to the method `write` is enclosed within a `try` block. The `try` block is followed by a `catch` block, which defines a handler for the exception `NoInkException`.

Option (b) is incorrect. The call to the method `write` is enclosed within a `try` block, followed by a `finally` block. The `finally` block is not used to handle an exception.

Option (c) is correct. Because `NoInkException` is a subclass of `Exception`, an exception handler for the class `Exception` can handle the exception `NoInkException` as well.

Option (d) is incorrect. This option defines an exception handler for the class `Runtime-Exception`. Because `NoInkException` is not a subclass of `Runtime-Exception`, this code won't handle `NoInkException`.



[1.1] Define the scope of variables

ME-Q80. What is the output of the following code? (Select 1 option.)

```
class EMyMethods {
    static String name = "m1";
    void riverRafting() {
        String name = "m2";
        if (8 > 2) {
            String name = "m3";
            System.out.println(name);
        }
    }
    public static void main(String[] args) {
        EMyMethods m1 = new EMyMethods();
        m1.riverRafting();
    }
}
```

- a m1
- b m2
- c m3
- d Code fails to compile.

Answer: d

Explanation: The class `EMyMethods` defines three variables with the name `name`:

- The static variable `name` with the value "`m1`".
- The local variable `name` in method `riverRafting` with the value "`m2`".
- The variable `name`, local to the `if` block in the method `riverRafting`, with the value "`m3`".

The code fails to compile due to the definition of two local variables with the same name (`name`) in the method `riverRafting`. If this code were allowed to compile, the scope of both these local variables would overlap—the variable `name` defined outside the `if` block would be accessible to the complete method `riverRafting`. The scope of the local variable `name`, defined within the `if` block, would be limited to the `if` block.

Within the `if` block, how do you think the code would differentiate between these local variables? Because there is no way to do so, the code fails to compile.



[2.7] Create and manipulate strings

ME-Q81. What is the output of the following code? (Select 1 option.)

```
class EBowl {
    public static void main(String args[]) {
        String eFood = "Corn";
        System.out.println(eFood);
        mix(eFood);
        System.out.println(eFood);
    }
    static void mix(String foodIn) {
        foodIn.concat("A");
        foodIn.replace('C', 'B');
    }
}
```

- a Corn
BornA
- b Corn
CornA
- c Corn
Born
- d Corn
Corn

Answer: d

Explanation: `String` objects are immutable. This implies that using any method can't change the value of a `String` variable. In this case, the `String` object is passed to a method, which seems to, but doesn't, change the contents of `String`.



[3.5] Use a switch statement

ME-Q82. Which statement is true for the following code? (Select 1 option.)

```
class SwJava {  
    public static void main(String args[]) {  
        String[] shapes = {"Circle", "Square", "Triangle"};  
        switch (shapes) {  
            case "Square": System.out.println("Circle"); break;  
            case "Triangle": System.out.println("Square"); break;  
            case "Circle": System.out.println("Triangle"); break;  
        }  
    }  
}
```

- a The code prints Circle.
- b The code prints Square.
- c The code prints Triangle.
- d The code prints

```
Circle  
Square  
Triangle
```

- e The code prints

```
Triangle  
Circle  
Square
```

- f The code fails to compile.

Answer: f

Explanation: The question tries to trick you; it passes a `String` value to a `switch` construct by passing it an array of `String` objects. The code fails to compile because an array isn't a valid argument to a `switch` construct. The code would have compiled if it passed an element from the array `shapes` (`shapes[0]`, `shapes[1]`, and `shapes[2]`).



[5.3] Create and use do-while loops

ME-Q83. Which of the following options include the ideal conditions for choosing to use a `do-while` loop over a `while` loop? (Select 2 options.)

- a Repeatedly display a menu to a user and accept input until the user chooses to exit the application.
- b Repeatedly allow a student to sit in the exam only if she carries her identity card.
- c Repeatedly serve food to a person until he wants no more.
- d Repeatedly allow each passenger to board an airplane if the passengers have their boarding passes.

Answer: a, c

Explanation: Option (a) is correct. A menu should be displayed to a user at least once so that she can select whether she wants to exit an application.

Option (b) is incorrect. Because the condition of possession of an identity card should be checked *before* a student is allowed to sit an exam, this condition is best implemented using a while loop.

Option (c) is correct. Because a person should be served the food at least once *before* asking whether he needs more, this condition is best implemented using a do-while loop.

Option (d) is incorrect. Because none of the passengers would be allowed to board without a boarding pass, this condition is best implemented using a while loop.



[8.4] Invoke a method that throws an exception

ME-Q84. Given the following definition of the classes Person, Father, and Home, which option, if used to replace /* INSERT CODE HERE */, will cause the code to compile successfully (select 3 options):

```
class Person {}
class Father extends Person {
    public void dance() throws ClassCastException {}
}
class Home {
    public static void main(String args[]) {
        Person p = new Person();
        try {
            ((Father)p).dance();
        }
        //INSERT CODE HERE
    }
}

 a catch (NullPointerException e) {}
    catch (ClassCastException e) {}
    catch (Exception e) {}
    catch (Throwable t) {}

 b catch (ClassCastException e) {}
    catch (NullPointerException e) {}
    catch (Exception e) {}
    catch (Throwable t) {}

 c catch (ClassCastException e) {}
    catch (Exception e) {}
    catch (NullPointerException e) {}
    catch (Throwable t) {}

 d catch (Throwable t) {}
    catch (Exception e) {}
    catch (ClassCastException e) {}
    catch (NullPointerException e) {}

 e finally {}
```

Answer: a, b, e

Explanation: Because `NullPointerException` and `ClassCastException` don't share a base class-derived class relationship, these can be placed before or after each other.

