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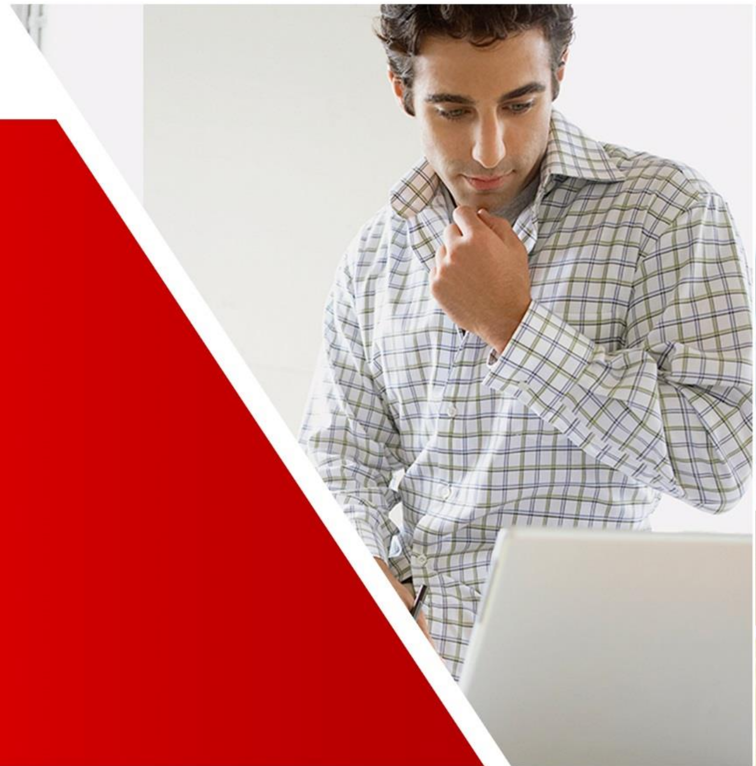

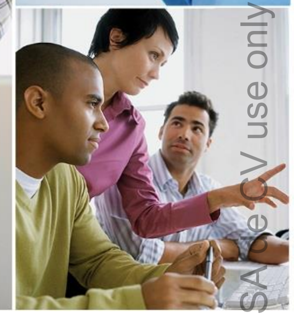

Integrated Cloud Applications & Platform Services

Java SE: Programming I

Student Guide - Volume I

D102470GC10

Edition 1.0 | August 2018 | D104107

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12 Using Inheritance

13 Using Interfaces

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Introduction

Audience

- Beginners to programming who have basic mathematical, logical, and analytical problem-solving skills and who want to begin learning the Java programming language
- Novice programmers and those programmers who prefer to start learning the Java programming language at an introductory level
- Students who beginning their study to become an Oracle Certified Professional (OCP)
  – Java SE Programmer I Exam (this course)
  – Java SE Programmer II Exam (the next course)

The audience for this course is a beginner to programming who has basic mathematical and problem-solving skills. The course is targeted at technical writers, web developers, technical managers, project managers, program managers, and individuals with a technical, nonprogramming background such as system administrators.

Introductions

Meet your classmates and briefly introduce yourself:

- Name
- Title or position
- Company
- Experience with Java programming and Java applications
- Reasons for attending

Course Objectives

After completing this course, you should be able to:

- Demonstrate knowledge of basic programming language concepts
- Demonstrate knowledge of the Java programming language
- Implement intermediate Java programming and object-oriented (OO) concepts

Demonstrate knowledge of basic programming language concepts.

- Source code versus machine code
- Platform dependence and platform independence
- The use of APIs and libraries

Demonstrate knowledge of the Java programming language

- Compile and run a Java program from both the command line and from NetBeans.
- Create a Java class with fields and methods.
- Declare and use arrays.
- Use methods of the `StringBuilder`, `String`, and `ArrayList` classes.
- Display and manipulate dates using one or two classes from the new `java.time` package.
- Write conditional statements.
- Write loop statements (enhanced for, for, while, do/while), as well as nested loops.
- Implement a `try` block to handle exceptions.

Implement intermediate Java programming and object-oriented (OO) concepts

- Instantiate an object and invoke its methods
- Explain how objects vs. primitive types or references are stored in memory
- Create an inheritance hierarchy of Java classes by creating a subclass or implementing a Java Interface
- Overload a method and a constructor
- Encapsulate the fields of a class and use modifiers to control access to a field or a method
- Create superclasses, abstract classes, and Interfaces and use them as reference types
- Use a Predicate lambda expression as the argument to a method

Schedule

Day One

- Getting Started
  - Lesson 1: Introduction
  - Lesson 2: What Is a Java Program?
- The Basic Shopping Cart
  - Lesson 3: Creating a Java Main Class
  - Lesson 4: Data in a Cart
  - Lesson 5: Managing Multiple Items

Schedule

Day Two

- Filling the Cart
  - Lesson 6: Describing Objects and Classes
  - Lesson 7: Manipulating and Formatting the Data in Your Program
- Improving Cart Efficiency
  - Lesson 8: Creating and Using Methods

Day Three

  - Lesson 9: Using Encapsulation
- Expanding the Business
  - Lesson 10: More on Conditionals
  - Lesson 11: Working with Arrays, Loops, and Dates

Schedule

Day Four

- Lesson 12: Using Inheritance
- Lesson 13: Using Interfaces
- Lesson 14: Handling Exceptions

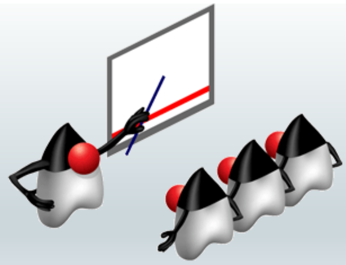
Day Five

- Lesson 15: Deploying and Maintaining the Soccer Application
- Lesson 16: Understanding Modularity
- Lesson 17: JShell

Lesson Format

Lecture / Student Guide (50%)

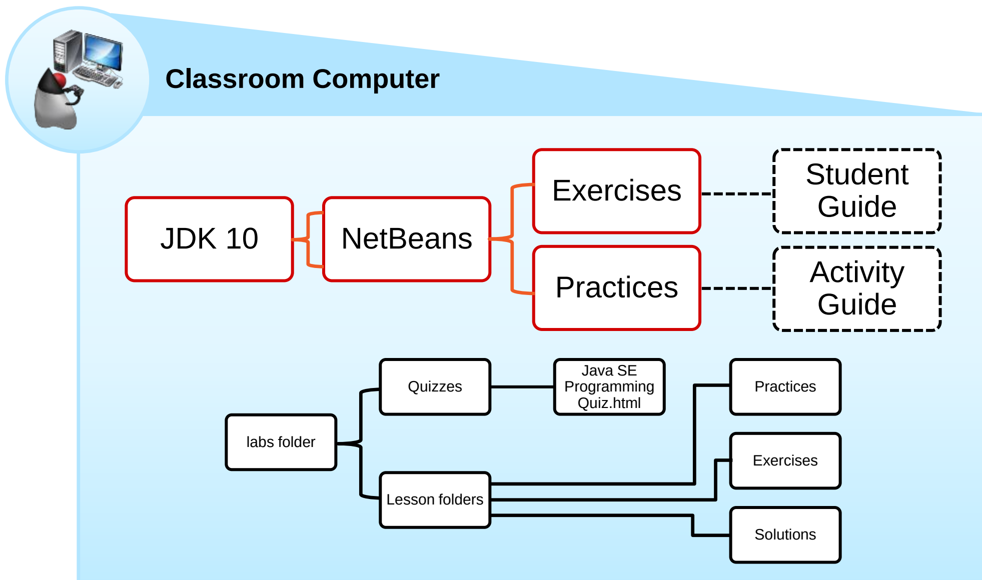
- Traditional slides
- Sample code
- Exercises
- Quizzes & interactive quizzes



Practices / Activity Guide (50%)

- Hands-on learning
- Work with Java code
- Larger-scale labs
- Intended for the OU Practice Environment

Course Environment



In this course, the following products are preinstalled for the lesson practices:

- **JDK 10:** The Java SE Development Kit includes the command-line Java compiler (`javac`) and the Java Runtime Environment (JRE), which supplies the `java` command needed to execute Java applications.
- **Firefox:** A web browser is used to view the HTML documentation (Javadoc) for the Java SE Platform libraries.
- **NetBeans :** The NetBeans IDE is a free and open-source software development tool for professionals who create enterprise, web, desktop, and mobile applications.
- **Student Guide:** The guide contains the instructional material for all the topics discussed in class and includes appendices with additional information. It also includes some introductory instructions for completing the exercises and practices.
- **Activity Guide:** These are resources to use during the practice portions of the course. The Activity Guide has instructions for completing the practices.
- **Lab Folder:** The lab folder includes interactive quizzes, practices, exercises, and solution files.

How Do You Learn More After the Course?

- In the Oracle Learning Library, there is a list of resources that you can use to learn more about Java programming. Look for the collection on the oracle.com/oll/java page.
- *Oracle Learning Library:*
  - http://www.oracle.com/goto/oll

Additional Resources

Resource	Website
Education and Training	http://education.oracle.com
Product Documentation	http://www.oracle.com/technology/documentation
Product Downloads	http://www.oracle.com/technology/software
Product Articles	http://www.oracle.com/technology/pub/articles
Product Support	http://www.oracle.com/support
Product Forums	http://forums.oracle.com
Product Tutorials	http://www.oracle.com/technology/obe
Sample Code	http://www.oracle.com/technology/sample_code

The table in the slide lists web resources where you can obtain additional information about Java.

Additional Resources

Resource	Website
Java Documentation	https://docs.oracle.com/javase
API Documentation	https://docs.oracle.com/javase/10/docs/api/index.html

The table in the slide lists web resources where you can obtain additional information about Java.

Summary

In this lesson, you reviewed the course objectives and the tentative class schedule. You met your fellow students, and you saw an overview of the computer environment that you will use during the course.

Enjoy the next five days of *Java SE Programming I*

2

What Is a Java Program?

Objectives

After completing this lesson, you should be able to:

- Contrast the terms “platform-dependent” and “platform-independent”
- Describe the purpose of the JVM
- Explain the difference between a procedural program and an object-oriented program
- Describe the purpose of `javac` and `java` executables
- Verify the Java version on your system
- Run a Java program from the command line

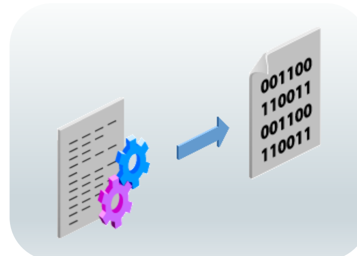
Topics

- Introduction to computer programs
- Introduction to the Java language
- Verifying the Java development environments
- Running and testing a Java program

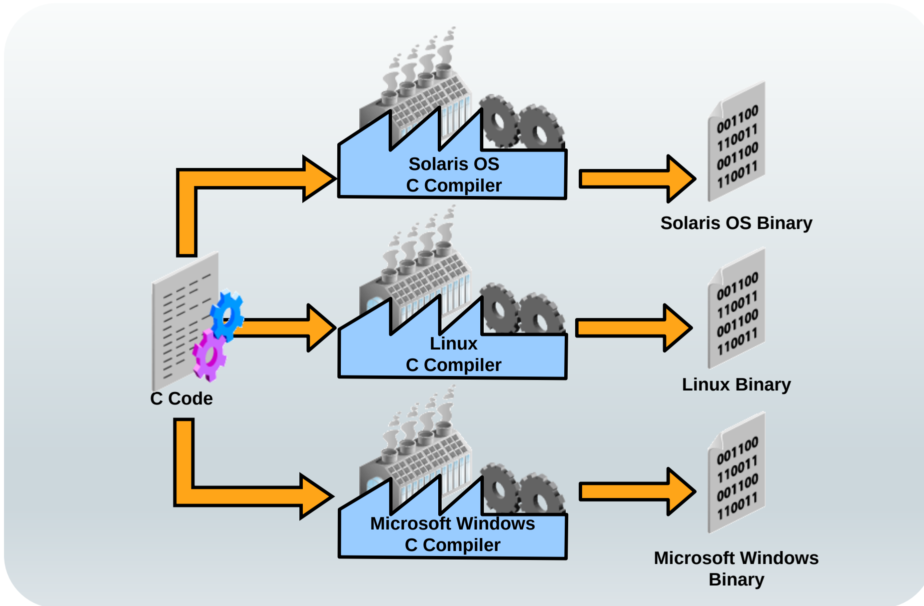
Purpose of a Computer Program

A computer program is a set of instructions that run on a computer or other digital device.

- At the machine level, the program consists of binary instructions (1s and 0s).
  - Machine code
- Most programs are written in *high-level* code (readable).
  - Must be translated to machine code



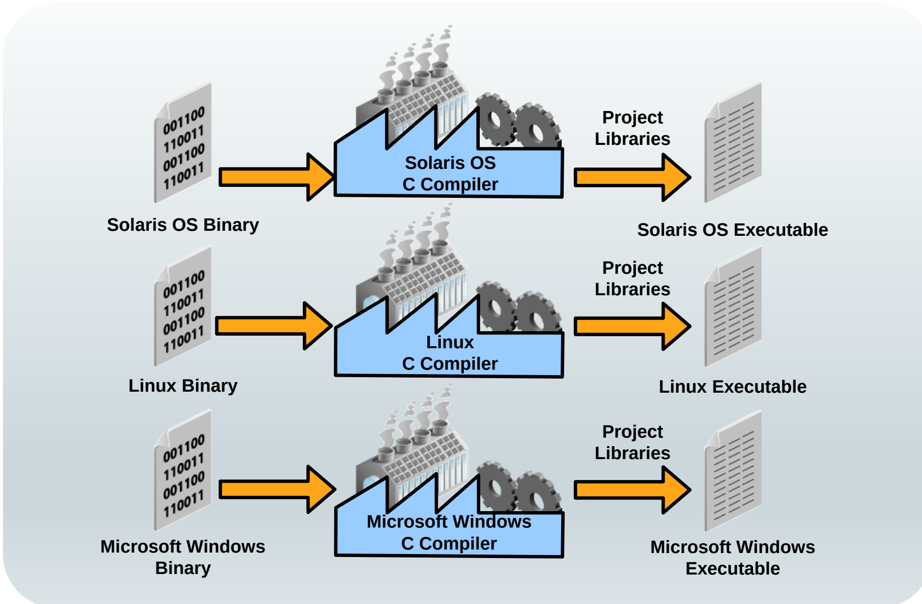
Translating High-Level Code to Machine Code



Programs written in most languages usually require numerous modifications to run on more than one type of computing platform, (a combination of a CPU and operating system). This platform-dependence is because most languages require you to write code specific to the underlying platform. Popular programming languages, such as C and C++, require programmers to compile and link their programs, resulting in an executable program unique to a platform. A compiler is an application that converts a program that you write into a CPU-specific code called *machine code*. These platform-specific files (binary files) are often combined with other files, such as libraries of prewritten code, using a linker to create a platform-dependent program, called an *executable*, which can be executed by an end user. Unlike C and C++, the Java programming language is platform-independent.

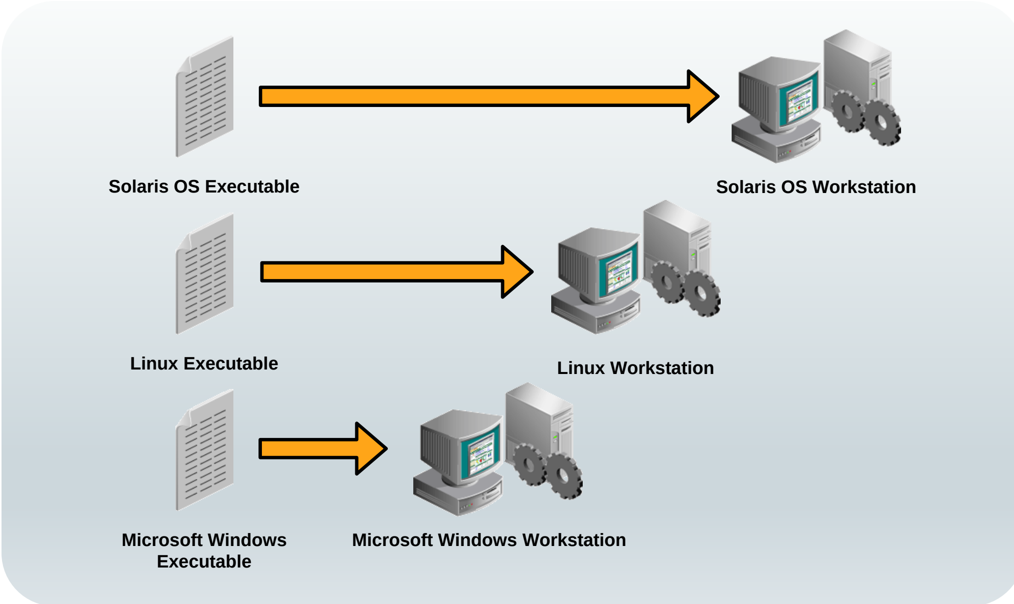
The image illustrates how a compiler creates a binary file.

Linked to Platform-Specific Libraries



The image illustrates how a binary file is linked with libraries to create a platform-dependent executable.

Platform-Dependent Programs



The image illustrates how platform-dependent executables can execute only on one platform.

Topics

- Introduction to computer programs
- Introduction to the Java language
- Verifying the Java development environment
- Running and testing a Java program

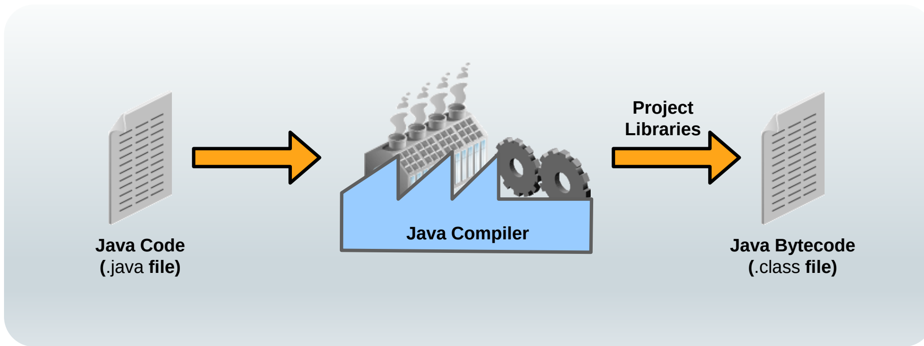
Key Features of the Java Language

Some of the features that set Java apart from most other languages are that:

- It is platform-independent
- It is object-oriented

There are several other key features of the Java language, but in this course, only the two mentioned above will be discussed.

Java Is Platform-Independent

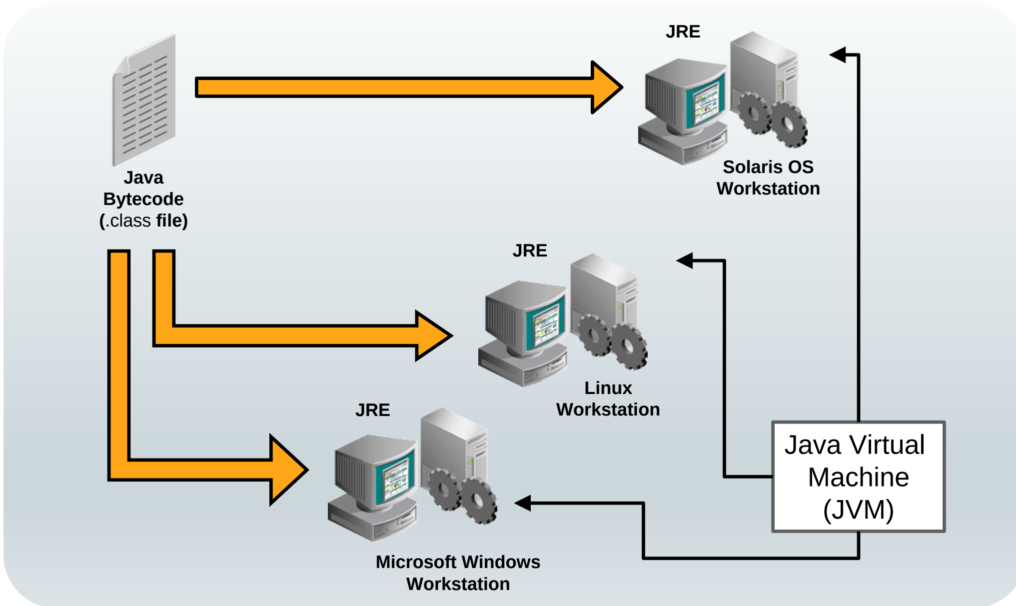


A Java program can run on several different CPUs and operating system combinations, such as the Solaris OS on a SPARC chip, Mac OS X on an Intel chip, and Microsoft Windows on an Intel chip, usually with few or no modifications.