The class `Throwable` is the base class of `Exception`. Hence, the exception handler for the class `Throwable` can't be placed before the exception handler of the class `Exception`. Similarly, `Exception` is a base class for `NullPointerException` and `ClassCastException`. Hence, the exception handler for the class `Exception` can't be placed before the exception handlers of either the class `ClassCastException` or `NullPointerException`.

Option (e) is okay because no checked exceptions are defined to be thrown.



[5.1] Create and use while loops

ME-Q85. What is the output of the following code? (Select 1 option.)

```
class Camera {
    public static void main(String args[]) {
        String settings;
        while (false) {
            settings = "Adjust settings manually";
        }
        System.out.println("Camera:" + settings);
    }
}
```

- a The code prints Camera:null.
- b The code prints Camera:Adjust settings manually.
- c The code will print Camera:..
- d The code will fail to compile.

Answer: d

Explanation: The key to answering this question is to remember that if the compiler finds unreachable code at compilation time, the code won't compile. Use of the literal value `false` in the while loop will ensure that the code in the loop's body won't execute, and this can be determined by the compiler at compilation time.



[6.2] Apply the static keyword to methods and fields

ME-Q86. The output of the class `TestEJavaCourse`, defined as follows, is 300:

```
class Course {
    int enrollments;
}
class TestEJavaCourse {
    public static void main(String args[]) {
```

```

        Course c1 = new Course();
        Course c2 = new Course();
        c1.enrollments = 100;
        c2.enrollments = 200;
        System.out.println(c1.enrollments + c2.enrollments);
    }
}

```

What will happen if the variable `enrollments` is defined as a `static` variable? (Select 1 option.)

- a No change in output. TestEJavaCourse prints 300.
- b Change in output. TestEJavaCourse prints 200.
- c **Change in output. TestEJavaCourse prints 400.**
- d The class TestEJavaCourse fails to compile.

Answer: c

Explanation: The code doesn't fail compilation after the definition of the variable `enrollments` is changed to a `static` variable. A `static` variable can be accessed using a variable reference of the class in which it's defined. All the objects of a class share the same copy of the `static` variable. When the variable `enrollments` is modified using the reference variable `c2`, `c1.enrollments` is also equal to 200. Hence, the code prints $200+200$, that is, 400.



[4.2] Declare, instantiate, initialize, and use a multidimensional array

ME-Q87. What is the output of the following code? (Select 1 option.)

```

String ejgStr[] = new String[][] {{null}, new String[] {"a", "b", "c"}, {new
    String()} [0] ;
String ejgStr1[] = null;
String ejgStr2[] = {null};

System.out.println(ejgStr[0]);
System.out.println(ejgStr2[0]);
System.out.println(ejgStr1[0]);

```

- a null
NullPointerException
- b null
null
NullPointerException
- c NullPointerException
- d null
null
null

Answer: b

Explanation: The trickiest assignment in this code is the assignment of variable ejgStr. The following line of code may *seem* to (but doesn't) assign a two-dimensional String array to the variable ejgStr:

```
String ejgStr[] = new String[][] {{null}, new String[] {"a", "b", "c"}, {new String()} }[0] ;
```

The preceding code assigns the first element of a two-dimensional String array to the variable ejgStr. The following indented code will make the previous statement easier to understand:

```
String ejgStr[] = new String[][] {
    {null},
    new String[] {"a", "b", "c"},
    {new String()}
} [0] ;
```

So, let's look at the simplified assignment:

```
String ejgStr[] = {null};
String ejgStr1[] = null;
String ejgStr2[] = {null};
```

Revisit the code that prints the array elements:

```
System.out.println(ejgStr[0]);
System.out.println(ejgStr2[0]);
System.out.println(ejgStr1[0]);
```

- 1 Prints null
- 2 Prints null
- 3 Throws NullPointerException

Because ejgStr refers to an array of length 1 ({null}), ejgStr[0] prints null. ejgStr2 also refers to an array of length 1 ({null}), so ejgStr2[0] also prints null. ejgStr1 refers to null, not to an array. An attempt to access the first element of ejgStr1 throws NullPointerException.



[4.3] Declare and use an ArrayList

ME-Q88. Examine the following code and select the correct statement (choose 1 option):

```
import java.util.*;
class Person {}
class Emp extends Person {}

class TestArrayList {
    public static void main(String[] args) {
        ArrayList<Object> list = new ArrayList<Object>();
        list.add(new String("1234")) ; //LINE1
        list.add(new Person()) ; //LINE2
```

```

        list.add(new Emp());           //LINE3
        list.add(new String[]{"abcd", "xyz"}); //LINE4
    }
}

```

- a The code on line 1 won't compile.
- b The code on line 2 won't compile.
- c The code on line 3 won't compile.
- d The code on line 4 won't compile.
- e **None of the above.**

Answer: e

Explanation: The type of an `ArrayList` determines the type of the objects that can be added to it. An `ArrayList` can add to it all the objects of its derived class. Because the class `Object` is the superclass of all Java classes, the `ArrayList` `list` as defined in this question will accept all types of objects, including arrays, because they are also objects.



[3.4] Create if and if-else constructs

ME-Q89. What is the output of the following code? (Select 1 option.)

```

public class If2 {
    public static void main(String args[]) {
        int a = 10; int b = 20; boolean c = false;
        if (b > a) if (++a == 10) if (c!=true) System.out.println(1);
                     else System.out.println(2); else System.out.println(3);
    }
}

 a 1
 b 2
 c 3
 d No output

```

Answer: c

Explanation: The key to answering questions about unindented code is to indent it. Here's how:

```

if (b > a)
    if (++a == 10)
        if (c!=true)
            System.out.println(1);
        else
            System.out.println(2);
    else System.out.println(3);

```

Now the code becomes much simpler to look at and understand. Remember that the last `else` statement belongs to the inner `if (++a == 10)`. As you can see, `if (++a == 10)` evaluates to `false`, and the code will print 3.



[5.4] Compare loop constructs

ME-Q90. Select the incorrect statement (choose 1 option):

- a An enhanced for loop can be used to iterate through the elements of an array and ArrayList.
- b **The loop counter of an enhanced for loop can be used to modify the current element of the array being iterated over.**
- c do-while and while loops can be used to iterate through the elements of an array and ArrayList.
- d The loop counter of a regular for loop can be used to modify the current element of an ArrayList being iterated over.

Answer: b

Explanation: Note that this question asks you to select the incorrect statements.

All the looping constructs—a regular for loop, an enhanced for loop, and do-while and while loops—can be used to iterate through elements of an array and ArrayList. But the notion of a loop counter is available only for the for loop. A loop counter is a variable that's defined and accessible with the definition of the for loop. In the following quick example, the variable `ctr` is referred to as a loop counter:

```
for (int ctr=0; ctr< 10; ++ctr)
```

appendix *Answers to Twist* *in the Tale exercises*

Chapters 1 to 7 include multiple Twist in the Tale exercises. The answers to these exercises are given in this appendix, with comprehensive explanations. The answers to each exercise include the following elements:

- *Purpose:* The aim of the exercise (the *twist* to which each exercise is trying to draw your attention)
- *Answer:* The correct answer
- *Explanation:* A comprehensive explanation of the answer

Let's get started with the first chapter.

A.1 Chapter 1: Java basics

Chapter 1 includes four Twist in the Tale exercises.

A.1.1 Twist in the Tale 1.1

Purpose: This exercise encourages you to practice code with a combination of the correct contents (classes and interfaces) of a Java source code file.

Answer: c, d

Explanation: Options (a) and (b) are incorrect.

Option (c) is correct because a Java source code file can define multiple interfaces and classes.

Option (d) is correct because a public interface or class can be defined in a Java source code file with a matching name. The public interface `Printable` can't be defined in the Java source code file, `Multiple.java`. It should be defined in `Printable.java`.

A.1.2 **Twist in the Tale 1.2**

Purpose: Though similar to Twist in the Tale 1.1, this question is different in terms of its wording and intent. It asks you to select the options that are correct *individually*. Selecting an option that's correct individually means that an option should be correct on its own and not in combination with any other option. You may get to answer similar questions in the real exam.

Answer: a, c, d

Explanation: Option (a) is correct and (b) is incorrect because Multiple2.java won't compile. Multiple2.java can't define a public class Car.

Option (c) is correct because removal of the definition of the public class Car from Multiple2.java will leave only one public interface in Multiple2.java—Multiple2. Because the names of the public interface Multiple2 and the source code file match, Multiple2.java will compile successfully.

Option (d) is correct. Changing public class Car to a non-public class will leave only one public interface in Multiple2.java—Multiple2. Because the names of the public interface Multiple2 and source code file match, Multiple2.java will compile successfully.

Option (e) is incorrect. If you change the access modifier of the public interface Multiple2 to non-public, Multiple2.java will contain a definition of a public class Car, which isn't allowed.

A.1.3 **Twist in the Tale 1.3**

Purpose: This exercise encourages you to execute the code in the options to understand the correct method signature of the method main together with the method parameters that are passed to it.

Answer: a, b

Explanation: All the options in this question are supposed to execute using the command javaEJava java one one. The purpose of each of these terms is as follows:

- Term 1: java—Used to execute a Java class
- Term 2: EJava—Name of class to execute
- Term 3: java—Passed as the first argument to the method main
- Term 4: one—Passed as the second argument to main
- Term 5: one—Passed as the third argument to main

To output "java one", the main method should output the first and either the second or third method parameters passed to it.

Options (a) and (b) are correct because they use the correct method signature of the method main. The name of the method parameter need not be args. It can be any other valid identifier. Option (a) outputs the values of the first and third terms passed to it. Option (b) outputs the values of the first and second terms passed to it.

Option (c) is incorrect because this `main` method accepts a two-dimensional array. Hence, it won't be treated as *the main* method.

Option (d) is incorrect because this code won't compile. The access modifier of a method (`public`) should be placed before its return type (`void`); otherwise, the code won't compile.

A.1.4 ***Twist in the Tale 1.4***

Purpose: Apart from determining the right access modifier that can limit the visibility of a class within a package, this exercise wants you to try out different access modifiers that can be used to declare a class.

Answer: The code submitted by Harry.

Explanation: The code submitted by Paul is incorrect because when the class `Curtain` is defined with the `public` access modifier, it will be accessible outside the package building.

The code submitted by Shreya and Selvan is incorrect because the class `Curtain` is a top-level class (it's not defined within another class), so it can't be defined using the access modifiers `protected` and `private`.

A.2 ***Chapter 2—Working with Java data types***

Chapter 2 includes four Twist in the Tale exercises. Twist in the Tale 2.1 has two parts.

A.2.1 ***Twist in the Tale 2.1 (part 1)***

Purpose: By default, `System.out.println()` will print out a number in its decimal base. It does so regardless of the base number system that you use to initialize a number.