As illustrated above, Java programs are compiled using a Java compiler. The resulting format of a compiled Java program is platform-independent Java bytecode instead of CPU-specific machine code.

After the bytecode is created, it is interpreted by a bytecode interpreter called the Java Virtual Machine or JVM. A virtual machine is a platform-specific program that understands platform-independent bytecode and can execute it on a particular platform. For this reason, the Java programming language is often referred to as an interpreted language, and Java technology programs are said to be portable or executable on any platform. Other interpreted languages include Perl.

Java Programs Run In a Java Virtual Machine



The image illustrates a Java bytecode file executing on several platforms where a Java runtime environment exists.

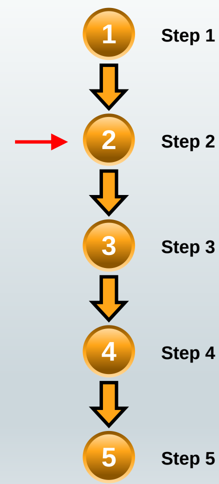
A virtual machine gets its name because it is a piece of software that runs code, a task usually accomplished by the CPU or hardware machine. For Java programs to be platform-independent, a virtual machine called the JVM is required on every platform where your program will run. The JVM is responsible for interpreting Java code, loading Java classes, and executing Java programs.

However, a Java program needs more than just a JVM to execute. A Java program also needs a set of standard Java class libraries for the platform. Java class libraries are libraries of prewritten code that can be combined with the code that you write to create robust applications.

Combined, the JVM software and Java class libraries are referred to as the Java Runtime Environment (JRE). Java Runtime Environments are available from Oracle for many common platforms.

Procedural Programming Languages

- Many early programming languages followed a paradigm called *Procedural Programming.*
- These languages use a sequential pattern of program execution.
- Drawbacks to procedural programming:
  - Difficult to translate real-world use cases to a sequential pattern
  - Difficult to maintain programs
  - Difficult to enhance as needed

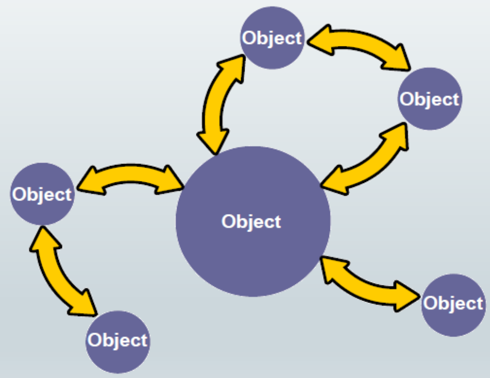


Earlier programming languages were based on a programming paradigm called “procedural”. Procedural languages use a sequential pattern of program execution such as you see in the diagram above. Some examples of procedural programming languages are COBOL, Fortran, C, and Pascal.

This style of programming has become less popular due to the difficulty of designing real-world applications using sequential pattern. It has also proven difficult to maintain and enhance programs structured in this way.

Java Is an Object-Oriented Language

- Interaction of objects
- No prescribed sequence
- Benefits:
  - Modularity
  - Information hiding
  - Code reuse
  - Maintainability



Object-oriented programming differs from procedural programming, because procedural programming stresses the sequence of coding steps required to solve a problem, whereas object-oriented programming stresses the interaction of objects. Java is an object-oriented programming (OO) language. One of the main goals of an OO language is to create objects—pieces of autonomous code—that can interact with other objects to solve a problem. OO programming languages began in 1967 and have led to popular programming languages such as C++, upon which Java is loosely based.

This provides many benefits:

- **Modularity:** The source code for an object can be written and maintained independently of the source code for other objects. After it is created, an object can be easily passed around inside the system.
- **Information hiding:** By interacting only with an object's methods, the details of its internal implementation remain hidden from the outside world.
- **Code reuse:** If an object already exists (perhaps written by another software developer), you can use that object in your program.
- **Maintainability:** If a particular object is found to be problematic, you can create another, slightly modified one and simply replace the original one in your application. This is analogous to fixing mechanical problems in the real world. If a bolt breaks, you replace the bolt, not the entire machine.

The diagram illustrates an object-oriented program's focus on objects and object interactions.

Topics

- Introduction to computer programs
- Introduction to the Java language
- Verifying the Java development environment
- Running and testing a Java program

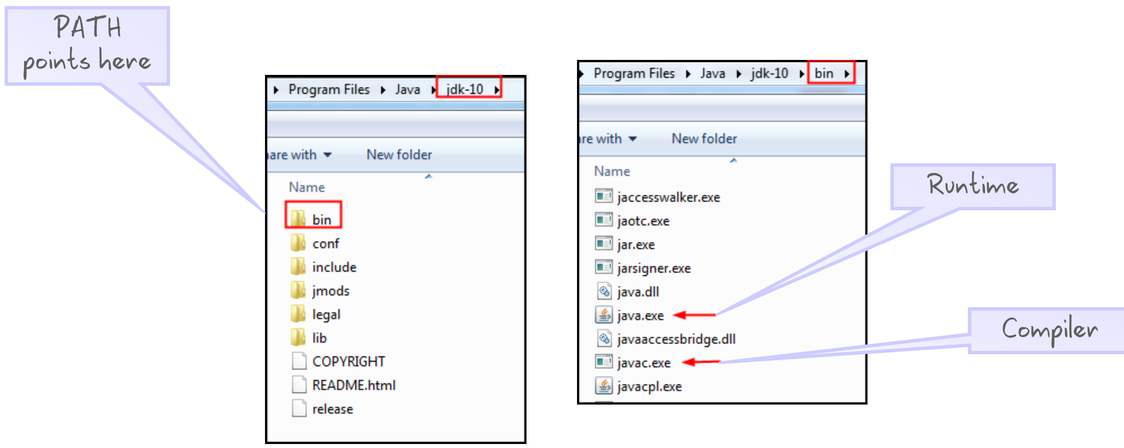
Verifying the Java Development Environment

1. Download and install the Java Development Kit (JDK) from oracle.com/java.
2. Explore the Java Help menu.
3. Compile and run a Java application by using the command line.

Setting up your Java development environment is a simple task. The JDK is available for free from the Oracle Java website.

- After you have installed the JDK, you can explore the Java environment by typing some commands at the command line. For example, open a terminal window and enter `java`.
- Review the command options displayed.
- Enter `java -version` to see what Java version is installed on your system.
- Compile and run a Java application using the command line.

Examining the Installed JDK: The Tools

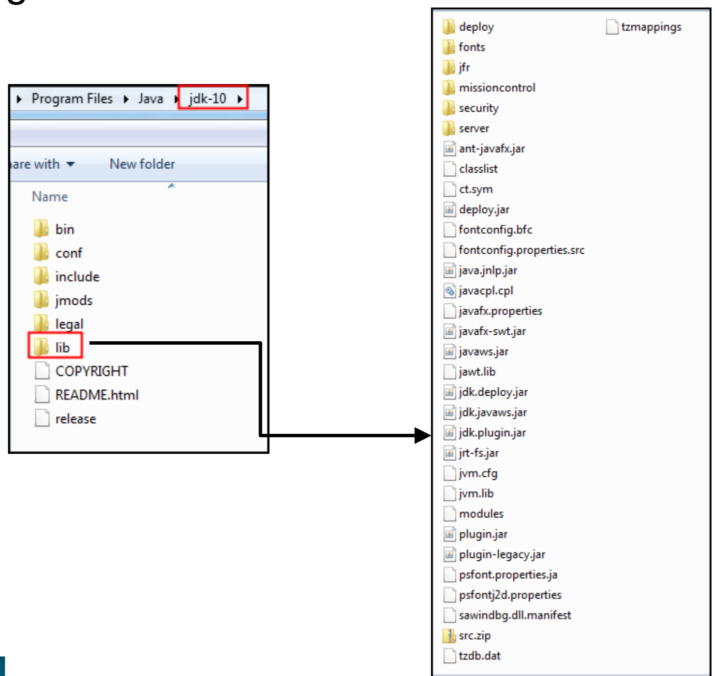


Java SE (Standard Edition) Development Kit

The Java SE Development Kit includes both the tools and classes that you will use to develop a Java program. The tools and utilities are stored in the `bin` directory. These are shown in the screenshot on the right. They include:

- A Java Virtual Machine (JVM) for the platform you choose. Here you see a Windows example. The runtime engine is started by running the `java` program.
- A Java compiler, started by running the `javac` program
- Additional utilities, such as utilities for creating Java archive files (`JAR` files) and for debugging Java programs
- The `bin` directory, which must be on the system PATH in order to run or compile a Java program. The Java installer automatically adds the bin to your system PATH.
- **Note:** The Java Runtime Environment used in *production* (commonly called the JRE) is also included with Java SE Development Kit. This is found in the `jre` directory.

Examining the Installed JDK: The Libraries



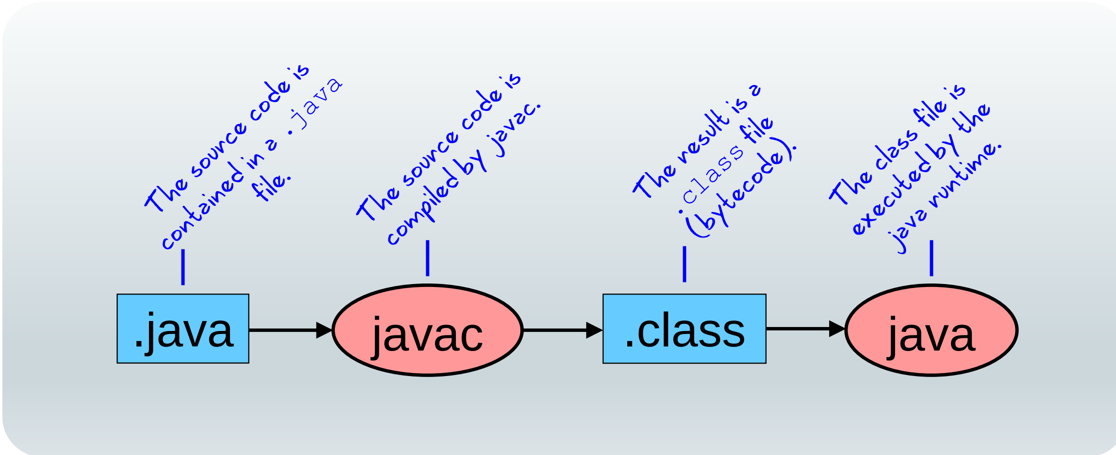
Java SE Development Kit

In addition to the executable files found in the `bin` directory of the JDK, various class libraries are installed that conform to the particular platform that you chose. Here you see a Windows example. The core libraries are found in the `lib` directory as shown above.

Topics

- Introduction to computer programs
- Introduction to the Java language
- Verifying the Java development environment
- Running and testing a Java program

Compiling and Running a Java Program



The diagram above shows what happens when you compile and run a Java program.

- The Java code is written in a file with the extension `.java`. This is called the "Java source code."
- You use the javac executable to compile the source code (the "c" stands for "compiler") into a bytecode file with the extension `.class`. This is called a Java class.
- You use the `java` executable to run the Java class. This is your Java program.

Compiling a Program

1. Go to the directory where the source code files are stored.
2. Enter the following command for each `.java` file you want to compile.

- Syntax:

```
javac <filename>
```

- Example:

```
javac SayHello.java
```


Compiling converts the source files that you write into bytecode that can be executed by a Java Virtual Machine. The source file has a `.java` extension. It also defines a public class of the same name. For example, the class, `SayHello`, must be saved in a file called `SayHello.java`. (You learn more about classes later in this course.)

To compile the `SayHello` source code, perform the following steps:

1. Go to the directory where the source code files are stored.
2. Enter the following command for each `.java` file that you want to compile (Note that the `.java` extension is required.):

   Example: `javac SayHello.java`

After the compilation has finished, and assuming no compilation errors have occurred, you should have a new file called `<classname>.class` in your directory for each source code file that you compiled.

Example: `SayHello.class`

Executing (Testing) a Program

1. Go to the directory where the class files are stored.
2. Enter the following for the class file that contains the main method:

- Syntax:

```
java <classname>
```

- Example:

Do not specify .class.

```
java SayHello
```

- Output:

```
Hello World!
```


When you have successfully compiled your source code files, you can execute and test them using the Java Virtual Machine.

To execute and test your program:

1. Go to the directory where the class files are stored.
2. Enter the following command for the class file that contains the `main` method. Note that here the file extension (`.class`) should *not* be included.

   Example: `java SayHello`

This command runs the `SayHello` class. The `SayHello` class contains the `main` method. This is the entry point to a Java application. The `java` executable only works with a class containing a main method. In the above example, the main method contains code that prints the string "Hello World!”.

Output for a Java Program

A Java program can output data in many ways. Here are some examples:

- To a file or database
- To the console
- To a webpage or other user interface

In this course, we will be outputting data only to the console. You can learn more about writing to other destinations, such as a file, database, or webpage, by taking the *Java SE Programming II* course.

Exercise 2-1

- From a Terminal window, enter `java -version` to see the system's Java version.
- Look for `SayHello.java` in:
  `/labs/02-GettingStarted/Exercises/Exercise1`
- Compile it: `javac SayHello.java`
- Run the resulting class file: `java SayHello`
  - Did you see the output?

In this exercise, you look at the Java version installed on your system, and then you run a simple Java program from the command line.

- Open a terminal window by double-clicking the Terminal shortcut on your desktop. It will open at your home directory, which is `/home/oracle`.
  - **Note:** A handy shortcut to navigate to your home directory from anywhere is **~**. Example: `cd ~` to go to `/home/oracle`.
- Enter `java` to see the available command options.
- Enter `java -version` to verify the version of Java installed on your system.
- Navigate to the folder containing the Java source file for this exercise:
  `cd labs/02-GettingStarted/Exercises/Exercise1`
- Enter `javac SayHello.java` to compile it.
- Enter `java SayHello` to run it. You should see a "Hello World!" message as output.

Quiz

Which of the following is correct? (Choose all that apply.)

a. `javac OrderClass`

b. `java OrderClass`

c. `javac OrderClass.java`

d. `java OrderClass.java`

Answer: b, c

The `.java` extension is needed only when you compile a class (using `javac`).

Summary

In this lesson, you should have learned how to:

- Describe the distinction between high-level language and machine code
- Describe what platform-independence means
- Describe how a Java program is compiled and to what format
- Explain what it means to say that Java is an object-oriented language
- Determine the version number of a Java install
- Use the `javac` tool to compile Java source code and the `java` tool to run or test your program

3

Creating a Java Main Class

Objectives

After completing this lesson, you should be able to:

- Use the NetBeans IDE to create and test Java classes
- Write a `main` method
- Use `System.out.println` to write a String literal to system output

Topics

- Java classes and packages
- The `main` method

Java Classes

A Java class is the building block of a Java application.

ShoppingCart.java ← Includes code that:

- Allows a customer to add items to the shopping cart
- Provides visual confirmation to the customer

Program Structure

- A class consists of:
  - The class name. Class names begin with a capital letter.
  - The body of the class surrounded with braces { }
    - Data (called fields)
    - Operations (called methods)
- Example:

Java is case-sensitive!

```
public class Hello {
   // fields of the class
   // methods
}
```


- A class is declared using the keyword, `class`, followed by the class name.
- Convention dictates that the class name start with a capital letter. If there are two words in the class name (SayHello), each word should begin with a capital letter. In the example above, the class name is Hello.
- The keyword `public` is called a *modifier*. You learn about these in the lesson titled “Using Encapsulation.”
- **Java is case-sensitive**. It does not recognize the following two words as being the same thing: `class` and `Class`.
- A class would typically contain data (called fields) and operations (called methods). You learn about this a little later.
- Notice that the body of the `Hello` class is enclosed in braces (`{ }`).

Java Packages

- A package provides a namespace for the class.
  - This is a folder in which the class will be saved.
  - The folder name (the package) is used to uniquely identify the class.
  - Package names begin with a lowercase letter.
- Example:

Package name

```
package greeting;

public class Hello {
    // fields and methods here
}
```

The class's unique name is: `greeting.Hello`

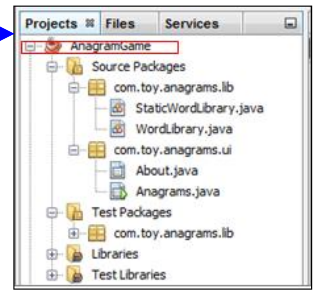
The use of a package when you create a Java class is not mandatory, but it is strongly recommended. Notice the semicolon after `package greeting;`

Semicolons are required at the end of each statement. It is similar to the period at the end of a sentence. The sentence may wrap to another line, but it is not complete until the period. The Java compiler interprets a statement as being complete when it encounters the semicolon.

Java IDEs

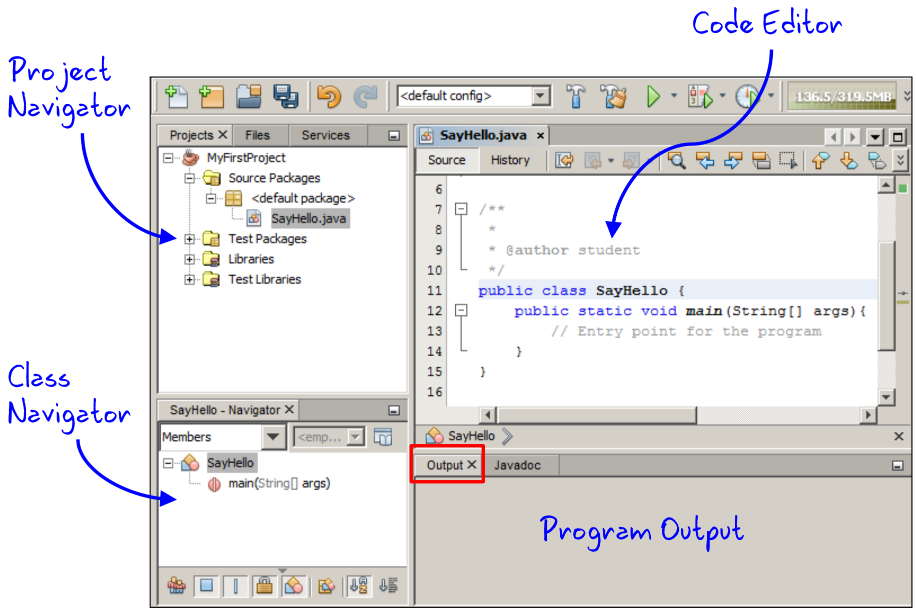
A Java Integrated Development Environment (IDE) is a type of software that makes it easier to develop Java applications.

- An IDE provides:
  - Syntax checking
  - Various automation features
  - Runtime environment for testing
- It enables you to organize all your Java resources and environment settings into a *Project*.
- Projects contain packages.
- Packages contain files, such as `.java`.



Some well-known Java IDEs are NetBeans (used in this class to perform the practices and exercises), Eclipse, and JDeveloper.

The NetBeans IDE



The Java project provides a mechanism by which you can organize all of the source and class files and other resources (connection profiles, configuration information, and so on) required by the Java application.

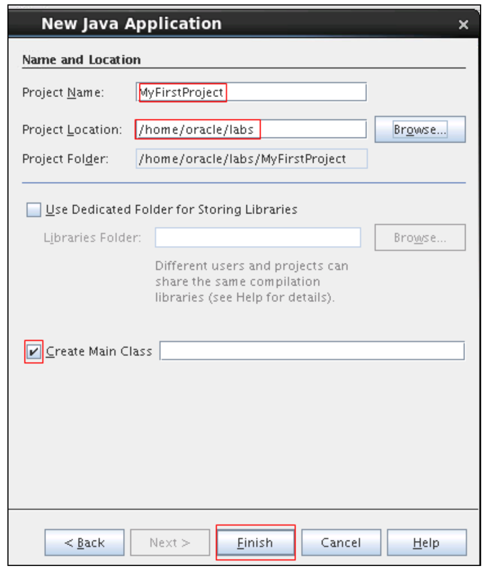
- When you begin working in NetBeans, you either create a project or open an existing one.
- The Project Navigator gives you a visual representation of the project contents.
- You can open files from your project in the code editor by double-clicking the file or using the context menu.