Answer: The code prints the following output:

```
534  
534
```

Explanation: Often programmers are tricked by similar questions. If a variable is assigned a value using `0b100001011` (a number in the binary number system), a programmer might believe that `System.out.println()` will print out numbers in the binary number system, which is incorrect. By default, `System.out.println()` will print out a number in its decimal base. All four variables `baseDecimal`, `octVal`, `hexVal`, and `binVal` represent the decimal value 267 in the decimal, octal, hexadecimal, and binary number systems. The addition operation adds these values and prints `534` twice.

You can use a method from the class `Integer` to print out a value in the binary number system as follows:

```
System.out.println(Integer.toBinaryString(0b100001011));
```

Note that the class `Integer` isn't on this exam and you won't be asked any questions on it. This class is mentioned only for your reference.

A.2.2 **Twist in the Tale 2.1 (part 2)**

Purpose: A new Java 7 language feature is the use of the underscore in literal number values. If you haven't worked with underscores in literal number values, this exercise's purpose is to help you get familiar with this feature.

Answer: Only var1, var6, and var7 correctly define a literal integer value.

Explanation: The literal value `0_x_4_13` defined by `var2` is incorrect because it uses underscores after the starting `0` and after the letter `x`, neither of which is allowed. The correct value is `0x4_13`.

The literal value `0b_x10_BA_75` defined by `var3` is incorrect. You can't place an underscore right after the prefixes `0b` and `0B` that are used to define binary literal values. Also, a binary value can contain only the digits `1` and `0`.

The literal value `0b_10000_10_11` defined by value `var4` is incorrect. You can't place an underscore right after the prefixes `0b` and `0B` used to define binary literal values. The correct value is `0b10000_10_11`.

The literal value `0xa10_AG_75` defined by `var5` is incorrect because it uses the letter `G`, which isn't allowed in a hexadecimal number system. A correct value is `0xa10_A_75`.

A.2.3 **Twist in the Tale 2.2**

Purpose: To reinforce the following concepts:

- Multiple variables of the *same type* can be defined on the same line of code.
- Variable assignment rule: if multiple variables of *similar types* are assigned values on the same line, assignment starts from right to left. Also, unlike other programming languages such as C, the literal value `0` can't be assigned to a variable of type `boolean`.
- Questions that ask you to select incorrect answers or code can be confusing. It's common to start by determining the incorrect options and then selecting the correct options. Make note of such questions.

Answer: a, b, c, e

Explanation: Options (a) and (b) are incorrect statements. You can define multiple variables of the same type on the same line. Also, you can assign values to variables of compatible types on the same line of code. Assignment starts from right to left. For proof, the following lines of code will compile:

```
int int1;
long long2;
long2 = int1 = 10;
```

But the following lines of code won't compile:

```
int i1;
long l2;
int1 = long2 = 10;
```

In the final line of the preceding code, a literal value 10 is assigned to the variable long2 of type long, which is acceptable. An attempt to assign the value of the variable long2 to int1 fails because it would need an explicit cast.

Option (c) is an incorrect statement because a literal value 0 can't be assigned to a variable of type boolean.

Option (d) is a correct statement.

Option (e) is an incorrect statement. The code doesn't define a variable with the name yes and thus seems to treat it like a literal value. Java doesn't define a literal value yes, so the code doesn't compile.

A.2.4 *Twist in the Tale 2.3*

Purpose: The exercise encourages you to

- Try code with increment and decrement postfix and prefix unary operators
- Get the hang of how variables are evaluated in an expression that has multiple occurrences of unary operators in postfix and prefix notation

Answer: 32

Explanation: The actual task is to evaluate the following expression:

```
int a = 10;
a = ++a + a + --a - --a + a++;
System.out.println(a);
```

This is the actual task because the question asks you to replace all occurrences of `++a` with `a++`, `--a` with `a--`, and vice versa. This expression is depicted in figure A.1:

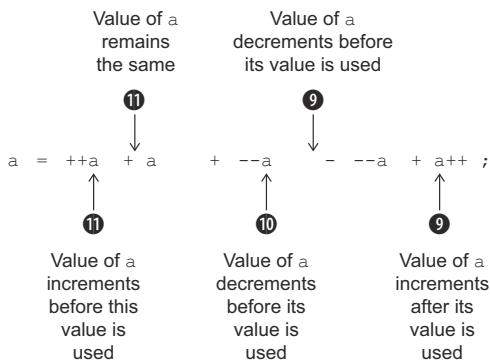


Figure A.1 Evaluation of an expression that has multiple unary operators in postfix and prefix notation

A.2.5 *Twist in the Tale 2.4*

Purpose: To determine whether the operands of an expression that uses the short-circuit operators `&&` and `||` will evaluate.

Answer: The operands that will execute are circled and the ones that won't are enclosed in squares in figure A.2.

```

class TwistInTaleLogicalOperators {
    public static void main(String args[]){
        int a=10;
        int b=20;
        int c=40;

        System.out.println(a++>10 || ++b<30); //line1
        System.out.println(a>90 && ++b<30);
        System.out.println(!c>20) && a==10;
        System.out.println(a>=99 || a<=33 && b==10);
        System.out.println(a>=99 && a<=33 || b==10);
    }
}

```

Figure A.2 In an expression that uses the short-circuit operators `&&` and `||`, the operands that are evaluated are circled and the ones that aren't evaluated are enclosed in rectangles.

Explanation: Both of the short-circuit operators, `&&` and `||`, will evaluate their first operand. For the short-circuit operator `&&`, if the first operand evaluates to false, it won't evaluate the second operator. For the short-circuit operator `||`, if the first operand evaluates to true, it won't evaluate the second operator.

For the expression `(a++ > 10 || ++b < 30)`, because `a++ > 10` evaluates to false, both operands will evaluate.

For the expression `(a > 90 && ++b < 30)`, because `a > 90` evaluates to false, the second operand won't execute.

For expression `(!(c > 20) && a == 10)`, because `!(c > 20)` evaluates to false, the second operand won't execute.

The expression `(a >= 99 || a <= 33 && b == 10)` has three operands together with the OR (`||`) and AND (`&&`) short-circuit operators. Because the short-circuit operator AND has higher operator precedence than the short-circuit operator OR, the expression is evaluated as follows:

```
(a >= 99 || (a <= 33 && b == 10))
```

Evaluation of the preceding expression starts with the evaluation of `(a <= 33 && b == 10)`. Because `a <= 33` evaluates to true, the operator `&&` evaluates the second operand (`b == 10`) to determine whether `(a <= 33 && b == 10)` will return true or false. `a <= 33` returns true and `b == 10` returns false, so the expression `(a <= 33 && b == 10)` returns false.

The original expression—`(a >= 99 || (a <= 33 && b == 10))`—is now reduced to the following expression:

```
(a >= 99 || false)
```

The short-circuit operator OR (`||`) executes its first operand (even if the value of the second operand is known), evaluating `a >= 99`. So for this expression, all three operands are evaluated.

The expression `(a >= 99 && a <= 33 || b == 10)` also has three operands, together with OR and AND short-circuit operators. Because the short-circuit operator AND has a

higher operator precedence than the short-circuit operator OR, this expression is evaluated as follows:

```
((a >= 99 && a <= 33) || b == 10)
```

a >= 99 evaluates to false, so the next operand (a <= 33) isn't evaluated. Because the first operand to operator ||, a >= 99 && a <= 33, evaluates to false, b == 10 is evaluated.

A.3 **Chapter 3—Methods and encapsulation**

Chapter 3 includes three Twist in the Tale exercises.

A.3.1 **Twist in the Tale 3.1**

Purpose: In the same way that the class TestPhone in this exercise defines a local variable with the same name as its instance variable, I strongly recommend that you try out different combinations of defining variables with the same name in a class, but with different scope.

Answer: a

Explanation: The class Phone defines an instance variable with the name phoneNumber. The method setNumber also defines a local variable phoneNumber and assigns a value to its local variable. A local variable takes precedence over an instance variable defined in the class with the same names. Because there is no change in the value of the instance variable phoneNumber, 123456789 is printed to the console from the method main, defined in the class TestPhone.

A.3.2 **Twist in the Tale 3.2**

Purpose: To learn that *recursive* or *circular* calls to constructors aren't allowed.

Answer: The code fails to compile, with the following compilation error message:

```
Employee.java:4: error: recursive constructor invocation
    Employee() {
        ^
1 error
```

Explanation: A method calling itself is called *recursion*. Two or more methods calling each other, in a circular manner, is called *circular method calling*.

Starting in Java version 1.4.1, the Java compiler won't compile code with *recursive* or *circular* constructors. A constructor is used to initialize an object, so it doesn't make sense to allow recursive calls to a constructor. You can initialize an object once and then modify it. You can't initialize an object multiple times.

In case you're wondering whether you can call a constructor conditionally from another constructor: you can't. A call to a constructor must be the first statement:

```
class Employee {
    String name;
    int age;
    Employee() {
```

```

        if (7<2)
            this();
    }
Employee(String newName, int newAge) {
    name = newName;
    age = newAge;
}
}

```

Won't compile—conditional execution of constructors isn't allowed. The call to this must be first statement in constructor.

Also, circular constructor calls aren't allowed:

```

class Employee {
    String name;
    int age;
    Employee() {
        this(null, 0);
    }
    Employee(String newName, int newAge) {
        this();
        name = newName;
        age = newAge;
    }
}

```

Won't compile. This constructor calls back the no-argument constructor resulting in a circular constructor call.

The previous example doesn't compile, with the following compilation error message:

```

Employee.java:8: error: recursive constructor invocation
    Employee(String newName, int newAge) {
        ^
1 error

```

Note that similar recursive or circular calls defined in methods don't result in compilation errors.

A.3.3 **Twist in the Tale 3.3**

Purpose: A class with public instance variable(s) can never be designated as a well-encapsulated class.

Answer: e

Explanation: This question tries to trick you by defining options that play with multiple access modifiers for methods `getWeight` and `setWeight`. Because the instance variable `model` of the class `Phone` is defined using the `public` access modifier, it's accessible outside this class. So `Phone` isn't a well-encapsulated class.

A.4 **Chapter 4—String, StringBuilder, Arrays, and ArrayList**

Chapter 4 includes four Twist in the Tale exercises.

A.4.1 **Twist in the Tale 4.1**

Purpose: To remind you to be careful with the overloaded methods of class `String` that accept either `char` or `String` or both, the code in this exercise passes an invalid method argument—a `char`—to method `startsWith`.

Answer: e

Explanation: When it comes to the `String` class, it's easy to confuse the methods that accept `char` or `String` values as method arguments. For example, the overloaded method `indexOf` can accept both `String` and `char` values to search for a target value in a `String`. The methods `startsWith` and `endsWith` accept only arguments of type `String`. The method `charAt` accepts only method arguments of type `int`. Hence, this method can be passed `char` values, which are stored as unsigned integer values.

A.4.2 ***Twist in the Tale 4.2***

Purpose: This exercise has multiple purposes:

- To confuse you with the use of method names, which are used in the Java API by other classes to create their objects.
- To encourage you to refer to the Java API documentation when you work with classes from the Java API. The Java API documentation is an extensive source of information and facts that are often not included in most books (because it's practically impossible to do so).