When you select a class within the project, the structure of that class is displayed in the Class Navigator, shown in the lower left part of the NetBeans window.

When you run a file or the entire Java program, any program output appears in the Output panel in the lower right part of the window.

Creating a Java Project

1. Select **File > New Project**.
2. Select Java Application.
3. Name and set the location for the project.
4. Select "Create Main Class" if you want it done for you automatically.
5. Click **Finish**.

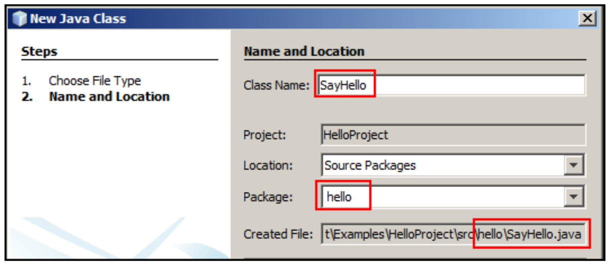


A NetBeans project is a mechanism for organizing the related files and resources used in a Java Application. To create a new project, perform the following steps:

1. Select **File > New Project** from the menu.
2. On the first page of the New Project Wizard (not shown here), select Java as the category and Java Application as the project type. Click **Next**.
3. On the second page of the wizard (shown above), enter a name for the project, and then enter or browse to the directory location to store project files.
4. It is possible to have NetBeans automatically generate a main class for the project.
5. Click **Finish**.

Creating a Java Class

1. Select **File > New File**.
2. Select your project and choose **Java Class**.
3. Name the class.
4. Assign a package.
5. Click **Finish**.



To create a class within your new project, perform the following steps:

1. Select **File > New File** from the menu.
2. On the first page of the New File Wizard, select your project, and then accept the default file type of Java Class. Click **Next**.
3. On the next page of the wizard, enter a name for the Java class. By convention, Java classes should start with an uppercase letter and each subsequent word in the class name should be capitalized (for example, `SayHello`). This is illustrated in the screenshot above.
4. Assign a package for the class.
5. Click **Finish**.

Note: If the package for this new class already exists, you can create the class by right-clicking the package in the Project Navigator panel in NetBeans and selecting **New > Java class** from the context menu instead of starting from the File menu.

Exercise 3-1:Creating a New Project and Java Class

In this exercise, you use NetBeans to create a new Java Class.

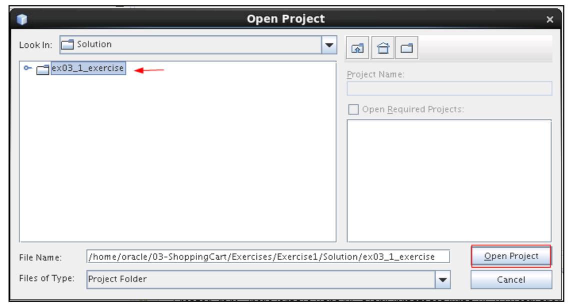
1. Create a new project called **`Exercise_03-1`**.
   – Deselect the box to create the `main` method. You will write the `main` method yourself in the next exercise.
2. Create a new **Java Class** file in this project.
   – Class name = `ShoppingCart`
   – Package name =`exercise`

The fully-qualified class name should be `exercise.ShoppingCart`. Note: You won't be able to run and test your code until create the main method in the next exercise.

Opening an Existing Java Project

If you need to open an existing project in NetBeans, perform the following steps:

1. Select **File > Open Project.**
2. Navigate to the directory that contains your projects.
3. Select the project file you want. (This file must be unzipped.)
4. Click **Open Project**.



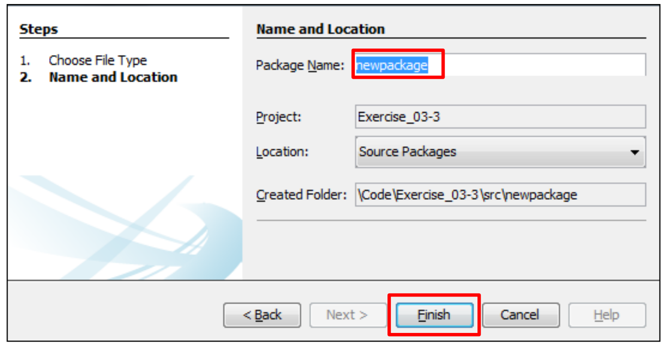
To open an existing project, perform the following steps:

1. Select **File > Open Project**.
2. Navigate to the directory that contains your projects.
3. Select the project file you want. (This file must be unzipped.)
4. Click **Open Project**.

Creating a New Java Package

If you ever need to create a new package, perform the following steps in NetBeans:

1. Right-click your project.
2. Select **New > Java Package**.
3. Name the package.
4. Click **Finish**.



To create a new package within your new project, perform the following steps:

1. Right-click your project.
2. Select **New > Java Package**.
3. Name the package.
4. Click **Finish**.

Topics

- Java classes and packages
- The `main` method

The `main` Method

- It is a special method that the JVM recognizes as the starting point for every Java program.
- The syntax is always the same:

```
public static void main (String[] args) {
   // code goes here in the code block
}
```

- It surrounds entire method body with braces { } .

- The main method is a special method that the Java Virtual Machine recognizes as the starting point for a Java program.
- Any program that you want to run must have a public `main` method.
- A class containing a main method is referred to as a "main class."

Note: Brackets (`[]`) can be placed to the right of `String` or to the right of `args`, but the former is recommended:

```
(String[] args)
(String args[])
```

A `main` Class Example

Class name

```
public class Hello {

    public static void main (String[] args) {
        // Entry point to the program.
        // Write code here:
        System.out.println ("Hello World!");
    }
}
```

Comments

main method

Program output

Here you see a simple example of a class (Hello) that includes a `main` method. The `main` method writes a message to the console (“Hello World!”). This is called *program output*.

You can include comments that the compiler will ignore, by preceding the comment line with two forward slashes: //

Output to the Console

- Syntax:

```
System.out.println (<some string value>);
```

- Example:

String literal

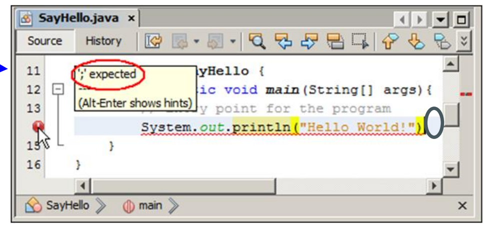
```
System.out.println ("This is my message.");
```

Be sure to include the semicolon

Use the `System.out.println` method to print a message to the console. Use double quotation marks to enclose the text of the message (called a String literal).

Avoiding Syntax Errors

- NetBeans will tell you if you have done something wrong.
- Common errors include:
  - Unrecognized word (check for case-sensitivity error)
  - Missing close quotation mark
  - Unmatched brace
  - Missing semicolon



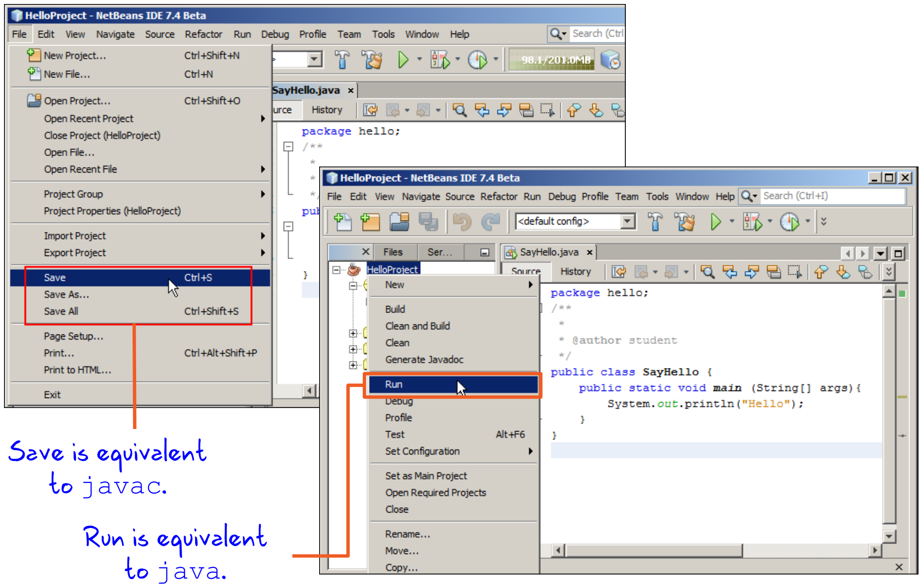
Most Java editors check the code syntax and show alerts by using icons and red underlines where there are errors in the code.

To avoid syntax problems, be sure to do the following:

- Observe any red bubble indicators in the code editor to locate syntax errors.
- Have a semicolon at the end of every line where one is required.
- Have an even number of symbols such as braces, brackets, and quotation marks.

The screenshot shows an error in Line 13, in which there is a missing semicolon. If you place your cursor over the red bubble, the editor offers a suggestion for fixing the error.

Compiling and Running a Program by Using NetBeans



Save invokes the `javac <classname(s)>` command for all `.java` files in the project. Right-clicking the source code and selecting Run File invokes the `java <classname>` command. Be sure to look for red bubble indicators in the code editor to locate syntax errors.

Exercise 3-2: Creating a `main` Method

In this exercise, you manually enter a `main` method that prints a message to the console.

1. Continue editing **`Exercise_03-1`** or open **`Exercise_03-2`**.
2. In the code editor, add the `main` method structure to the ShoppingCart class.
3. In the code block of the `main` method, use a `System.out.println` method to print "Welcome to the Shopping Cart!"
4. Save your program.
5. Click the **Run** button to test program.
   - Select **`exercise.ShoppingCart`** as the main class.

In this exercise, you manually enter a `main` method that prints a message to the console.

Quiz

Which `main` method syntax is correct?

a. `Public static void main (String[ ] args){ }`
b. `public Static void Main (String[ ] args){ }`
c. `public static void main (String ( ) args)[ ]`
d. `public static void main (String[ ] args){ }`

Answer: d

- a is incorrect. It should be “public”, not “Public”.
- b is incorrect. Both “Static” and “Main” should begin with a lowercase letter.
- c is incorrect because there should be brackets following “String” and braces defining the method scope.
- d is correct.

Summary

In this lesson, you should have learned how to:

- Use the NetBeans IDE to create and test Java classes
- Write a `main` method
- Use `System.out.println` to write a String literal to system output

4

Data in a Cart

Objectives

After completing this lesson, you should be able to:

- Describe the purpose of a variable in the Java language
- List and describe four data types
- Declare and initialize `String` variables
- Concatenate `String` variables with the '+' operator
- Make variable assignments
- Declare and initialize `int` and `double` variables
- Modify variable values by using numeric operators
- Override default operator precedence using ( )

Topics

- Introducing variables
- Working with `String` variables
- Working with numbers
- Manipulating numeric data

Variables

- A variable refers to something that can change.
  - Variables can be initiated with a value.
  - The value can be changed.
  - A variable holds a specific type of data.

The type of data | Variable name | The value of the variable

```
String firstName = "Mary";

firstName = "Gary";
```


A variable is simply a storage location in memory that holds a specific value. That value can be changed by copying (or “assigning”) a different value to that variable.

Variable Types

- Some of the types of values a variable can hold:
  - `String` (example: "Hello")
  - `int` (examples: -10, 0, 2, 10000)
  - `double` (examples: 2.00, 99.99, -2042.00009)
  - `boolean` (true or false)
- If uninitialized, variables have a default value:
  - `String:` null
  - `int:` 0
  - `double:` 0.0
  - `boolean:` false

Variables are declared to hold a specific type of data. Some of the more common types are:

- `String`: This is text data, such as "Hello".
- `int`: This is integer data—positive or negative whole numbers.
- `double`: These are positive or negative *real* numbers containing a decimal portion.
- `boolean`: This data type has a value of either true or false.

Most variables that have not been initialized are given a default value. The default values for String, `int`, `double`, and `boolean` are shown above. (Local variables are the exception. You will learn about local variables in the lesson titled "Creating and Using Methods.")

Notice that `String` begins with an uppercase letter, but the other types do not. You will learn the reason for this later, when you also learn about some other data types.

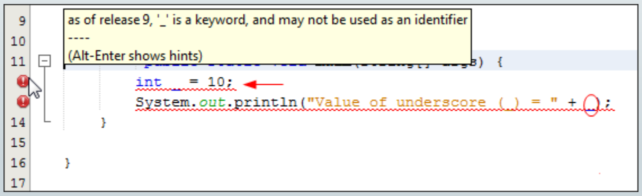
Naming a Variable

Guidelines:

- Begin each variable with a lowercase letter. Subsequent words should be capitalized:
  - `myVariable`
- Names are case-sensitive.
- Names cannot include white space.
- Choose names that are mnemonic and that indicate to the casual observer the intent of the variable.
  - `outOfStock    (a boolean)`
  - `itemDescription   (a String)`

Java SE 9: The Underscore Character Is Not a Legal Name

- If you use the underscore character ("_") as a one-character identifier in source code, then your code won't compile in Java SE 9.
- For example:



Using underscore as a identifier generates a warning in JDK 8 and an error in Java SE 9.

Uses of Variables

- Holding data used within a method:

```
String name = "Sam" ;
double price = 12.35;
boolean outOfStock = true;
```

- Assigning the value of one variable to another:

```
String name = name1;
```

- Representing values within a mathematical expression:

```
total = quantity * price ;
```

- Printing the values to the screen:

```
System.out.println(name);
```


Variables are used extensively in the Java programming language for tasks such as:

- Holding data used within a method, such as the `main` method
- Assigning the value of one variable to another. In the first example above, the `name` variable is initialized with the value, “Sam”, and in the second example, its value is changed to the value of `name1` (unknown here).
- Representing values within a mathematical expression (* is the symbol for multiplication)
- Printing the values to the screen. For example, the same `System.out.println` method that you used in the last exercise to print out the text literal, “Welcome to the Shopping Cart”, can also be used to print out the value stored in the `name` variable.

Topics

- Introducing variables
- Working with `String` variables
- Working with numbers
- Manipulating numeric data

Examples: Variable Declaration and Initialization

- Basic Example :

```
String address = "123 Oak St";          //one variable declared
                                        // and initialized
```

$\underbrace{\texttt{String}}_{\text{type}}\ \underbrace{\texttt{address}}_{\text{identifier}}\ \texttt{=}\ \underbrace{\texttt{"123 Oak St";}}_{\text{value}}$

- Other Examples:

```
String customer;              //One variable declared

String name, city             //Two variables declared

String country ="USA", state="CO" //Two variables declared
                                  //and initialized

city=" USA";           //One variable initialized after
                       //being declared earlier
```


The syntax for declaring and initializing a variable is:

`type identifier [= value];`

where:

- **`type`** represents the type of information or data held by the variable. In the examples in the slide, you see only `String` variable types declared.
- **`identifier`** is the variable name. In the first example in the slide, the variable name is `customer`.

The second example shows how you can declare any number of variables of the same type on a single line without initializing them. Notice that when declaring multiple variables in a single line, they are separated by a comma.

You can either declare a variable without assigning an initial or you can initialize the variable at the same time you declare it.

`String` Concatenation

- `String` variables can be combined using the '+' operator.
  - `stringVariable1 + stringVariable2`
  - `stringVariable1 + "String literal"`
  - `stringVariable1 + "String literal" + stringVariable2`

- Example:

```
String greet1 = "Hello";
String greet2 = "World";
String message = greet1 + " " + greet2 + "!";
String message = greet1 + " " + greet2 + " " + 2014 +"!";
```


Combining multiple Strings is called "concatenation." You can concatenate a `String` variable to another `String` variable. You can also concatenate a `String` literal to a `String` variable.

As you can see in the example above, you can concatenate any number of `String` variables and `String` literals to achieve your goal.

You may find the last example surprising. You can also concatenate a number into a `String` variable. The compiler converts the numeric value to its equivalent `String` value. If we were to print the `message` variable after the last example, the output would be "Hello World 2014!"

`String` Concatenation

You can concatenate `String` variables outside or inside a method call:

```
String greet1 = "Hello";
String greet2 = "World";
String message = greet1 + " " +greet2  + "!";

System.out.println(message);
System.out.println(greet1 + " " + greet2 + "!");
```

Output:

```
Hello World!
Hello World!
```


In the examples in the slide, you see two variations of printing out String data by using the `System.out.println` method.

- In the first example, the message variable will be printed.
- In the second example, the expression containing the concatenation of variables plus String literals can be used within the method parentheses. The concatenation will be completed by the runtime engine before the `println` method is executed.
- As you can see, the output of both method invocations is the same.

Exercise 4-1: Using `String` Variables

1. In NetBeans, open the project **`Exercise_04-1`**.
2. Declare and initialize two String variables: `custName` and `itemDesc`.
3. Declare a String variable called `message`. Do not initialize it.
4. Assign the `message` variable with a concatenation of the `custName` and `itemDesc`. Include a String literal that results in a complete sentence.
   – Example: "Mary Smith wants to purchase a Shirt"
5. Print `message` to the System output.

In this exercise, you declare, initialize, and concatenate String variables and literals.

Quiz

Which of the following variable declarations and/or initializations are correct?

a. `int count = 5; quantity = 2;`

b. `string name, label;`

c. `boolean complete = "false";`

d. `boolean complete = true;`

Answer: d

- a is incorrect because each `int` declaration and assignment must be separated by a comma and not a semicolon.
- b is incorrect because `String` is not capitalized.
- c is incorrect because a `boolean` type variable does not hold `String` values. It holds only `true` and `false`.
- d is correct.

Topics

- Introducing variables
- Working with `String` variables
- Working with numbers
- Manipulating numeric data

int and double Values

- int variables hold whole number values between:
  - -2,147,483,648
  - 2,147,483,647
  - Examples: 2, 1343387, 1_343_387
- double variables hold larger values containing decimal portions.
  - Use when greater accuracy is needed.
  - Examples: 987640059602230.7645 , -1111, 2.1E12

- The int data type stores 32 bits of data. This means that you can store whole numbers within the range: -2,145,483,648 and 2,147,483,647. You cannot use commas to make the number more readable when you assign a value to an int variable. However, you can use underscores (_) to make your code more readable, as shown in one of above int examples. The compiler ignores these underscores. If you print the number to system output, the underscores will not appear. The only benefit of this is readability in your code.
- The double data type stores 64 bits of data. This means that you can store extremely large values—either negative or positive. The examples above show:
  - An extremely large number with four decimal points of precision
  - A negative whole number
  - A decimal number using exponential notation

Initializing and Assigning Numeric Values

- `int` variables:
  - `int quantity = 10;`
  - `int quantity = 5.5;` Compilation fails!
- `double` variables:
  - `double price = 25.99;`
  - `double price = 75;` Run time will interpret as 75.0.

Topics

- Introducing variables
- Working with `String` variables
- Working with numbers
- Manipulating numeric data

Standard Mathematical Operators

Purpose	Operator	Example	Comments
Addition	+	`sum = num1 + num2;`	If num1 is 10 and num2 is 2, sum is 12.
Subtraction	–	`diff = num1 – num2;`	If num1 is 10 and num2 is 2, diff is 8.
Multiplication	*	`prod = num1 * num2;`	If num1 is 10 and num2 is 2, prod is 20.
Division	/	`quot = num1 / num2;`	If num1 is 31 and num2 is 6, quot is 5. The remainder portion is discarded. Division by 0 returns an error.

The table above assumes that all operands and result variables are integers (`int`). Mixing `double` and `int` types can alter the results. For instance, in the division example, if the quotient and dividend (or if all three) are `double` values, the quotient would show the decimal portion:

```
double quot, num1;
num1 = 31;
int num2 = 5;
quot = num1 / num2;
```

Answer: `quot = 6.2`

Increment and Decrement Operators (++ and --)

The long way:

```
age = age + 1;
```

or

```
count = count - 1;
```

The short way:

```
age++;
```

or

```
count--;
```


A common requirement in programs is to add or subtract 1 from the value of a variable. You can do this by using the + operator as follows:

```
age = age + 1;
```

Operator Precedence

Here's an example of the need for rules of precedence.