Answer: d

Explanation: The correct way to create an object of class `StringBuilder` with a default capacity of 16 characters is to call `StringBuilder`'s no-argument constructor, as follows:

```
StringBuilder name = StringBuilder();
```

A.4.3 ***Twist in the Tale 4.3***

Purpose: Identify the difference between an array element that isn't initialized and an array element that doesn't exist. A pictorial representation of a multidimensional array is quick to draw, and you can easily refer to its nonexistent or null array elements. This concept is shown in figure A.3.

Answer: b, d

Explanation: Option (a) is incorrect. Initializing a row of array `multiStrArr` with `{"Jan", "Feb", null}` and `{"Jan", "Feb", null, null}` isn't the same. The former option defines *three* array elements with the last array element assigned to `null`. The

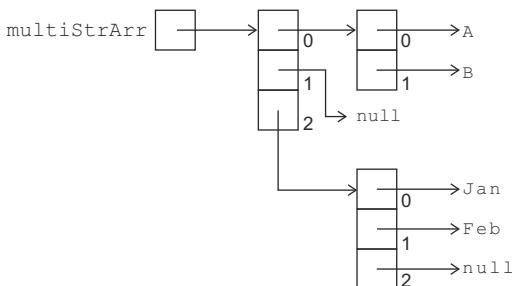


Figure A.3 Array `multiStrArr` and its elements

latter option defines *four* array elements with the last two array elements assigned to null.

Option (b) is correct. The array element at the position exists but isn't assigned any value. It's assigned to null.

Option (c) is incorrect. Because `multiStrArr[1]` refers to null, `multiStrArr[1][1]` doesn't exist.

Option (d) is correct. As shown in figure A.3, the array `multiStrArr` doesn't define an equal number of elements in each row, so it's asymmetric.

A.4.4 ***Twist in the Tale 4.4***

Purpose: This exercise tries to trick you by using multiple objects of `ArrayList`, assigning the object reference of one `ArrayList` to another, and modifying the value of the `ArrayList` objects. `String` objects are immutable—you can't change their values.

Answer: a

Explanation: Option (a) is correct, and options (b), (c), and (d) are incorrect. The `ArrayLists` `myArrList` and `yourArrList` contain `String` objects. The value of `String` objects can't be modified once created.

A.5 ***Chapter 5—Flow control***

Chapter 5 includes four *Twist in the Tale* exercises.

A.5.1 ***Twist in the Tale 5.1***

Purpose: To emphasize multiple points:

- A variable of any type can be (re)assigned a value in an expression used in an `if` condition.
- `if-else-if` statements execute each `if` condition as control is passed to them, changing the value of any variable that's manipulated in the evaluation of the expression.
- An expression used in an `if` condition should evaluate to a boolean value.

Answer: f

Explanation: The flow of execution of code statements in this exercise is shown in figure A.4.

The arrows on the left in figure A.4 show the flow of execution of statements for this code snippet. The `if` conditions on the right show the actual values that are compared after the expression used in the `if` statements is evaluated. Following is a detailed description:

- The initial value of variable `score` is 10. The first condition `((score = score + 10) == 100)` reassigns the value of variable `score` to 20 and then compares it to the literal integer value 100. The expression `20 == 100` returns a boolean value `false`. The control doesn't evaluate the *then* part of the `if` construct and moves on to the evaluation of the second `if` condition defined in the `else` part.

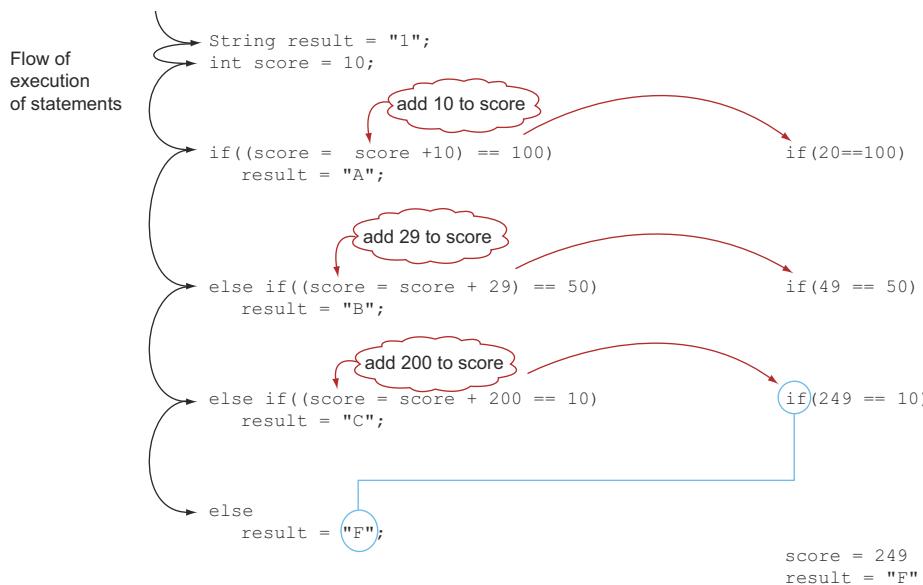


Figure A.4 Flow of execution of code in Twist In the Tale 5.1

- The second condition `((score == score + 29) == 50)` adds 29 to the existing value 20 of variable `score` and then compares the new value 49 with 50. The expression `49 == 50` returns `false` again. The control doesn't evaluate the *then* part of the `if` construct and moves on to evaluation of the second `if` condition defined in the `else` part.
- The third condition `((score == score + 200) == 10)` adds a value of 200 to the existing value 49 of variable `score`, making it 249, and compares that with the integer literal value 10. Because `249 == 10` evaluates to `false`, control moves to the `else` part. The `else` part assigns a literal value `F` to the variable `result`. At the end of execution of the `if-else-if` statement, the variable `score` is assigned a value of 249 and `result` is assigned a value of `F`. The code outputs `F:249`.

A.5.2 *Twist in the Tale 5.2*

Purpose: The `switch` construct uses the `equals` method to compare the value of its argument with the case values. It doesn't compare the variable references.

Answer: c

Explanation: You may have answered questions with code like the following, which prints `false`:

```
String aDay = new String("SUN");
System.out.println(aDay == "SUN");
```

String objects, which are created using an assignment operator (=), are stored in a pool of Strings. String objects, which are created using the operator new, aren't stored in the pool of String objects.

When a String object is passed as an argument to a switch construct, it doesn't compare the object references; it compares the object values using the equals method. In the code snippet shown in the question, a match is found for the String literal value SUN, so the code prints Weekend!, executes the break statement, and exits the block.

A.5.3 **Twist in the Tale 5.3**

Purpose: Note the type of the variable that's passed as an argument to the switch construct. Among the primitive data types, you can pass on variables of types byte, short, char, and int to a switch construct. Other data types that you can pass to a switch construct are Byte, Short, Integer, Character, enum, and String.

This question tries to take your attention off this simple basic requirement and to move your focus to the logic of the question.

Answer: The submission by Harry.

Explanation: Paul's submission doesn't compile because a switch construct doesn't accept an argument of the long primitive data type.

A.5.4 **Twist in the Tale 5.4**

Purpose: When an unlabeled break statement is used within nested loops (for any combinations of for, do-while, or while loops), a break statement will end the execution of the *inner loop*, not all the nested loops. The *outer loop* will continue to execute, starting with its *next* iteration value.

Answer: a

Explanation: Let's start with the *outer loop*'s first iteration. In the first iteration, the value of the variable outer is Outer.

For the outer loop's first iteration, the inner loop should execute for the values Outer and Inner for the variable inner. For the first iteration of the inner loop, the value of the variable inner is Outer, so the condition inner.equals("Inner") evaluates to false and the break statement doesn't execute. The code prints the value of variable inner, which is Outer: and starts with the next iteration of the inner loop. In the second iteration of the inner loop, the value of the variable inner is Inner, so the condition inner.equals("Inner") evaluates to true and the break statement executes, ending the execution of the inner loop and skipping the code that prints out the value of the variable inner.

The outer loop starts its execution with the second iteration. In this iteration, the value of the variable outer is Outer. For the outer loop's iteration, the inner loop executes twice in the same manner as mentioned in the previous paragraph. This

iteration of the outer loop again prints the value of the variable `inner` when it's equal to `Outer`.

The nested loops included in the question print out the value `Outer`: twice:

`Outer:Outer:`

A.6 Chapter 6—Working with inheritance

Chapter 6 includes four Twist in the Tale exercises.

A.6.1 Twist in the Tale 6.1

Purpose: This question is an example of a simple concept (private members are not accessible to a derived class) that is made to look complex by including code and options that try to divert your attention. Expect similar questions on the exam.

Answer: e

Explanation: The code fails to compile because the private members of a class can't be accessed outside a class—not even by its derived class. The compiler can detect such attempts; this code won't compile.

A.6.2 Twist in the Tale 6.2

Purpose: To help you to work with a combination of

- Arrays
- Assigning an object of a derived class to a reference variable of the base class
- Assigning an object of a class that implements an interface to a reference variable of the interface

Answer: a, c

Explanation: The rules you need to follow to assign a value to an array element are the same rules you follow when you assign an object to a reference variable. Because the type of array `interviewer` is `Interviewer`, you can assign objects of classes that implement this interface. The inheritance of classes `Employee`, `Manager`, and `HRExecutive`, and the interface `Interviewer` are shown in figure A.5.

As you can see in figure A.5, the classes `Manager` and `HRExecutive` implement the interface `Interviewer`. The class `Employee` doesn't implement the interface `Interviewer`; hence, an object of the class `Manager` can't be added to an array of type `Interviewer`.

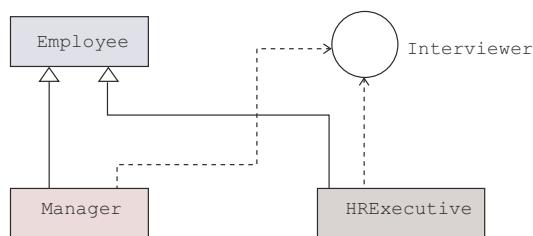


Figure A.5 UML notation of inheritance hierarchy of the classes Employee, Manager, and HRExecutive, and the interface Interviewer

From this explanation, it's apparent that options (a) and (c) are correct and option (b) is incorrect.

Option (d) is incorrect because you can't create objects of an interface. Option (d) tries to create an object of the interface `Interviewer`. Code that tries to create an instance of an interface won't compile.

A.6.3 ***Twist in the Tale 6.3***

Purpose: If there is no collision with the name of a variable defined in the base class or derived class, the variable can be accessed using both `super` and `this` references from a derived class. If there is a collision, the base class variable can be accessed using the `super` reference.

Answer: b

Explanation: In a derived class, you'd normally use the implicit reference `super` to refer to a method or variable of a base class. Similarly, you'd normally use the implicit reference `this` to refer to a method or variable defined in the same class. A derived class contains within it an object of its base class and can access non-private members of its base class. A derived class can *also* refer to the members of its base class as its own members using the reference `this`. This approach is acceptable only if the same member isn't defined in the derived class; that is, if there are no name collisions.