Is the answer to the following problem 34 or 9?

```
int c = 25 - 5 * 4 / 2 - 10 + 4;
```

Operator Precedence

Rules of precedence:

1. Operators within a pair of parentheses
2. Increment and decrement operators (++ or --)
3. Multiplication and division operators, evaluated from left to right
4. Addition and subtraction operators, evaluated from left to right

In a complex mathematical statement with multiple operators on the same line, how does the computer pick which operator it should use first? To make mathematical operations consistent, the Java programming language follows the standard mathematical rules for operator precedence. Operators are processed in the following order:

1. Operators within a pair of parentheses
2. Increment and decrement operators
3. Multiplication and division operators, evaluated from left to right
4. Addition and subtraction operators, evaluated from left to right

If standard mathematical operators of the same precedence appear successively in a statement, the operators are evaluated from left to right.

Using Parentheses

Examples:

```
int c = (((25 - 5) * 4) / (2 - 10)) + 4;
int c = ((20 * 4) / (2 - 10)) + 4;
int c = (80 / (2 - 10)) + 4;
int c = (80 / -8) + 4;
int c = -10 + 4;
int c = -6;
```


Your expression will be automatically evaluated with the rules of precedence. However, you should use parentheses to provide the structure you intend:


```
int c = (((25 - 5) * 4) / (2 - 10)) + 4;
int c = ((20 * 4) / (2 - 10)) + 4;
int c = (80 / (2 - 10)) + 4;
int c = (80 / -8) + 4;
int c = -10 + 4;
int c = -6;
```

Exercise 4-2: Using and Manipulating Numbers

1. Continue editing **`Exercise_04-1`** or open **`Exercise_04-2`**.
2. Declare and initialize numeric fields: `price` (double) `tax` (double), and `quantity` (int). Also declare a double called `total`, but do not initialize it.
3. Change the `message` variable to include `quantity`
   – Example: "Mary Smith wants to purchase 1 Shirt.“
4. Calculate total by multiplying price * quantity * tax.
5. Print a message showing the total cost (example: "Total cost with tax is: 25.78.").

In this exercise, you declare and initialize numeric variables, and concatenate Strings with numbers.

Quiz

Which of the following statements are correct Java code?

a. `int count = 11.4;`

b. `double amount = 11.05;`

c. `int cost = 133_452_667;`

d. `double total = 1.05 * amount;`

Answer: b, c, d

- a is incorrect because the assignment of a decimal value to an `int` is a possible loss of precision and therefore will not compile.
- b is correct.
- c is correct because underscores can be used to make a number more readable.
- d is correct.

Quiz

Given:

```
String name = "Bob";
String msg;
int num = 3;
```

Which of the following statements correctly assigns the value “Bob wrote 3 Java programs.” to the msg variable?

```
a. msg = name + " wrote " + num " Java programs.";
b. msg = name + " wrote " + 3 + " Java programs.";
c. msg = "Bob wrote "+ (2+1) + " Java programs.";
d. msg = name + " wrote " + 2+1 + " Java programs.";
```

Answer: b, c

- a is incorrect because it is missing a + sign between the num variable and the final `String` literal.
- b is correct because the compiler converts the `int` of value 3 to a `String`.
- c is correct because, due to the use of parentheses, the addition operation is performed first, before the concatenation.
- d is incorrect because it would result in “Bob wrote 21 Java programs.” The compiler converts each number to a `String` separately and concatenates them together.

Summary

In this lesson, you should have learned how to:

- Describe the purpose of a variable in the Java language
- List and describe four data types
- Declare and initialize `String` variables
- Concatenate `String` variables with the '+' operator
- Make variable assignments
- Declare and initialize `int` and `double` variables
- Modify numeric values by using operators
- Override default operator precedence using ( )

5

Managing Multiple Items

Objectives

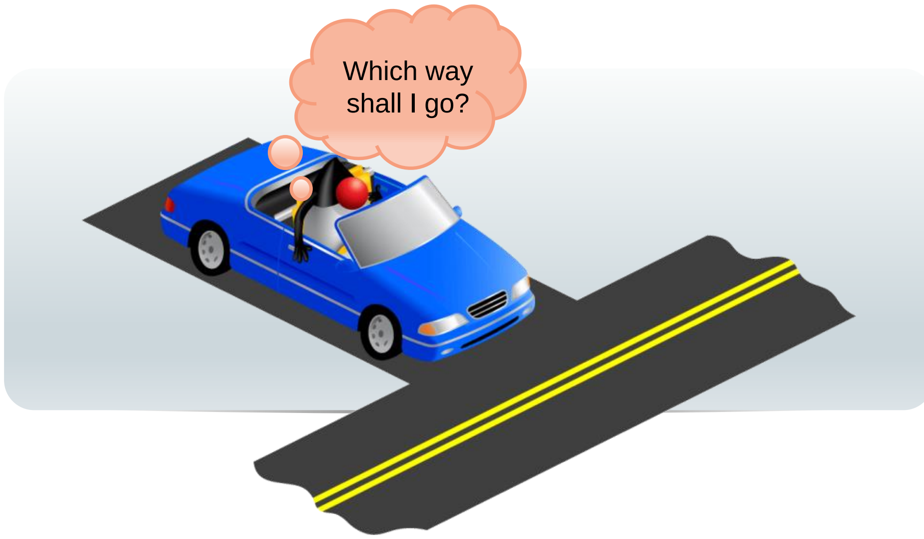
After completing this lesson, you should be able to:

- Explain what a boolean expression is
- Create a simple `if/else` statement
- Describe the purpose of an array
- Declare and initialize a `String` or `int` array
- Access the elements of an array
- Explain the purpose of a `for` loop
- Iterate through a `String` array using a `for` loop

Topics

- Working with conditions
- Working with an array of items
- Processing an array of items

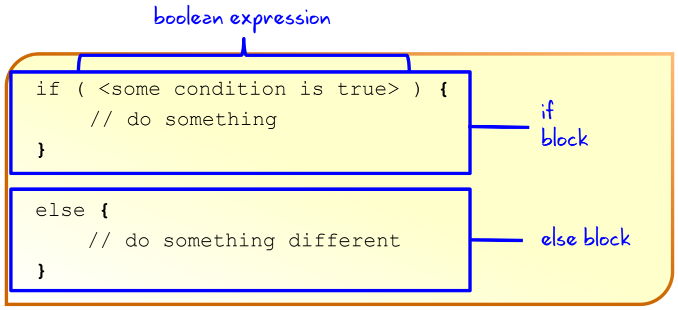
Making Decisions



In your daily life, you have to make a lot of decisions, and you often use the word "if" with some condition when making those decisions. For example, "If I can see my destination on the left, I will turn left, otherwise I'll turn right."

One of the tasks that programs often perform is to evaluate a condition and, depending on the result, execute different blocks or branches of code. This is called conditional logic, and it is handled through the use of an `if/else` statement.

The `if/else` Statement



The `if/else` statement is one way of branching your code depending on some condition. It uses the two Java keywords, `if` and `else`.

- If some condition is true, execute the code within the `if` block.
- Else, if that condition is false, execute the code in the `else` block.

The condition to be evaluated is surrounded by parentheses. It is referred to as a Boolean expression because it must evaluate to either `true` or `false`.

Boolean Expressions

Review:

- `boolean` data type has only two possible values:
  - `true`
  - `false`

A boolean expression is a combination of variables, values, and operators that evaluate to `true` or `false`.

```
length > 10;
size <= maxSize;
total == (cost * price);
```

Relational operators

Remember that a `boolean` data type can have only two possible values: `true` and `false`.

In the same way, a boolean expression, made up of some combination of variables, values and operators, must also evaluate to either `true` or `false`.

This usually involves a special kind of operator called a relational operator. Several of these are used in the three examples above:

- Greater than (>)
- Less than or equal to (<=)
- Equal to (==). In the example above, the result of `cost *price` is compared to the value of `total`. If they are equal, the entire expression evaluates to `true`.

Relational Operators

Condition	Operator	Example
Is equal to	`==`	`int i=1;` `(i == 1)`
Is not equal to	`!=`	`int i=2;` `(i != 1)`
Is less than	`<`	`int i=0;` `(i < 1)`
Is less than or equal to	`<=`	`int i=1;` `(i <= 1)`
Is greater than	`>`	`int i=2;` `(i > 1)`
Is greater than or equal to	`>=`	`int i=1;` `(i >= 1)`

Here you see a more complete list of relational operators. The table lists the different conditions you can test by using relational operators. The result of all relational operators is a boolean value. All of the examples in the table yield a boolean result of true.

Note: The equal sign (=) is used to make an assignment, whereas the == sign merely makes a comparison and returns a boolean.

Examples

Sometimes there is a quicker way to meet your objective. Boolean expressions can be used in many ways.

```
24        int attendees = 4;
25        boolean largeVenue;
26
27        // if statement example
28        if (attendees >= 5){
29            largeVenue = true;
30        }
31        else {
32            largeVenue = false;
33        }
34
35        // same outcome with less code
36        largeVenue = (attendees >= 5);
```

Assign a boolean by using an `if` statement.

Assign the boolean directly from the boolean expression.

In the slide above, you see examples of two different ways to set the `largeVenue boolean` value:

- In lines 28–33, an `if` statement tests the value of the `attendees` variable. If it is greater than 5, `largeVenue` is set to `true`; otherwise it is set to `false`.
- In line 36, the same outcome is achieved with one line of code. The result of the same boolean expression that was evaluated in the `if` statement (`attendees >=5`) is directly assigned to the `largeVenue boolean`.

Exercise 5-1: Using `if` Statements

1. Open the project **`Exercise_05-1`**.
2. Use an `if` statement to test the `quantity` of the item:
   - `if` it is > 1, concatenate an `'s'` to `message` so that it indicates multiple items.
3. Declare a boolean, `outOfStock.`
4. Use an `if|else` statement to test if the item is out of stock:
   - `if` item is out of stock, inform the user that the item is unavailable.
   - `else,` print the `message` and total cost
5. Run the program with `outOfStock = true`.
6. Run it again with `outOfStock = false`.

In this exercise, you use an `if` and an `if/else` statement to check if an item is out of stock.

Quiz

What is the purpose of the `else` block in an `if/else` statement?

a. To contain the remainder of the code for a method
b. To contain code that is executed when the expression in an `if` statement is false
c. To test if an expression is false

Answer: b

Topics

- Working with conditions
- Working with an array of items
- Processing an array of items

What If There Are Multiple Items in the Shopping Cart?

```
// Without an array
String itemDesc1 = "Shirt";        Not realistic if 100s of items!
String itemDesc2 = "Trousers";
String itemDesc3 = "Scarf";
                                   Much better!
// Using an array
String[] items = {"Shirt","Trousers","Scarf"};
```

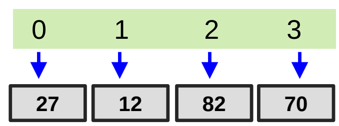

Think about how your code would look if there were multiple items in the shopping cart. You would have to initialize each item description separately. Imagine if you had a thousand items!

As you continued to build out this shopping cart application, the amount of code needed to handle each item individually would not only be time-consuming, but would make your code hard to read and difficult to maintain.

The code example above shows a better alternative that we will explore now: the array.

Introduction to Arrays

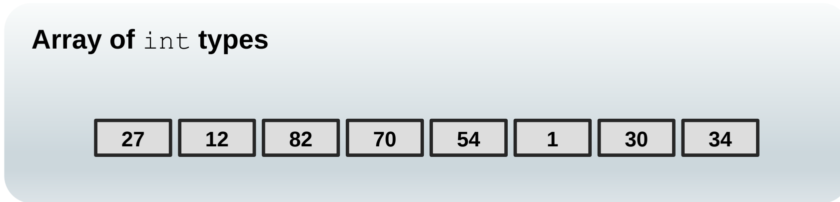
- An array is an indexed container that holds a set of values of a single type.
- Each item in an array is called an *element*.
- Each element is accessed by its numerical index.
- The index of the first element is 0 (zero).
  - A four-element array has indices: 0, 1, 2, 3.



The array is a container that holds a set of `String` values, or a set of `int` values, or a set of `double` values, and so on.

The elements (items) of the array are accessed through a numeric index. Using this index, you can set or get a value from a specific element.

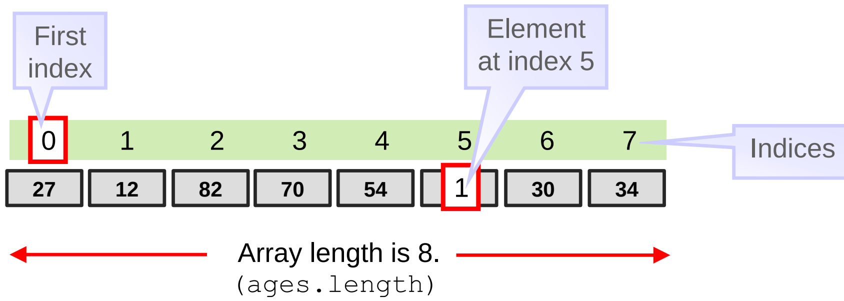
Array Examples



Arrays can be of any data type, but all elements have to share the same type.

Array Indices and Length

The `ages` array has eight elements.



- An array is a container object that holds a fixed number of values of a single type. The length of an array is established when the array is created. After creation, the length of an array cannot be changed.
- Each item in an array is called an *element*, and each element is accessed by its numerical index. As shown in the diagram above, index numbering begins with 0. For example, the eighth element would be accessed at index 7.
- The length of an array can be accessed using dot notation to access the `length` field. Assuming that the array in the diagram is called `ages`, you can determine how many elements are in the array by using:

```
int agesLength = ages.length;
```

Declaring and Initializing an Array

- Syntax:

```
type[] arrayIdentifier = {comma-separated list of values};
```

- Declare arrays of types `String` and `int`:

```
String[] names = {"Mary", "Bob", "Carlos"};
int[] ages = {25, 27, 48};
```

All in one line

In this slide, you see the syntax and an example of how to declare the array and initialize the values. (This assumes that you know at this time what the values will be).

- Syntax for declaring an array:

  `type [] arrayIdentifier = {comma-separated list of values};`

  - **Note:** Another acceptable syntax is: `type arrayIdentifier[] = {comma-separated list of values};`

where:

- `type` represents the data type for each of the values stored in the array
- `[ ]` informs the compiler that you are declaring an array
- `arrayIdentifier` is the variable name that you use when you refer to the array
- You can list as many values as you need. Separate the values with a comma.

Declaring and Initializing an Array

Examples:

```
1    int[] ages = new int[3];
2    ages[0] = 19;
3    ages[1] = 42;
4    ages[2] = 92;
5
6    String[] names = new String[3];
7    names[0] = "Mary";
8    names[1] = "Bob";
9    names[2] = "Carlos";
```

Multistep approach

Multistep approach

In this example, the `int` array, `ages`, is instantiated with a size of 3 on line 1. The creation of the array uses the ***new*** keyword. You will learn much more about the purpose of this keyword in the lesson titled “Describing Objects and Classes.”

On lines 2 through 4, the elements of the `ages` array are initialized.

Likewise, on line 6, the `String` array, `names`, is instantiated with a size of 3, and its elements are initialized on lines 7 through 9.

Accessing Array Elements

- Get values from the `ages` array:

```
int[] ages = {25, 27, 48};
int myAge = ages[0];
int yourAge = ages[1];
System.out.println("My age is " + ages[0]);
```

- Set values from the `names` array:

```
String[] names = {"Mary", "Bob", "Carlos"};
names[0] = "Gary";
names[1] = "Rob";
```


Elements of the array are accessed by referencing the index of that element. For example:

- To get the value from the first element of the `ages` array, use `ages[0]`.
- To get the value from the second element of the `ages` array, use `ages[1]`.
- You can directly use the value of an array element in an expression by using the same syntax. In the third example, you see `ages[0]` referenced directly when calling `System.out.println`.
- To set a value in the first element of the `names` array, use `names[0] = "some value"`.

Exercise 5-2: Using an Array

1. Open the project **`Exercise_05-2`** in NetBeans.
2. Declare a `String` array and initialize it with four elements.
   – Each element represents a different item description ("Shirt", for instance).
3. Change `message` to show how many items the customer wants to purchase.
   – Hint: Use the `.length` property of your array.
4. Print just one element in the array.
   – What happens if you use index number 4?

In this exercise, you declare and initialize a `String` array to hold item descriptions. Then you experiment with accessing the array.

Quiz

Why does the following code not compile? Select all that apply.

```
int[] lengths = {2, 4, 3.5, 0, 40.04};
```

a. `lengths` cannot be used as an array identifier.

b. All of the element values should have the same format (all using `double` values, or all using `int` values).

c. The array was declared to hold `int` values. `double` values are not allowed.

Answer: c

a is incorrect because `lengths` is a perfectly valid array identifier.

b is incorrect because it implies that this array could contain elements of type `double`.

c is correct.

Quiz

Given the following array declaration, which of the following statements are true?

```
int[] classSize = {5, 8, 0, 14, 194};
```

a. `classSize[0]` is the reference to the first element in the array.

b. `classSize[5]` is the reference to the last element in the array.

c. There are 5 integers in the `classSize` array.

d. `classSize.length = 5`

Answer: a, c, d

a is correct.

b is incorrect because the array index begins with 0. Thus, the index for the last element is one less than the total number of elements.

c is correct.

d is correct.

Topics

- Working with conditions
- Working with an array of items
- Processing an array of items

Loops

Loops are used in programs to repeat blocks of statements

- Until an expression is false

  or

- For a specific number of times:
  - I want to print each element of an array.
  - I want to print each element of an `ArrayList`. (The `ArrayList` class is covered in the lesson titled “Working with Arrays, Loops, and Dates.”

Processing a String Array

Loop accesses each element in turn.

names array of String types

George	Jill	Xinyi	Ravi

```
for (String name : names ) {
   System.out.println("Name is " + name);
}
```

Each iteration returns the next element of the array.

Output:

```
Name is George
Name is Jill
Name is Xinyi
Name is Ravi
```


The for loop syntax is:

```
for (<type> <variable> : <array name>) {
      <code_block to be performed for each array element>
}
```

where:

- for indicates that a loop is being defined
- <type> is the data type of each of the elements within the array
- <variable> is a placeholder used to store each element of an array
- : indicates that the object reference that follows is an array
- <array name> is the array, whose length determines the number of iterations to perform
- code_block is the code that will be executed in each iteration of the loop

In the example above, there are four elements in the names array. Therefore, the code block will be executed four times. Each time, the name variable holds a different array element.

Using `break` with Loops

`break` example:

```
01  int passmark = 12;
02  boolean passed = false;
03  int[] scores = {4,6,2,8,12,35,9};
04  for (int unitScore : scores){
05      if (unitScore >= 12){
06          passed = true;
07          break;
08      }
09  }
10  System.out.println("At least one passed? " +passed);
```

No need to go through the loop again, so use break.

Output:

```
At least one passed? true
```


Occasionally, some condition occurs that makes it unnecessary to continue the loop. The `break` keyword enables you to do this. When `break` is encountered, the program execution moves to the first line of code outside the `for` block.

- The example in the slide shows the use of `break`. You will notice that it uses an `if` statement within the `for` block. This `if` statement is executed on each iteration of the loop.
- Assuming that the purpose of the code is to find out whether any of the scores in the array are equal or above the `passmark`, you can set `passed` to `true` and jump out of the loop as soon as the first such score is found.
- When `break` is called on line 7, execution of the program skips to line 10.

Exercise 5-3: Using a Loop to Process an Array

1. In NetBeans,continue editing **`Exercise_05-2`** or open **`Exercise_05-3`**.
2. Create a `for` loop that iterates through the array of item descriptions, displaying each element.
3. Precede the list of elements with the message: "Items purchased:".

In this exercise, you loop through the array of item descriptions, printing each element.

Quiz

Given the following code,

```
int[] sizes = {4, 18, 5, 20};
for (int size : sizes){
    if (size > 16){break;}
    System.out.println("Size: "+size + ", ");
}
```

which option below shows the correct output?

a. `Size: 4,`

b. `Size: 4`

c. `Size: 4,`
`Size: 5,`

d. There is no output.

Answer: a

a is correct.

b is incorrect because the comma appears within each `println` method.

c is incorrect because when the first size greater than 16 is found, the loop breaks and does not return.

d is incorrect because the first iteration of the loop would print.

Summary

In this lesson, you should have learned how to:

- Use a boolean expression
- Create a simple `if/else` block
- Describe the purpose of an array
- Declare and initialize a `String` or `int` array
- Access the elements of an array
- Explain the purpose of a `for` loop
- Iterate through a `String` Array using a `for` loop

Describing Objects and Classes

6

ORACLE

Interactive Quizzes

Before you start today's lessons, test your knowledge by answering some quiz questions that relate to yesterday's lessons. Open the Quiz files by clicking the quizzes.html shortcut from the desktop of your VM. In the welcome page, JavaSEProgrammingI.html, click the links for Lessons 2, 3 ,4, and 5.

Objectives

After completing this lesson, you should be able to:

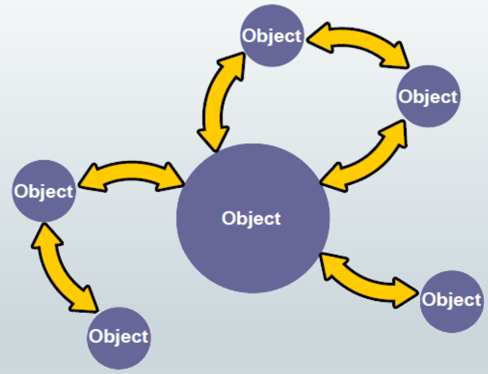
- List the characteristics of an object
- Define an object as an instance of a class
- Instantiate an object and access its fields and methods
- Describe how objects are stored in memory
- Instantiate an array of objects
- Describe how an array of objects is stored in memory
- Declare and instantiate an object as a field

Topics

- Describing objects and classes
- Defining fields and methods
- Declaring, instantiating, and using objects
- Working with object references
- Doing more with arrays
- Introducing the soccer league use case

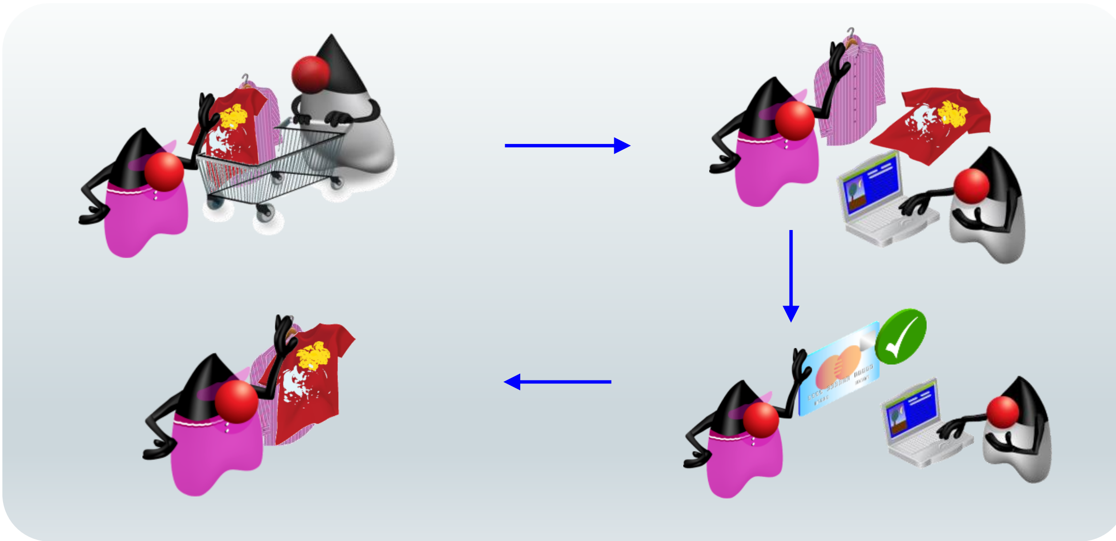
Object-Oriented Programming

- Interaction of objects
- No prescribed sequence



You have seen this diagram before in the “What Is a Java Program?” lesson. The diagram illustrates how object-oriented programming stresses the interaction of objects. The current lesson teaches you how to identify the objects that are required for the application that you would like to build. You first identify what the objects are, you determine the object’s characteristics or properties, and then you determine the object’s behaviors or operations. You then translate that analysis into Java code to create your application. It is time to learn more about objects.

Duke's Choice Order Process



In the first five lessons, the exercises mention a shopping cart class that contains items. Take another look at the shopping cart scenario.

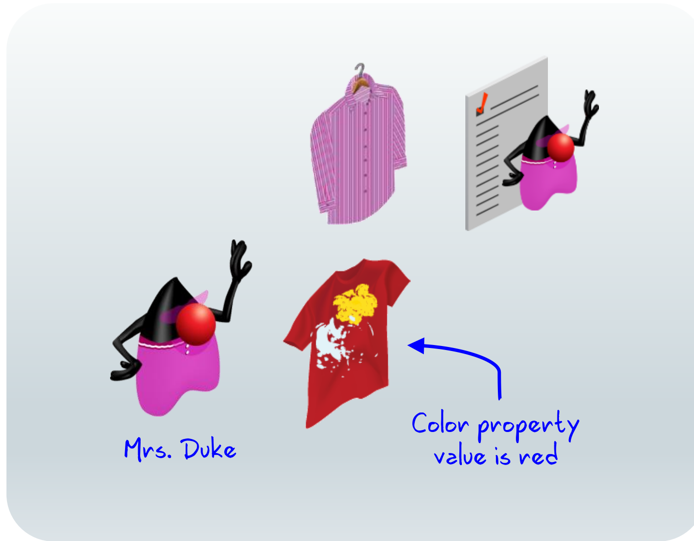
Imagine an online store called Duke's Choice. His number one shopper is his mother, Mrs. Duke. As Mrs. Duke shops, she places items in a shopping cart. Mrs. Duke likes shirts, so she places shirts in her cart. After she fills the cart, she checks out. The checkout process applies the purchase to a credit card, which is verified, and then Mrs. Duke receives an order number so that she can track her order or return it.

As a software developer, when you are presented with a scenario such as Duke's Choice for an application that you need to develop, you can analyze the scenario by breaking it into steps and defining the objects of the scenario.

Characteristics of Objects

Objects are physical or conceptual.

- Objects have **properties**:
  - Size
  - Shape
  - Name
  - Color
- Objects have **behaviors**:
  - Shop
  - Put item in cart
  - Pay

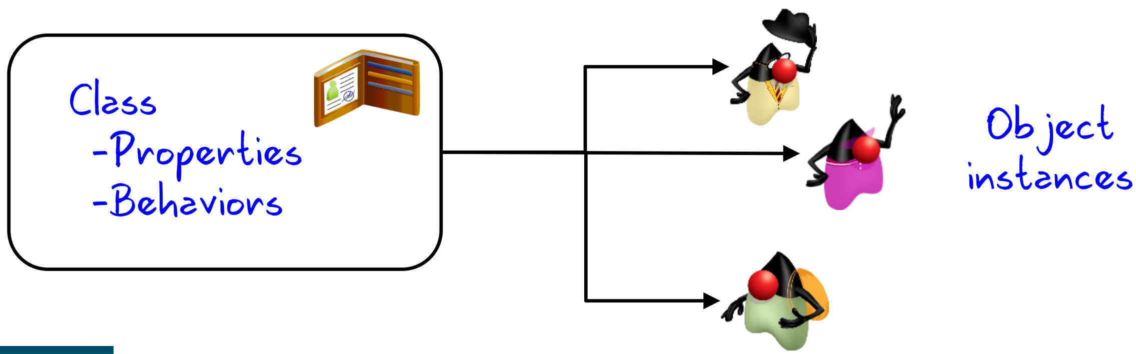


To validate objects in a problem domain, such as the Duke's Choice order process, you identify the properties of all objects:

- Objects can be physical or conceptual. A customer's credit card account is an example of a conceptual object, because it is not something you can physically touch. A shirt is an example of a physical object.
- Objects have properties (attributes) such as size, name, and shape that represent the state of the object. For example, a person has a name (Mrs. Duke), and an object might have a color property. The value of all of an object's properties is often referred to as the object's current state. An object might have a color property with the value of red and a size property with a value of large.
- Objects also have behaviors (things they can do) such as, in our example, shop, put an item in the cart, and purchase.

Classes and Instances

- A class:
  - Is a blueprint or recipe for an object
  - Describes an object's properties and behaviors
  - Is used to create object instances



You just learned about some of the objects, characteristics, and behaviors in the Duke's Choice scenario. Here is an example of one of Duke's Choice objects, the `Customer`, and its function in the store. `Customer` is the class, and a class is a blueprint or recipe for an object. The class describes an object's properties and behaviors.

Classes are used to create object instances, such as the three `Customer` object instances, as illustrated by the three images.

Quiz

Which of the following statements is true?

a. An object is a blueprint for a class.
b. An object and a class are exactly the same.
c. An object is an instance of a class.
d. A class is an instance of an object.

Answer: c

- a is false because a class is a blueprint for an object.
- b is false because an object is an instantiation of a class, and a class serves as a blueprint for the object.
- c is correct.
- d is false because an object is an instance of a class.

Topics

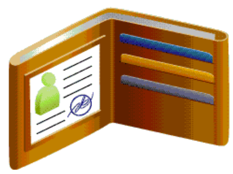
- Describing objects and classes
- Defining fields and methods
- Declaring, instantiating, and using objects
- Working with object references
- Doing more with arrays
- Introducing the soccer league use case

You have just learned about objects, classes, and their characteristics (properties and behaviors). Now it is time to look at fields and methods.

The Customer Properties and Behaviors

Properties:
- Name
- Address
- Age
- Order number
- Customer number

Behaviors:
- Shop
- Set Address
- Add item to cart
- Ask for a discount
- Display customer details



Think of some properties and behaviors that are in the `Customer` class of Duke's Choice. Think about how you would write this information as a Java class.

The Components of a Class

Class declaration

```
public class Customer {
    public String name = "Junior Duke";
    public int    custID = 1205;
    public String address;
    public int    orderNum;
    public int    age;

    public void displayCustomer(){
        System.out.println("Customer: "+name);
    }
}
```

Fields (Properties) (Attributes)

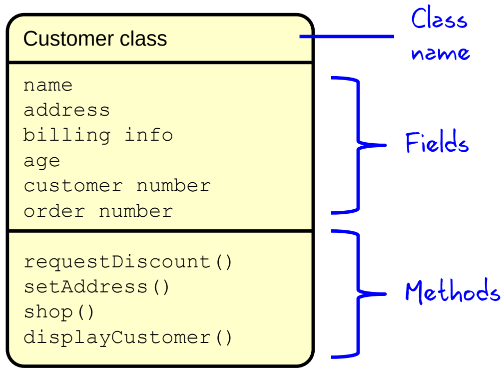
Methods (Behaviors)

In the previous slide, you have identified some properties and behaviors that might be in the `Customer` class. This code example demonstrates how the properties and methods are created in Java. The basic components of a Java class are:

- The class declaration. Notice that the entire class is surrounded by braces.
- Fields of the class. These represent the properties or attributes of the class.
- Methods of the class. These represent the behaviors or operations. Here you see just one method, `displayCustomer`.

  Note: In the code example above, the word "public" is a modifier, and you learn about modifiers later in the course.

Modeling Properties and Behaviors



As you design an application, it is often helpful to create a simple model that describes the components of a class. In the table above, the class name is listed at the top. The properties or fields are listed in the second row, and the behaviors, or methods, are listed in the third row. If you compare this modeling in terms of language, you can think of the class as a noun, the properties or fields as adjectives, and the behaviors or methods as verbs.

Exercise 6-1: Creating the `Item` Class

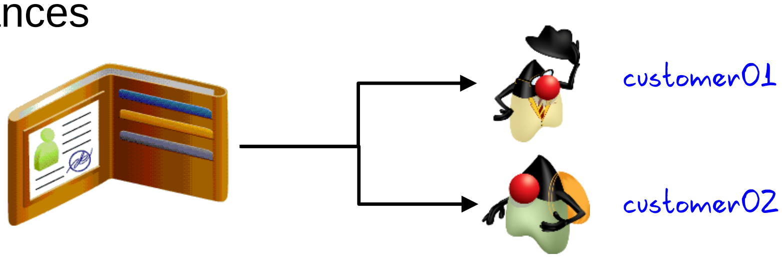
1. Open the project **`Exercise_06-1`** in NetBeans
2. Create the Item class as a plain **Java class**.
3. Declare public fields for `ID` (int), `descr` (String), `price` (double), and `quantity` (int).
   – You will not be able to test the `Item` class until Exercise 6-2.

In this exercise, you create the Item class and declare public fields.

Topics

- Describing objects and classes
- Defining fields and methods
- Declaring, instantiating, and using objects
- Working with object references
- Doing more with arrays
- Introducing the soccer league use case

Customer Instances




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

    Customer customer01 = new Customer();
    Customer customer02 = new Customer();

    customer01.age = 40;
    customer02.name = "Duke";

    customer01.displayCustomer();
    customer02.displayCustomer();
    }
}
```

Create new instances (instantiate).

Fields are accessed.

Methods are called.

In the code example, two new instances of the `Customer` object called `customer01` and `customer02` are created. (Another term for created is “instantiated.”) After the objects are instantiated, the reference variables `customer01` and `customer02` can be used to access fields and methods of the objects. The next two slides explain variations on instantiation, and the dot operator. There is more information on methods in the lesson titled “Creating and Using Methods.”

Object Instances and Instantiation Syntax

variable becomes a reference to that object.

The new keyword creates (instantiates) a new instance.

The syntax is:

```
<class name> variable = new <class name>()
```

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

   Customer customer01 = new Customer();   //Declare and instantiate

   Customer customer02;                    //Declare the reference
   customer02 = new Customer();            //Then instantiate

   new Customer();                 //Instantiation without a reference
                                   //We can't use this object later
                                   //without knowing how to reference it.
   }
}
```


By using the `new` keyword, a new instance of the class is now available to be accessed through the variable, which stores a reference to that object. It can be referred to as a reference variable or an object reference.

Notice that, following the `new` keyword, you see the class name followed by parentheses. This looks similar to calling a method, doesn't it? You are calling a method—the `constructor` method of the Customer class. Every class has a `constructor` method that has the same name as the class. Constructors are covered in more detail in the lesson titled "Creating and Using Methods."

To summarize, there are three steps to getting an object reference:

1. Declare the reference.
2. Instantiate the object using the new keyword and the class `constructor` method.
3. Assign the object to the reference.

Note that the way that the assignment operator (an = symbol) works requires that the reference and the newly created object must be in the same statement. (Statements are ended with the semicolon symbol and are not the same as lines. The end of a line means nothing to the Java compiler; it only helps make the code more readable.)

The Dot (.) Operator

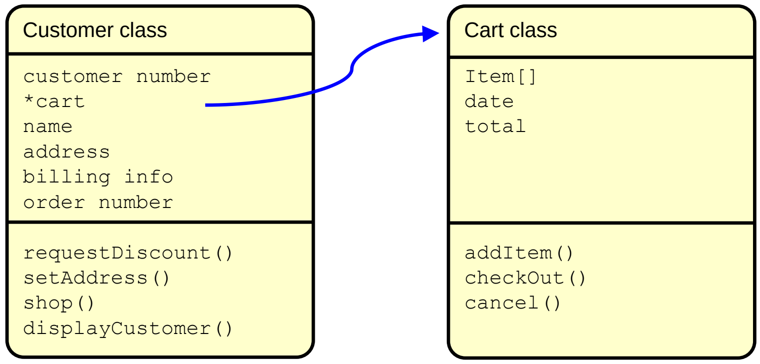
Follow the reference variable with a dot operator (.) to access the fields and methods of an object.

Customer class

```
name
address
billing info
age
customer number
order number

requestDiscount()
setAddress()
shop()
displayCustomer()
```

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

    Customer customer01 = new Customer();

    //Accessing fields
    System.out.println(customer01.name);
    customer01.age = 40;

    //Calling methods
    customer01.requestDiscount();
    customer01.displayCustomer();
    }
}
```

Objects with Another Object as a Property




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

   Customer customer01 = new Customer();
   customer01.cart.cancel();               //How to access methods of an
                                           //object within another object
}
```


So far you have seen objects with properties such as `boolean`, `int`, `double`, and `String`. What if you wanted an object's property to be another object with its own set of properties and behaviors, such as a costumer with a cart property? That way, an instance of a `Customer` would have access to the properties and behaviors found in a `Cart`. This would enable the customer to add items to the cart and then `checkOut` (purchase) the cart. Can this be done? The answer is yes.

You can access fields and methods of objects within another object by applying the dot operator multiple times.

Note: A best practice is to use attribute and operation names that clearly describe the attribute or operation. The asterisk (*) denotes an attribute that is a reference to another object.

Quiz

Which of the following lines of code instantiates a `Boat` object and assigns it to a `sailBoat` object reference?

a. `Boat sailBoat = new Boat();`

b. `Boat sailBoat;`

c. `Boat = new Boat()`

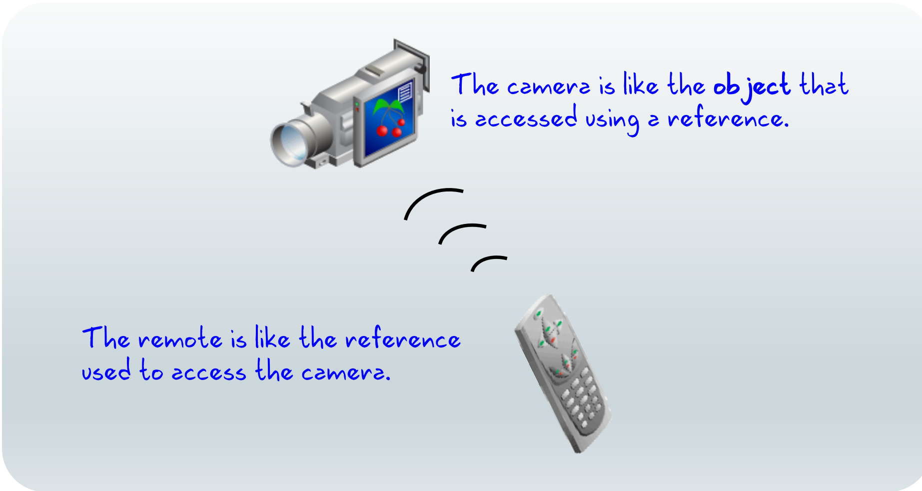
d. `Boat sailBoat = Boat();`

Answer: a

Topics

- Describing objects and classes
- Defining fields and methods
- Declaring, instantiating, and using objects
- Working with object references
- Doing more with arrays
- Introducing the soccer league use case

Accessing Objects by Using a Reference



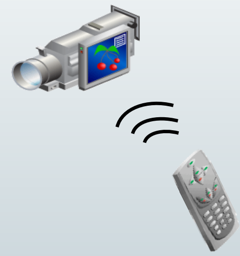
What you have learned up to this point is:

- Objects are accessed using references.
- Objects are instantiated objects of their class type.
- Objects consist of properties and operations, which in Java are fields and methods.

To work with an object, you need to access it using a reference. A good analogy is using a remote control to operate an electronic device. The buttons on the remote control can be used to modify the behavior of the device (in this case, a camera). For example, you can make the camera stop, play, or record by interacting with the remote.