The base class `Employee` defines two non-private variables, `name` and `address`, which are accessible in `Employee`'s derived class `Programmer`. The class `Programmer` also defines an instance variable `name`, so the variable `name` should be prefixed with the explicit references `super` and `this` to refer to the variable `name` defined in the classes `Employee` and `Programmer`. The variable `address` can be referred to using both `super` and `this` in the derived class `Programmer`.

Option (a) is incorrect. The derived class `Programmer` can refer to the variable `address` defined in the base class using `this.address`. This value won't print `null`.

Option (c) is incorrect. `this.address` won't print blank when accessed from the derived class `Programmer`.

Option (d) is incorrect. The code has no compilation issues.

A.6.4 ***Twist in the Tale 6.4***

Purpose: Polymorphic methods should define a method's overriding rules.

Answer: a

Explanation: Polymorphic methods exist when classes or interfaces share an inheritance relationship. A polymorphic method can be defined by a derived class if

- The derived class implements an abstract method defined in a base class or interface
- The derived class overrides a non-abstract method defined in a base class

Options (b) and (d) are incorrect. A method can't be overridden if it defines a different parameter list.

Option (c) is incorrect. The return type of the overridden method must be the same in the base class and the derived class.

A.7 **Chapter 7—Exception handling**

Chapter 7 includes five Twist in the Tale exercises.

A.7.1 **Twist in the Tale 7.1**

Purpose: A finally block can't be placed before the catch blocks. A number of programmers have compared this question with placing the label default before label case in a switch construct. Though the latter approach works, the finally and catch blocks aren't so flexible.

Answer: d

Explanation: Options (a), (b), and (c) are incorrect because code that defines a finally block before catch blocks won't compile.

A.7.2 **Twist in the Tale 7.2**

Purpose: Unhandled exceptions thrown by an inner exception handler are passed on to the outer try-catch block to handle.

Answer: a

Explanation: Options (b), (c), and (d) are incorrect. The question assumes that a text file players.txt exists on your system so that the following code won't throw a FileNotFoundException exception:

```
players = new FileInputStream("players.txt");
```

The code defined for this question doesn't initialize the static variable coach before executing the following code, which is bound to throw NullPointerException:

```
coach.close();
```

The previous line of code is defined in the inner try block, which doesn't define an exception handler for the exception NullPointerException. This exception is propagated to the outer exception-handler block. The outer exception handler *catches* the NullPointerException thrown by the inner try block and executes the appropriate exception handler. Hence, the code prints the following:

```
players.txt found  
NullPointerException
```

A.7.3 **Twist in the Tale 7.3**

Purpose: To determine whether exception-handling code for errors will execute.

Answer: b

Explanation: We know that typically errors shouldn't be handled programmatically and that they should be left for the JVM to take care of. Also, you can't be sure that error-handling code for all the errors will execute. For example, error-handling code for `StackOverflowError` may execute but (as the name suggests) may not execute for `VirtualMachineError`.

A.7.4 **Twist in the Tale 7.4**

Purpose: `ClassCastException` is a runtime exception. As you know, a runtime exception can be thrown only by the JVM.

Answer: b, d

Explanation: Options (a) and (c) are incorrect because the code throws `ClassCastException`, which is a runtime exception, for the following code:

```
printable = (Printable)blackInk;
```

Option (d) is correct because neither the class `BlackInk` nor any of its base classes implement the interface `Printable`. Thus, the code that assigns `blankInk` to `printable` without an explicit cast will fail to compile.

A.7.5 **Twist in the Tale 7.5**

Purpose: Trying to access a nonexistent position of an array throws `ArrayIndexOutOfBoundsException`. Calling a member on a null value stored in an array throws `NullPointerException`.

Answer: c

Explanation: Let's indent the assignment of the two-dimensional array `oldLaptops` so that it's easier to understand the values that are assigned to it:

```
String[][] oldLaptops = {
    {"Dell", "Toshiba", "Vaio"},
    null,
    {"IBM"},
    new String[10]
};
```

The preceding code results in the following assignments:

```
oldLaptops[0] = {"Dell", "Toshiba", "Vaio"};
oldLaptops[1] = null;
oldLaptops[2] = {"IBM"};
oldLaptops[3] = new String[10];
```

A pictorial representation of the two-dimensional `String` array `oldLaptops` is shown in figure A.6.

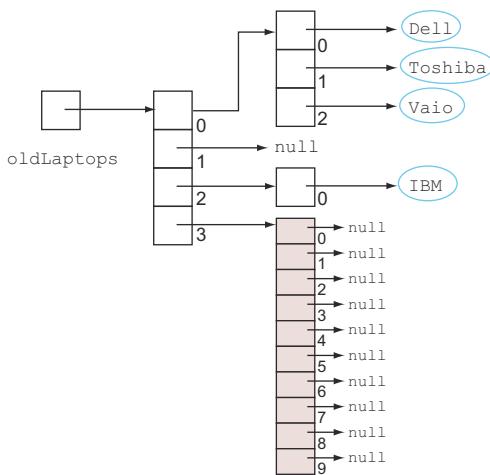


Figure A.6 The array `oldLaptops`

As you can see, `oldLaptops[3]` is an array of ten uninitialized `String` objects. All the members (from index position 0 to 9) of the array `oldLaptops[3]` are assigned a `null` value. The code on line 4 tries to call the method `length` on the first element of array `oldLaptops[0]`, which is `null`, throwing a `NullPointerException`.

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