Working with Object References

1 Pick up the remote to gain access to the camera.



1 Create a Camera object and get a reference to it.

```
Camera remote1;

remote1 =  new Camera();

remove1.play();
```

2 Press the remote's controls to have camera do something.

2 Call a method to have the Camera object do something.

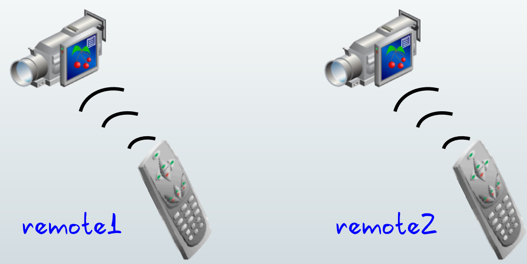
Consider the analogy of using a remote control to operate an electronic device. To operate an electronic device with a remote, you need to:

1. Pick up the remote (and possibly turn it on)
2. Press a button on the remote to do something on the camera

Similarly, to do something with a Java object, you need to:

1. Get its "remote" (called a reference)
2. Press its "buttons" (called methods)

Working with Object References

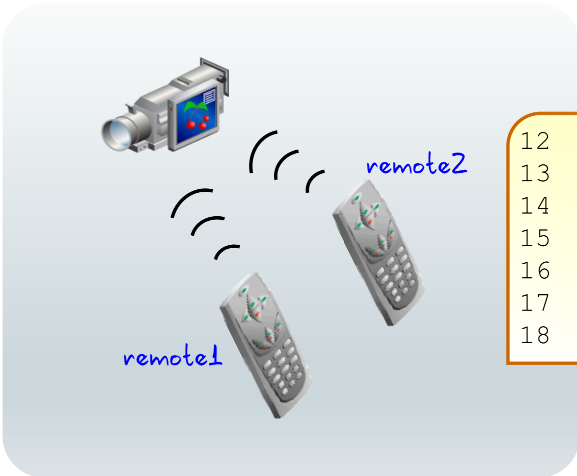



```
Camera remote1 = new Camera();

Camera remote2 = new Camera();

remote1.play();

remote2.play();
```

There are two Camera objects.

There are two camera objects in this example. Each camera has its own unique remote. remote2 will not work on remote1's camera, and remote1 will not work on remote2's camera. This reflects how in Java, two different objects can be instantiated with their own unique references. These references can be used to call methods on their respective objects.

Working with Object References

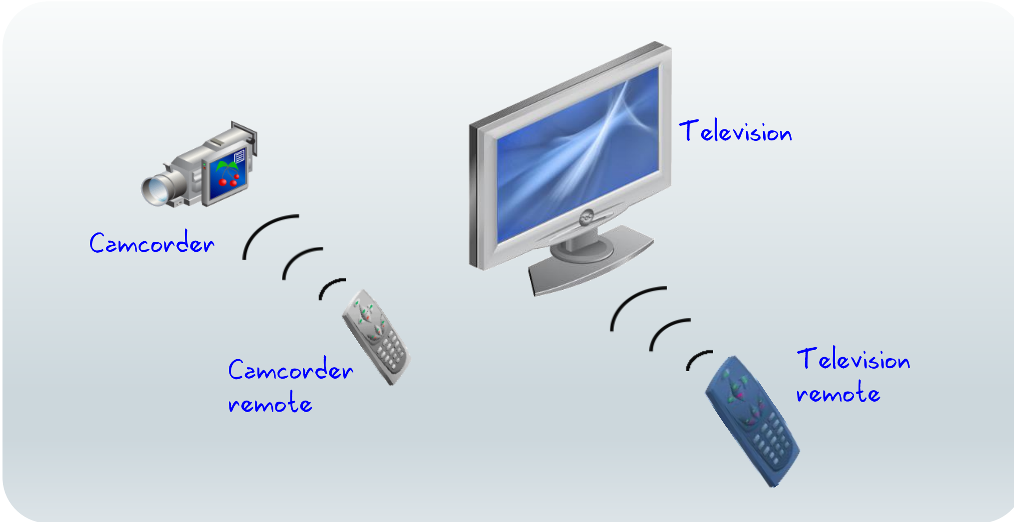


There is only one Camera object.

```
Camera remote1 = new Camera();

Camera remote2 = remote1;

remote1.play();

remote2.stop();
```


The diagram shows another important aspect of how references work. In this example, a `Camera` object is created and its reference assigned to a Camera reference, `remote1`. This reference is then assigned to another Camera reference, `remote2`. Now both references are associated with the same Camera object, and methods called on either reference will affect the same Camera object. Calling `remote1.play` is no different than calling `remote2.play`. Both remotes operate the same camera.

References to Different Objects



To extend the analogy just a little further, to work with a different type of object (for example, a television), you need a remote for that object. In the Java world, you need a reference of the correct type for the object that you are referencing.

You can ignore the fact that there is such a thing as a universal remote controller, although later in the course you will discover that Java also has the concept of references that are not limited to a single object type! For the moment, let's just say that a reference of the same type as the object is one of the reference types that can be used, and is a good place to start exploring the world of Java objects.

References to Different Objects

Reference type

Reference variable

Create a new object.

```
Camera remote1 = new Camera();
remote1.menu();

TV remote2 = new TV();
remote2.menu();

Shirt myShirt = new Shirt();
myShirt.display();

Trousers myTrousers = new Trousers();
myTrousers.display();
```


`remote1` references a `Camera` object.

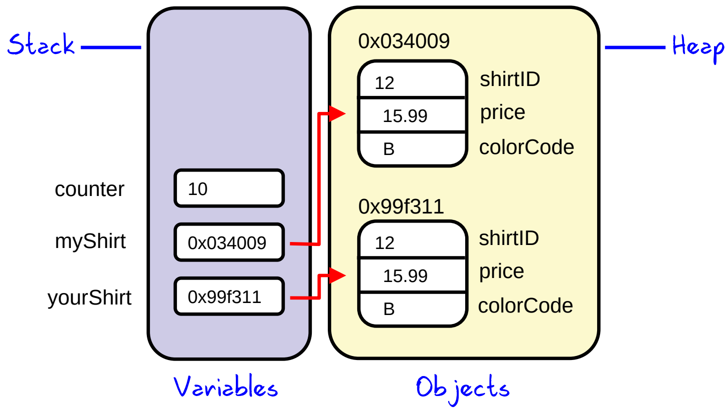
`remote2` references a `TV` object.

`myShirt` references a `Shirt` object.

`myTrousers` references a `Trousers` object.

References and Objects in Memory

```
12 int counter = 10;
13 Shirt myShirt = new Shirt();
14 Shirt yourShirt = new Shirt();
```

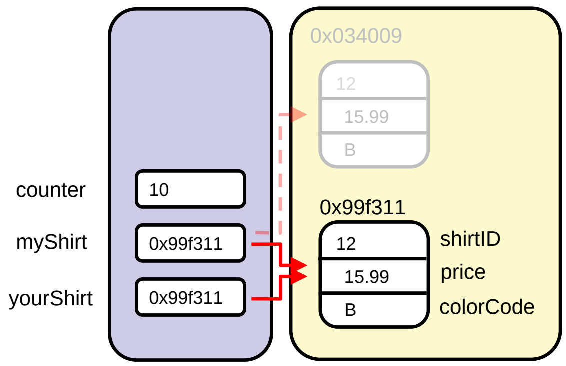


This diagram shows how references point to a particular object in memory. Note that there are two objects in memory, although they are both of type `Shirt`. Also note that there are two `Shirt` references pointing to these two `Shirt` objects.

The diagram also shows two types of memory that Java uses: the stack and the heap. The stack holds local variables, either primitives or reference types, whereas the heap holds objects. Later in this course, you will learn a little more about local variables, but for now it is sufficient to know that local variables are not fields of an object.

Assigning a Reference to Another Reference

```
myShirt = yourShirt;
```



The diagram shows what happens if the `myShirt` reference, after having its own object (in the previous slide), is now assigned the reference `yourShirt`. When this happens, the `myShirt` reference will drop its current object and be reassigned to the same object that `yourShirt` has. As a result, two references, `myShirt` and `yourShirt`, now point to the same object. Any changes to the object made by using one reference can be accessed using the other reference, and vice versa.

Another effect of assigning the reference `yourShirt` to the reference `myShirt` is that if the previous object referred to by `myShirt` has no other references, it will now be inaccessible. In due course, it will be garbage collected, meaning that its memory will become available to store other objects.

Two References, One Object

Code fragment:

```
Shirt myShirt = new Shirt();
Shirt yourShirt = new Shirt();

myShirt = yourShirt;    //The old myShirt object is
                        //no longer referenced
myShirt.colorCode = 'R';
yourShirt.colorCode = 'G';

System.out.println("Shirt color: " + myShirt.colorCode);
```

Output from code fragment:

```
Shirt color: G
```


This example now shows what happens if you use either reference to make a change or get a value from the object. References `yourShirt` and `myShirt` refer to the same object, so making a change or getting a field value by using one reference is exactly the same as doing it with the other reference. The old object that was previously referenced by `myShirt` goes away.

Exercise 6-2: Modifying the `ShoppingCart` to Use `Item` Fields

1. Continue editing **`Exercise_06-1`** or open **`Exercise_06-2`** in NetBeans.
2. Create a new Java Main Class called `ShoppingCart`. This class contains a single main method. The rest of this exercise is spent modifying `ShoppingCart.java`.
3. Declare and instantiate two objects of type Item. Initialize only the descry field in each, using different values for each.
4. Print the description for each item and run the code.
5. (Optional) Above the code that prints the descriptions, assign item2 to item1. Run it again.

In this exercise, you declare and instantiate two variables of type Item in the `ShoppingCart` class and experiment with accessing properties and calling methods on the object.

Topics

- Describing objects and classes
- Defining fields and methods
- Declaring, instantiating, and using objects
- Working with object references
- Doing more with arrays
- Introducing the soccer league use case

Arrays Are Objects

Arrays are handled by an implicit Array *object*.

- The Array variable is an *object reference*, not a primitive data type.
- It must be instantiated, just like other objects.
  - Example:

```
int[] ages = new int[4];
```

This array can hold four elements.

- Previously, you have been using a shortcut to instantiate your arrays.
  - Example:

```
int[] ages = {8,7,4,5};
```


An array is actually an object type and is handled implicitly through a class called `Array` (not available in the Java API documentation). Therefore, like other object types (`String` is an exception) it must be instantiated using the new keyword.

- In the top example, an `int` array called `ages` is declared and instantiated with a capacity to hold four elements.

Declaring, Instantiating, and Initializing Arrays

- Examples:

```
String[] names = {"Mary","Bob","Carlos"};

int[] ages = new int[3];
ages[0] = 19;
ages[1] = 42;
ages[2] = 92;
```

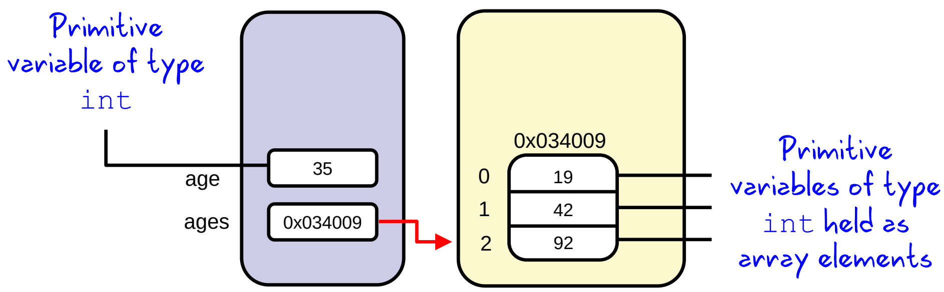
- Not permitted (compiler will show an error):

```
int[] ages;
ages = {19, 42, 92};
```


As introduced in the lesson titled “Managing Multiple Items,” there are two approaches for creating and initializing arrays. Using the ***new*** keyword allows you to declare and instantiate an array of a particular size and initialize it at a later time.

Storing Arrays in Memory

```
int age = 35;
int[] ages = {19, 42, 92};
```



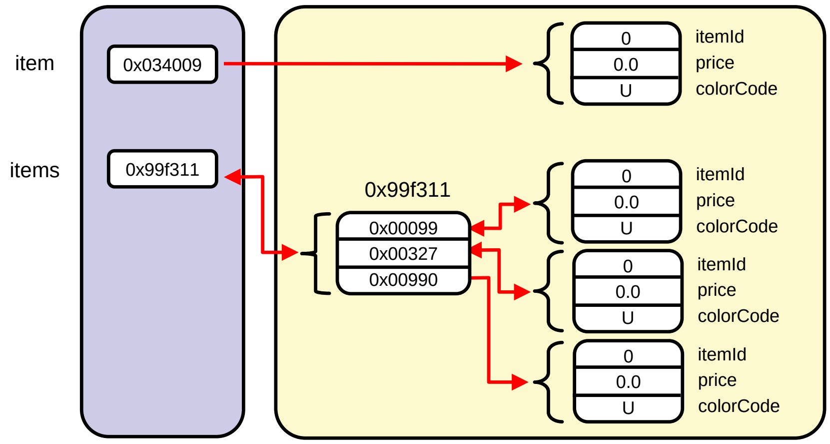
Arrays are objects referred to by an object reference variable. The diagram in the slide illustrates how a primitive array is stored in memory in comparison to how a primitive data type is stored in memory.

The value of the `age` variable (an int primitive) is `35`. The value of `ages` is `0x034009`, an object reference pointing to an object of type `array` (of `int` types) with three elements.

- The value of `ages[0]` is `19`.
- The value of `ages[1]` is `42`.
- The value of `ages[2]` is `92`.

Storing Arrays of Object References in Memory

```
Item item = new Item();
Item[] items = { new Item(), new Item(), new Item() };
```



The diagram in the slide illustrates how an object reference array is stored in memory. The value of the `item` object reference is x034009, which is an address to an object of type Item with the values 0, 0.0, and U.

The value of the `items[ ]` object reference is x99f311, which is an address to an object of type `Array` (of Item object references) containing three object references:

- The value of the `items[0]` index is 0x00099, which is an object reference pointing to an object of type Item.
- The value of the `items[1]` index is 0x00327, which is an object reference pointing to another object of type Item.
- The value of the `items[2]` index is 0x00990, which is an object reference pointing to another object of type Item.

Quiz

The following code is the correct syntax for _____ an array:

```
array_identifier = new type[length];
```

a. Declaring
b. Setting array values for
c. Instantiating
d. Declaring, instantiating, and setting array values for

Answer: c

a is incorrect. Declaring the array would look like this, assuming an array of object types: `Type[] array_identifier;`

b is incorrect. Setting array values would look like this, assuming an array of object types:

```
array_identifier[0]= new Type();
```

c is correct. The code example shows the array being initialized to a specific size.

d is incorrect. Declaring, instantiating, and setting array values would look like this, assuming an array of object types:

```
Type[] array_identifier = {new Type(), new Type(), new Type()};
```

Quiz

Given the following array declaration, which of the following statements are true?

```
int[ ] ages = new int[13];
```

a. `ages[0]` is the reference to the first element in the array.

b. `ages[13]` is the reference to the last element in the array.

c. There are 13 integers in the `ages` array.

d. `ages[5]` has a value of 0.

Answer: a, c, d

Topics

- Describing objects and classes
- Defining fields and methods
- Declaring, instantiating, and using objects
- Working with object references
- Doing more with arrays
- Introducing the soccer league use case

Soccer Application

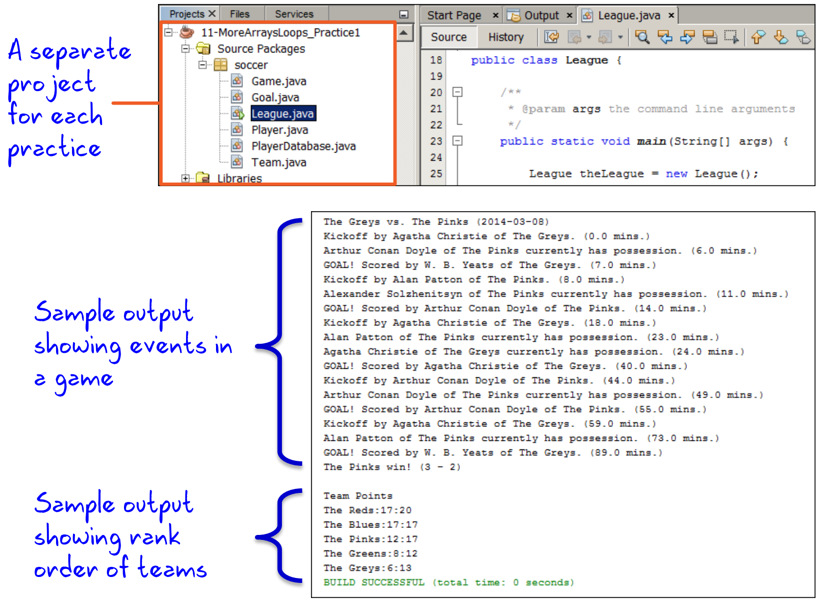
Practices 6 through 14 build a soccer league application with the following features:

- Any number of soccer teams, each with up to 11 players
- Set up an all-play-all league.
- Use a random play game generator to create test games.
- Determine the rank order of teams at the end of the season.

In the remaining practices in this course, you will build an application that manages a Soccer League. The application will keep details on teams and players, as well as the results of games.

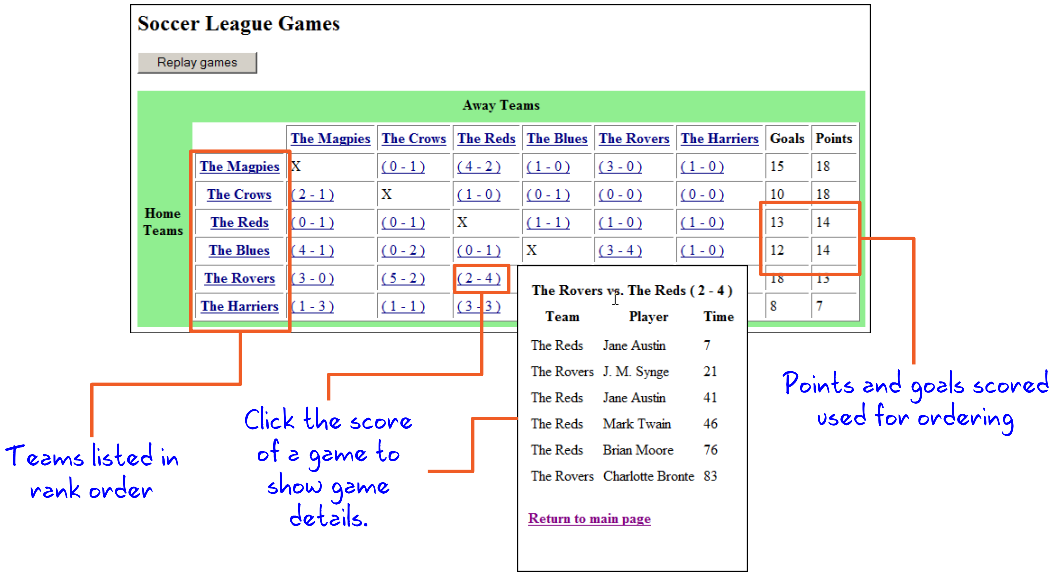
You will also write code that will randomly generate game results so that you can then develop code to list the Teams in rank order.

Creating the Soccer Application



Initially, your application will be developed in NetBeans and you will see the results of running your code as text in the output window.

Soccer Web Application



The code that you write in the practices can be used by a simple web application to view the results of games in the league. You will see a demonstration of this.

Summary

In this lesson, you should have learned how to:

- Describe the characteristics of a class
- Define an object as an instance of a class
- Instantiate an object and access its fields and methods
- Describe how objects are stored in memory
- Instantiate an array of objects
- Describe how an array of objects is stored in memory
- Declare an object as a field

Practices Overview

- 6-1: Creating Classes for the Soccer League
- 6-2: Creating a Soccer Game

7

Manipulating and Formatting the Data in Your Program

ORACLE

Objectives

After completing this lesson, you should be able to:

- Describe the `String` class and use some of the methods of the `String` class
- Use the JDK API documentation to search for and learn how to use a class
- Describe the `StringBuilder` class
- Explain what a constant is and how to use it
- Explain the difference between promoting and casting of variables

Topics

- Using the `String` class
- Using the Java API docs
- Using the `StringBuilder` class
- Doing more with primitive data types
- Using the remaining numeric operators
- Promoting and casting variables

String Class

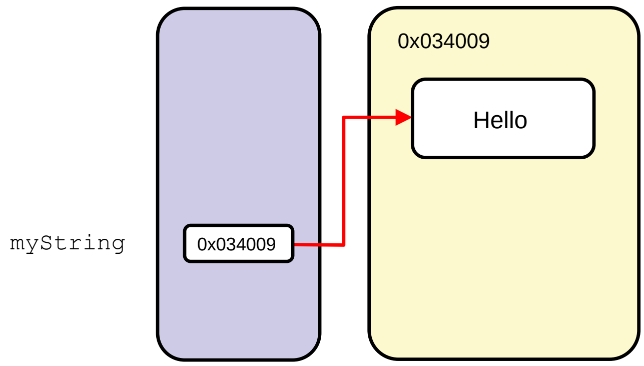
```
String hisName = "Fred Smith";  —— Standard syntax

  The new keyword can be used,
  but it is not best practice:

String herName = new String("Anne Smith");
```

- A `String` object is immutable; its value cannot be changed.
- A String object can be used with the string concatenation operator symbol (+) for concatenation.

- The `String` class is one of the many classes included in the Java class libraries. The `String` class provides you with the ability to store a sequence of characters. You will use the `String` class frequently throughout your programs. Therefore, it is important to understand some of the special characteristics of strings in the Java programming language. Because a `String` object is immutable, its value cannot be changed. (There are technical reasons, beyond the scope of this course, as to why this immutability is useful. One simple example is that this immutability ensures that a `String` can be used by several different classes safely because it cannot be changed.)
- Creating a `String` object using the `new` keyword creates two `String` objects in memory, whereas creating a `String` object by using a string literal creates only one object; therefore, the latter practice is more memory-efficient. To avoid the unnecessary duplication of `String` objects in memory, create `String` objects without using the `new` keyword.

Concatenating Strings

```
String myString = "Hello";
```

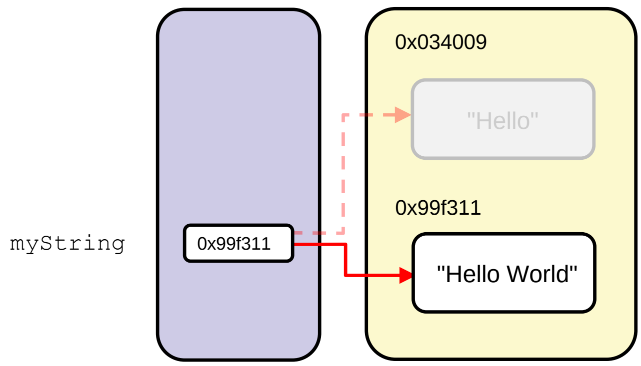


Because `String` is immutable, concatenating two strings requires creating a new string.

The diagram shows a `String` object containing the string “`Hello`”.

Concatenating Strings

```
String myString = "Hello";
myString = myString.concat(" World");
```

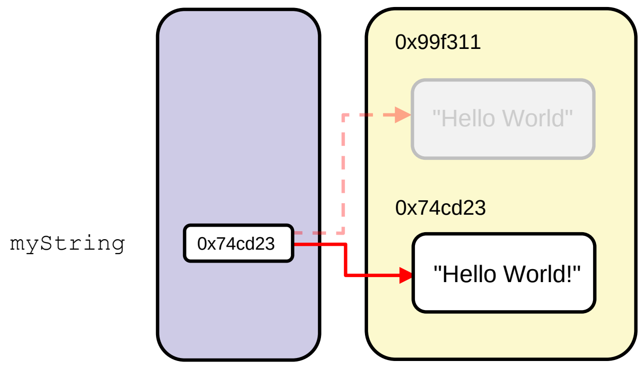


Here is the string “ `World`” being concatenated to the original string. The `concat` method is being used here, but whether you use that or the concatenation operator (`+`), a new `String` object is created and a new `String` reference is returned that points to this new object.

In the diagram, this is shown by the fact that the `String` reference `myString` is no longer 0x034009, and because that object is no longer referred to, it is now inaccessible and will be garbage collected.

Concatenating Strings

```
String myString = "Hello";
myString = myString.concat(" World");
myString = myString + "!"
```



Finally, on concatenating another string, this time using the concatenation operator, the same thing happens again. A new object is created and the reference for this object is assigned to `myString`.

`String` Method Calls with Primitive Return Values

A method call can return a single value of any type.

- An example of a method of primitive type `int`:

```
String hello = "Hello World";
int stringLength = hello.length();
```


Like most classes, the `String` class has a number of useful methods. Almost all of these methods do their useful work by returning a single value (Java allows only a single return from a method). The return type (essentially the type of the method) can be a primitive or a reference to an object.

To be able to use the return value in your code, you will typically use the assignment operator to assign the value (or reference) to a type that you have declared for this purpose.

The example in the slide shows the use of reference `hello` to call the method `length`. Because the object this reference refers to is the string `Hello World`, this method call will return the value `11` and place it in the variable `stringLength`. `int` is the type of the method `length`.

`String` Method Calls with Object Return Values

Method calls returning objects:

```
String greet = " HOW ".trim();
String lc = greet + "DY".toLowerCase();
```

Or

```
String lc = (greet + "DY").toLowerCase();
```


This example shows several method calls that return object references.

First, the `String` object `"  HOW  "` is instantiated and has the method `trim` called on it. Because a string literal returns an object reference, this is exactly the same as calling the method `trim` on the reference. Notice that the string `"  HOW  "` has two spaces on either side of the word. The string returned will be just three characters long because these spaces will be removed. This new string will be referenced by `greet`.

The next example shows a method call not being assigned to a type, but simply used in an expression. The method `toLowerCase` is called on the string `"DY"`, returning `"dy"`. `lc` now references an object containing `"HOWdy"`.

Finally, note how an alternative version with parentheses ensures that the two strings are concatenated (creating a new string) before `toLowerCase` is called. `lc` now references an object containing `"howdy"`.

Topics

- Using the `String` class
- Using the Java API docs
- Using the `StringBuilder` class
- Doing more with primitive data types
- Using the remaining numeric operators
- Promoting and casting variables

Java API Documentation

Consists of a set of webpages;

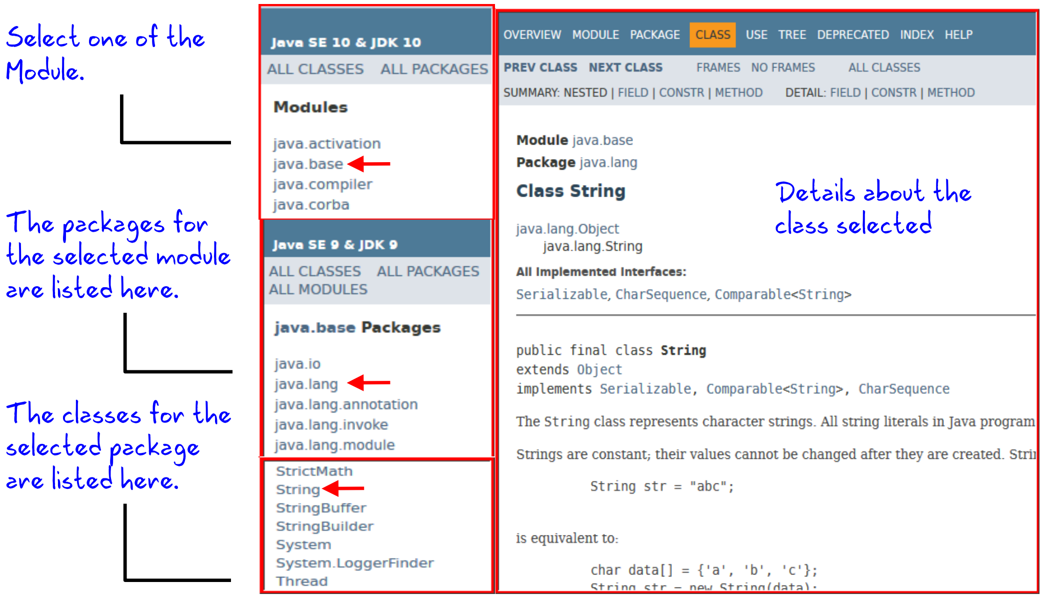
- Lists all the classes in the API
  - Descriptions of what the class does
  - List of constructors, methods, and fields for the class
- Highly hyperlinked to show the interconnections between classes and to facilitate lookup
- Available on the Oracle website at:
  https://docs.oracle.com/javase/10/docs/api/overview-summary.html

All of the Java technology JDKs contain a series of prewritten classes for you to use in your programs. These Java technology class libraries are documented in the Java API documentation for the version of the JDK that you are using. The class library specification is a series of HTML webpages that you can load in your web browser.

A Java class library specification is a very detailed document outlining the classes in the API. Every API includes documentation describing the use of classes and their fields and methods. When you are looking for a way to perform a certain set of tasks, this documentation is the best source for information about the classes in the Java class libraries.

You learn more about constructors in the “Using Encapsulation” lesson.

JDK 10 API Documentation



In the screenshot in the slide, you can see the three main panels of the webpage.

Modules are a new programming construct introduced in JDK 9 and you will learn more about modules in Lesson 16 of this course.

The top-right panel allows you to select a module. The packages of a particular module are listed. You can select a class from a particular package. But if you do not know the package of a particular class, you can select All Classes.

The bottom-left panel gives the list of packages in a module, you can then select a particular package and then all the classes in that are listed.

In this panel, the class `String` has been selected, populating the main panel on the right with the details of the class `String`. The main panel on the right contains a lot of information about the class, so you need to scroll down to access the information you need.

Java Platform SE and JDK Version 10 API Specification

This document is divided into three sections:

- **Java SE:**
  - The Java Platform, Standard Edition (Java SE) APIs define the core Java platform for general-purpose computing.
  - These APIs are in modules whose names start with java.
- **JDK**
  - The Java Development Kit (JDK) APIs are specific to the JDK and will not necessarily be available in all implementations of the Java SE Platform.
  - These APIs are in modules whose names start with jdk.
- **JavaFX:**
  - The JavaFX APIs define a set of user-interface controls, graphics, media, and web packages for developing rich client applications.
  - These APIs are in modules whose names start with javafx.

Java Platform SE 10: Method Summary

```
public int charAt(String str)
```

The return type of the method

The name of the method

The type of the parameter that must be passed into the method

Method Summary

All Methods | Static Methods | Instance Methods | Concrete Methods | Deprecated Methods

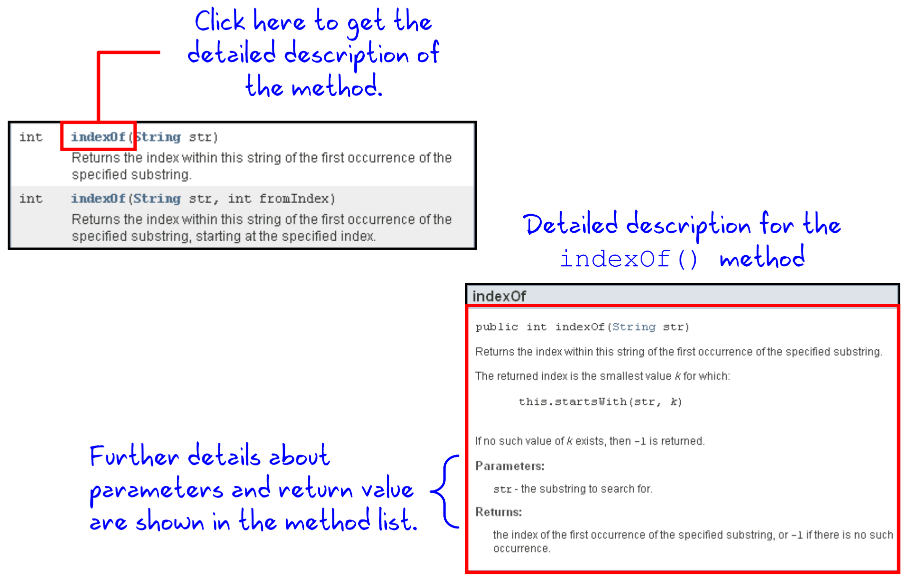
Modifier and Type	Method	Description
char	charAt(int index)	Returns the char value at the specified index.
IntStream	chars()	Returns a stream of int zero-extending the char values from this sequence.
int	codePointAt(int index)	Returns the character (Unicode code point) at the specified index.
int	codePointBefore(int index)	Returns the character (Unicode code point) before the specified index.
int	codePointCount(int beginIndex, int endIndex)	Returns the number of Unicode code points in the specified text range of this String.

Java ORACLE

If you keep scrolling through the details for the `String` class, you will come to the list of methods (only a small subset of this list is shown here).

This master list of methods gives the basic details for the method. In this case, you can see that the name of the method is `charAt`, its type is `char`, and it requires an index (of type `int`) to be passed in. There is also a brief description that this method returns the `char` value at a particular index in the string. For any of the methods, the method name and the parameter types are hyperlinked so that you can get more details.

Java Platform SE 10: Method Detail



For any of the methods, the method name and the parameter types are hyperlinked so that you can get more details. The example here shows the detailed description for one of the `indexOf()` methods of `String`.

`indexOf` Method Example

```
String phoneNum = "404-543-2345";
int idx1 = phoneNum.indexOf('-');
System.out.println("index of first dash: "+ idx1);


int idx2 = phoneNum.indexOf('-', idx1+1);
System.out.println("second dash idx: "+idx2);
```

The 1-arg version

The 2-arg version

This example shows how to get the location of the first '-' character by using the 1-arg version of `indexOf`, and then by using the 2-arg version to get the location of the second '-'.

If you wanted to convert the phone number to an `int`, you could do something like this:

1. Find the dashes by using the `indexOf` method (as shown above).
2. Build a new `String` without dashes by using the `substring` method and concatenation.
3. Convert this `String` to an `int` by using the `parseInt` method of `Integer`.

The `parseInt` method of the `Integer` class is covered in the lesson "Using Encapsulation."

Exercise 7-1: Use `indexOf` and `substring` Methods

In this exercise, you get and display a customer's first name.

1. Open the project **`Exercise_07-1`** in NetBeans.
2. Use the `indexOf` method to get the index for the space character (" ") within `custName`. Assign it to `spaceIdx`.
3. Use the `substring` method and the `spaceIdx` to get the first name portion of `custName`.
   - Assign it to `firstName`.
   - Print `firstName`.

In this exercise, you use `indexOf` and `substring` methods to get just the customer's first name and display it.

Topics

- Using the `String` class
- Using the Java API docs
- Using the `StringBuilder` class
- Doing more with primitive data types
- Using the remaining numeric operators
- Promoting and casting variables

`StringBuilder` Class

`StringBuilder` provides a mutable alternative to `String`. `StringBuilder`:

- Is instantiated using the `new` keyword
- Has many methods for manipulating its value
- Provides better performance because it is mutable
- Can be created with an initial capacity

`String` is still needed because:

- It may be safer to use an immutable object
- A method in the API may require a string
- It has many more methods not available on `StringBuilder`

The `StringBuilder` class is "mutable." This means that it can be changed in place. You will recall that when you modify the value of a `String` variable, a new `String` object is created for the new value. `String` objects are "immutable." A `String` object's value cannot be changed.

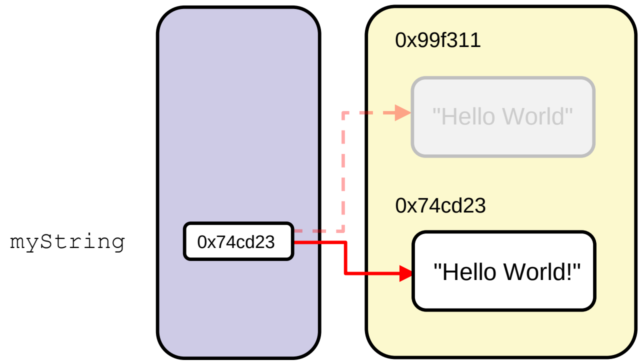
- Unlike `String`, there is no shortcut to instantiate a `StringBuilder`. It is simply instantiated like any other object by using the `new` keyword.
- A small sampling of the `StringBuilder` methods for manipulation of data values are: `append`, `delete`, `insert`, and `replace`.
- `StringBuilder` provides better performance because it does not create new objects in memory whenever a change is made. Performance is also benefited whenever you can set an initial capacity for the object, as opposed to letting it grow and allocate memory dynamically.
- `StringBuilder` is not a complete replacement for `String`, but it is more suitable if many modifications are likely to be made to its value.

`StringBuilder` Advantages over String for Concatenation (or Appending)

String Concatenation

- Costly in terms of creating new objects

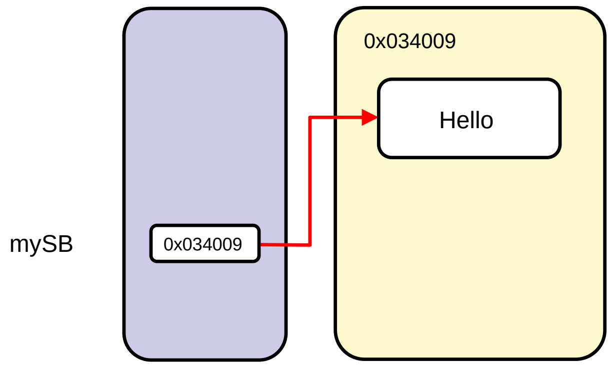
```
String myString = "Hello";
myString = myString + " World";
```



This slide offers a reminder of what happens when the strings `"Hello"` and `" World"` are concatenated. A new `String` object is created, and the reference for that object is assigned to `myString`.

StringBuilder: Declare and Instantiate

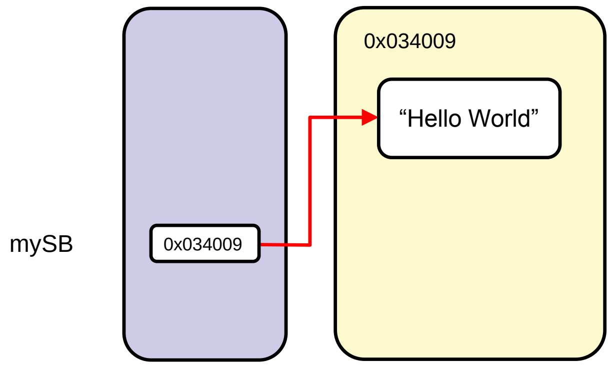
```
StringBuilder mySB = new StringBuilder("Hello");
```



This diagram shows the start of a sequence involving a `StringBuilder`. A new `StringBuilder` is instantiated, populated with the string `"Hello"`, and the reference for this new object is assigned to `mySB`.

StringBuilder Append

```
StringBuilder mySB = new StringBuilder("Hello");
mySB.append(" World");
```



To append the string `" World"`, all you need to do is call the `append` method and pass in "`World`". Note that no assignment (=) is necessary because there is already a reference to the `StringBuilder` object, and this `StringBuilder` object now contains a representation of the combined strings `"Hello World"`.

Even if you did assign the return type of the `append` method (which is `StringBuilder`), there would still be no object creation cost; the `append` method modifies the current object and returns the reference to that object, the one already contained in `mySB`.

Quiz

Which of the following statements are true? (Choose all that apply.)

a. The dot (`.`) operator creates a new object instance.

b. The `String` class provides you with the ability to store a sequence of characters.

c. The Java API specification contains documentation for all of the classes in a Java technology product.

d. `String` objects cannot be modified.

Answer: b, c, d

Exercise 7-2: Instantiate the `StringBuilder` object

1. Open the project **`Exercise_07-2`** or continue editing the previous exercise.
2. Instantiate a `StringBuilder` object (`sb`), initializing it to `firstName`, using the `StringBuilder` constructor.
3. Use the `append` method of the `StringBuilder` to append the last name back onto the first name. You can just use a String literal for the last name. Print the `StringBuilder` object and test your code. It should show the full name.
4. (Optional) Can you append the last name without using a String literal?

In this exercise, you instantiate a `StringBuilder` object, initializing it to `firstName` using the `StringBuilder` constructor.

Topics

- Using the `String` class
- Using the Java API docs
- Using the `StringBuilder` class
- Doing more with primitive data types
- Using the remaining numeric operators
- Promoting and casting variables

Primitive Data Types

- Integral types (`byte`, `short`, `int`, and `long`)
- Floating point types (`float` and `double`)
- Textual type (`char`)
- Logical type (`boolean`)

Many of the values in Java technology programs are stored as primitive data types. The slide lists the eight primitive types built in to the Java programming language. You have already learned about some of these and have been using them in your exercises and practices. Now you will see the remaining primitive types.

Some New Integral Primitive Types

Type	Length	Range
`byte`	8 bits	-2^7 to $2^7 - 1$ (–128 to 127, or 256 possible values)
`short`	16 bits	-2^{15} to $2^{15} - 1$ (–32,768 to 32,767, or 65,535 possible values)
`int`	32 bits	-2^{31} to $2^{31} - 1$ (–2,147,483,648 to 2,147,483,647, or 4,294,967,296 possible values)
`long`	64 bits	-2^{63} to $2^{63} - 1$ (–9,223,372,036854,775,808 to 9,223,372,036854,775,807, or 18,446,744,073,709,551,616 possible values)

There are four integral primitive types in the Java programming language. You have already been using the `int` data type, so the focus here is on the other three. Integral types are used to store numbers that do not have decimal portions. They are shown here in order of size.

- **`byte`:** If you need to store people's ages, a variable of type `byte` would work because `byte` types can accept values in that range.
- **`short`:** A `short` will hold 16 bits of data.
- **`long`:** When you specify a literal value for a `long` type, put a capital `L` to the right of the value to explicitly state that it is a `long` type. Integer literals are assumed by the compiler to be of type `int` unless you specify otherwise by using an `L` indicating `long` type.
- You can express any of the integral types as `binary` (0s and 1s). For instance, a `binary` expression of the number 2 is shown as an allowed value of the `byte` integral type. The binary value is `0b10`. Notice that this value starts with `0b` (that is, zero followed by either a lowercase or uppercase letter *B*). This indicates to the compiler that a `binary` value follows.

Examples of allowed literal values:

- `byte` = 2, -114, 0b10 (binary number)
- `short` = 2, -32699
- `int` (default type for integral literals) = 2, 147334778, 123_456_678
- `long` = 2, –2036854775808L, 1

Note: The only reason to use the `byte` and `short` types in programs is to save memory consumption. Because most modern desktop computers contain an abundance of memory, most desktop application programmers do not use `byte` and `short` types. This course uses primarily `int` and `long` types in the examples.

Floating Point Primitive Types

Type	Float Length
`float`	32 bits
`double` (default type for floating point literals)	64 bits

Example:

```
public float pi = 3.141592F;
```


There are two types for floating point numbers: `float` and `double`. Again, the focus is on the new data type here, the `float`. Floating point types are used to store numbers with values to the right of the decimal point, such as 12.24 or 3.14159.

- `float` is used to store smaller floating point numbers. A float variable can hold 32 bits.
- Floating point values are assumed to be of type `double` unless you specify by putting a capital `F` (`float`) to the right of the value to explicitly state that it is a `float` type, not a `double` type.

Examples of allowed literal values:

`float = 99F, -327456,99.01F, 4.2E6F` (engineering notation for $4.2 * 10^6$)

`double = -1111, 2.1E12, 99970132745699.999`

Note: Use the `double` type when a greater range or higher accuracy is needed.

Textual Primitive Type

- The only primitive textual data type is `char`.
- It is used for a single character (16 bits).
- Example:
  - `public char colorCode = 'U';`

Single quotes must be used with char literal values.

Another data type that you use for storing and manipulating data is single-character information. The primitive type used for storing a single character (such as a 'y') is char, which is 16 bits in size. The Shirt class shows the use of one textual literal value to specify the default value for a colorCode:

```
public char colorCode = 'U';
```

When you assign a literal value to a char variable, you must use single quotation marks around the character as shown in the code example above.

Java Language Trivia: Unicode

- Unicode is a standard character encoding system.
  - It uses a 16-bit character set.
  - It can store all the necessary characters from most languages.
  - Programs can be written so they display the correct language for most countries.

Character	UTF-16	UTF-8	UCS-2
A	0041	41	0041
c	0063	63	0063
Ö	00F6	C3 B6	00F6
亜	4E9C	E4 BA 9C	4E9C
𝄞	D834 DD1E	F0 9D 84 9E	N/A

Did You Know? Many older computer languages use American Standard Code for Information Interchange (ASCII), an 8-bit character set that has an entry for every English character, punctuation mark, number, and so on.

The Java programming language uses a 16-bit character set called Unicode that can store all the necessary displayable characters from the vast majority of languages used in the modern world. Therefore, your programs can be written so that they work correctly and display the correct language for most countries. Unicode contains a subset of ASCII (the first 128 characters).

Constants

- Variable (can change):
  - `double salesTax = 6.25;`
- Constant (cannot change):
  - `final int NUMBER_OF_MONTHS = 12;`

The `final` keyword causes a variable to be read only.

In this lesson, you have learned about variables that have values that you can change. In this section, you learn how to use constants to represent values that cannot change.

Assume that you are writing part of a scheduling application, and you need to refer to the number of months in a year. Make the variable a constant by using the `final` keyword to inform the compiler that you do not want the value of the variable to be changed after it has been initialized. Example:

```
final int NUMBER_OF_MONTHS = 12;
```

Any values that do not need to change are good candidates for a constant variable (for example, `MAX_COUNT`, or `PI`).

If someone attempts to change the value of a constant after it has already been assigned a value, the compiler gives an error message. If you modify your code to provide a different value for the constant, you need to recompile your program.

Guidelines for Naming Constants

You should name constants so that they can be easily identified. Generally, constants should be capitalized, with words separated by an underscore (_).

Quiz

The variable declaration `public int myInteger=10;` adheres to the variable declaration and initialization syntax.

a. True

b. False

Answer: a

Topics

- Using the `String` class
- Using the Java API docs
- Using the `StringBuilder` class
- Doing more with primitive data types
- Using the remaining numeric operators
- Promoting and casting variables

Modulus Operator

Purpose	Operator	Example	Comments

Remainder	`%`
	modulus
		`num1` = 31;
		`num2` = 6;
		
		`mod = num1 % num2;`
		
		`mod is 1`
			Remainder finds the remainder of the first number divided by the second number.
			5 R 1
			6 | 31
			30
			----- 	
			1
			Remainder always gives an answer with the same sign as the first operand.

Programs do a lot of mathematical calculating, from the simple to the complex. Arithmetic operators let you specify how the numerical values within variables should be evaluated or combined. The standard mathematical operators (often called *binary operators*) used in the Java programming language are shown in the tables in this section.

Note: The `%` is known as the modulus operator.

Combining Operators to Make Assignments

Purpose	Operator	Examples `int a = 6, b = 2;`	Result
Add to and assign	+=	a += b	a = 8
Subtract from and assign	-=	a -= b	a = 4
Multiply by and assign	*=	a *= b	a = 12
Divide by and assign	/=	a /= b	a = 3
Get remainder and assign	%=	a %= b	a = 0

Several very useful shortcuts are shown in the table above. You can combine any operator with the equal sign to abbreviate your code. For example:

```
a = a + b;
```

can be expressed as:

```
a += b;
```

More on Increment and Decrement Operators

Operator	Purpose	Example

`++`	Preincrement (`++variable`)	`int id = 6;`
		`int newId = ++id;`
		`id is 7, newId is 7`

	Postincrement (`variable++`)	`int id = 6;`
		`int newId = id++;`
		`id is 7, newId is 6`

`--`	Predecrement (`--variable`)	*(same principle applies)*
	Postdecrement (`variable--`)	

You have used increment and decrement operators before, placing them *after* the variable that you wish to affect. But did you know that these operators can come before (preincrement and predecrement) or after (postincrement and postdecrement) a variable.

When you put the `++` or `--` operator before a variable, the value is changed immediately. When you put the operator after the variable, it is not changed until after that expression is evaluated.

- In the first code example above, `id` is initialized to 6. In the next line, you see `newId = ++id`. Because the operator precedes `id`, this increment is immediately evaluated and, therefore, the value assigned to `newId` is 7.
- In the second code example, the `++` operator follows `id`, rather than precedes it. `id` was incremented after the assignment occurred. Therefore, `newId` is 6.
- These same behaviors apply to a decrement (`--`) operator, in regard to its placement before or after the variable.

Increment and Decrement Operators (++ and −−)

Examples:

```
int count=15;
int a, b, c, d;
a = count++;
b = count;
c = ++count;
d = count;
System.out.println(a + ", " + b + ", " + c + ", " + d);
```

Output:

```
15, 16, 17, 17
```


The example in the slide shows basic use of the increment and decrement operators:

```
int count=15;
int a, b, c, d;
a = count++;
b = count;
c = ++count;
d = count;
System.out.println(a + ", " + b + ", " + c + ", " + d);
```

The result of this code fragment is:

```
15, 16, 17, 17
```

Discussion: What is the result of the following code?

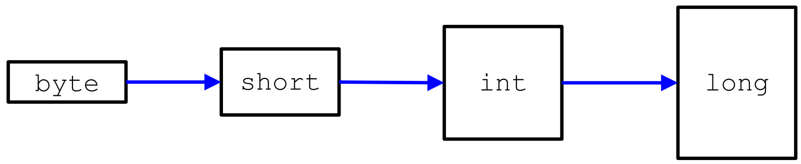
```
int i = 16;
System.out.println(++i + " " + i++ + " " + i);
```

Topics

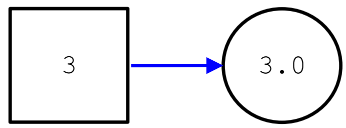
- Using the `String` class
- Using the Java API docs
- Using the `StringBuilder` class
- Doing more with primitive data types
- Using the remaining numeric operators
- Promoting and casting variables

Promotion

- Automatic promotions:
  - If you assign a smaller type to a larger type



  - If you assign an integral type to a floating point type



- Examples of automatic promotions:
  - `long intToLong = 6;`
  - `double intToDouble = 3;`

In some circumstances, the compiler changes the type of a variable to a type that supports a larger size value. This action is referred to as a *promotion*. Some promotions are done automatically by the compiler. These promotions include:

- If you assign a smaller type (on the right of the =) to a larger type (on the left of the =)
- If you assign an integral type to a floating point type (However, in some cases, such as an assignment of long to float, this could lead to loss of data.)

Caution with Promotion

Equation:

$$55555 * 66666 = 3703629630$$

Example of potential issue:

```
int num1 = 55555;
int num2 = 66666;
long num3;
num3 = num1 * num2;          //num3 is -591337666
```

Example of potential solution:

```
int num1 = 55555;
long num2 = 66666;
long num3;
num3 = num1 * num2;          //num3 is 3703629630
```

Changed from int to long

Before being assigned to a variable, the result of an equation is placed in a temporary location in memory. The location's size is always equal to the size of an `int` type or the size of the largest data type used in the expression or statement. For example, if your equation multiplies two `int` types, the container size will be an `int` type in size, or 32 bits.

If the two values that you multiply yield a value that is beyond the scope of an `int` type, (such as 55555 * 66666 = 3,703,629,630, which is too big to fit in an `int` type), the `int` value must be truncated to fit the result into the temporary location in memory. This calculation ultimately yields an incorrect answer because the variable for your answer receives a truncated value (regardless of the type used for your answer). To solve this problem, set at least one of the variables in your equation to the `long` type to ensure the largest possible temporary container size.

Caution with Promotion

Equation:

7 / 2 = 3.5

Example of potential issue:

```
int num1 = 7;
int num2 = 2;
double num3;
num3 = num1 / num2;          //num3 is 3.0
```

Example of potential solution:

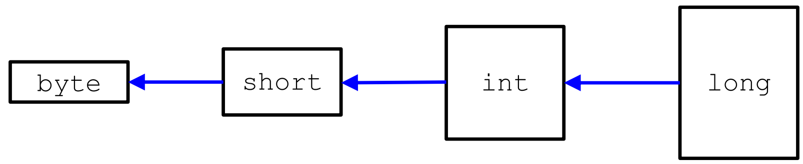
```
int num1 = 7;
double num2 = 2;   ——— Changed from int to double
double num3;
num3 = num1 / num2;          //num3 is 3.5
```


The same issue occurs with other data types. Before being assigned to a variable, the result of an equation is placed in a temporary location in memory. The location's size is always equal to the size of the largest data type used in the expression or statement. For example, if your equation divides two `int` types, the container size will be an `int` type in size, or 32 bits.

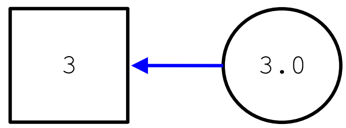
If the two values that you use yield a value that is beyond the scope of an `int` type, (such as 7 / 2 = 3.5), the value must be truncated to fit the result into the temporary location in memory. This calculation ultimately yields an incorrect answer because the variable for your answer receives a truncated value (regardless of the type used for your answer). To solve this problem, set at least one of the variables in your equation to the `double` type to ensure the largest possible temporary container size.

Type Casting

- When to cast:
  – If you assign a larger type to a smaller type



  – If you assign a floating point type to an integral type



- Examples of casting:
  – `int longToInt = (int)20L;`
  – `short doubleToShort = (short)3.0;`

Type casting lowers the range of a value, chopping it down to use a smaller amount of memory, by changing the type of the value (for example, by converting a `long` value to an `int` value). You do this so that you can use methods that accept only certain types as arguments, so that you can assign values to a variable of a smaller data type, or so that you can save memory.

The syntax for type casting a value is: **identifier = (target_type) value,** where:

- `identifier` is the name you assign to the variable
- `value` is the value you want to assign to the identifier
- `(target_type)` is the type to which you want to type cast the value. Notice that the `target_type` must be in parentheses.

Caution with Type Casting

Example of potential issue:

```
int myInt;
long myLong = 123987654321L;
myInt = (int) (myLong); // Number is "chopped"
                        // myInt is -566397263
```

Safer example of casting:

```
int myInt;
long myLong = 99L;
myInt = (int) (myLong); // No data loss, only zeroes.
                        // myInt is 99
```


The loss of precision with casting can sometimes lead to situations where numbers are truncated, leading to errors in calculations.

Caution with Type Casting

- Be aware of the possibility of lost precision.

Example of potential issue:

```
int myInt;
double myPercent = 51.9;
myInt = (int) (myPercent);  // Number is "chopped"
                            // myInt is 51
```


If you type cast a `float` or `double` value with a fractional part to an integral type such as an `int`, all decimal values are lost. However, this method of type casting is sometimes useful if you want to truncate the number down to the whole number (for example, 51.9 becomes 51).

Using Promotion and Casting

Example of potential issue:

```
int num1 = 53; // 32 bits of memory to hold the value
int num2 = 47; // 32 bits of memory to hold the value
byte num3;      // 8 bits of memory reserved
num3 = (num1 + num2); // causes compiler error
```

Solution using a larger type for num3:

```
int num1 = 53;
int num2 = 47;
int num3;
num3 = (num1 + num2);
```

Changed from byte to int

Solution using casting:

```
int num1 = 53; // 32 bits of memory to hold the value
int num2 = 47; // 32 bits of memory to hold the value
byte num3;      // 8 bits of memory reserved
num3 = (byte)(num1 + num2); // no data loss
```


Assigning a variable or an expression to another variable can lead to a mismatch between the data types of the calculation and the storage location that you are using to save the result. Specifically, the compiler will either recognize that precision will be lost and not allow you to compile the program, or the result will be incorrect. To fix this problem, variable types have to be either promoted to a larger size type, or type cast to a smaller size type. In the above example, the compiler assumes that because you are adding `int` values, the result will overflow the space allocated for a `byte`.

A `byte`, though smaller than an `int`, is large enough to store a value of `100`. However, the compiler will not make this assignment and, instead, issues a “possible loss of precision” error because a `byte` value is smaller than an `int` value. To fix this problem, you can either type cast the right-side data type down to match the left-side data type, or declare the variable on the left side (`num3`) to be a larger data type, such as an `int`.

Compiler Assumptions for Integral and Floating Point Data Types

- Most operations result in an `int` or `long`:
  - `byte`, `char`, and `short` values are automatically promoted to `int` prior to an operation.
  - If an expression contains a `long`, the entire expression is promoted to `long`.
- If an expression contains a floating point, the entire expression is promoted to a floating point.
- All literal floating point values are viewed as `double`.

The Java technology compiler makes certain assumptions when it evaluates expressions. You must understand these assumptions to make the appropriate type casts or other accommodations. The next few slides give examples.

Automatic Promotion

Example of potential problem:

```
short a, b, c;
a = 1 ;
b = 2 ;
c = a + b ; //compiler error
```

a and b are automatically promoted to integers.

Example of potential solutions:

- Declare `c` as an `int` type in the original declaration:

  `int c;`

- Type cast the `(a+b)` result in the assignment line:

  `c = (short)(a+b);`

In the following example, an error occurs because two of the three operands (`a` and `b`) are automatically promoted from a `short` type to an `int` type before they are added. In the last line, the values of `a` and `b` are converted to `int` types and the converted values are added to give an `int` result. Then the assignment operator (`=`) attempts to assign the `int` result to the `short` variable (`c`). However, this assignment is illegal and causes a compiler error.

The code works if you do either of the following:

- Declare `c` as an `int` in the original declaration:

  `int c;`

- Type cast the (`a+b`) result in the assignment line:

  `c = (short)(a+b);`

Using a long

```
public class Person {

  public int ageYears = 32;

  public void calculateAge() {

    int ageDays = ageYears * 365;
    long ageSeconds = ageYears * 365 * 24L * 60 * 60;

    System.out.println("You are " + ageDays + " days old.");
    System.out.println("You are " + ageSeconds + " seconds old.");

  } // end of calculateAge method
} // end of class
```

Using the L to indicate a long will result in the compiler recognizing the total result as a long.

The code example uses principles from this section to calculate a person's age in days and seconds. Because the `ageSeconds` variable is declared as a `long`, one of the literal values used as operands in the assigned expression must be initialized as a `long` value ('L') so that the compiler will allow the assignment.

Using Floating Points

Example of potential problem:

Expressions are automatically promoted to floating points.

```
int num1 = 1 + 2 + 3 + 4.0;                    //compiler error
int num2 = (1 + 2 + 3 + 4) * 1.0;              //compiler error
```

Example of potential solutions:

- Declare num1 and num2 as double types:

```
double num1 = 1 + 2 + 3 + 4.0;                 //10.0
double num2 = (1 + 2 + 3 + 4) * 1.0;           //10.0
```

- Type cast num1 and num2 as int types in the assignment line:

```
int num1 = (int)(1 + 2 + 3 + 4.0);             //10
int num2 = (int)((1 + 2 + 3 + 4) * 1.0);       //10
```


If an expression contains a floating point, the entire expression is promoted to a floating point.

Floating Point Data Types and Assignment

- Example of potential problem:

```
float float1 = 27.9;   //compiler error
```

- Example of potential solutions:
  - The `F` notifies the compiler that 27.9 is a `float` value:

```
float float1 = 27.9F;
```

  - `27.9` is cast to a `float` type:

```
float float1 = (float) 27.9;
```


Just as integral types default to `int` under some circumstances, values assigned to floating point types always default to a `double` type, unless you specifically state that the value is a `float` type.

For example, the following line causes a compiler error. Because `27.9` is assumed to be a `double` type, a compiler error occurs because a `double` type value cannot fit into a `float` variable.

```
float float1 = 27.9;   //compiler error
```

Both of the following work correctly:

- The `F` notifies the compiler that `27.9` is a `float` value:

```
float float1 = 27.9F;
```

- `27.9` is cast to a `float` type:

```
float float1 = (float) 27.9;
```

Quiz

Which statements are true?

a. There are eight primitive types built in to the Java programming language.

b. `byte`, `short`, `char`, and `long` are the four integral primitive data types in the Java programming language.

c. A `boolean` type variable holds `true`, `false`, and `nil`.

d. `short Long = 10;` is a valid statement that adheres to the variable declaration and initialization syntax.

Answer: a, d

- a is correct.
- b is incorrect. It should be `byte`, `short`, `int`, and `long`.
- c is incorrect because a `boolean` type variable holds only `true` and `false`.
- d is correct. `long` is a reserved keyword but `Long` is not.

Exercise 7-3: Declare a `Long`, `Float`, and `Char`

1. Open the project **`Practice_07-3`** in NetBeans.
2. Declare a `long`, using the `L` to indicate a long value. Make it a very large number (in the billions).
3. Declare and initialize a `float` and a `char`
4. Print the `long` variable with a suitable label.
5. Assign the `long` to the `int` variable. Correct the syntax error by casting the `long` as an `int`.
6. Print the `int` variable. Note the change in value when you run it.

In this exercise, you experiment with the data types introduced in this lesson. You:

Declare and initialize variables

Cast one numeric type to another

Summary

In this lesson, you should have learned how to:

- Describe the `String` class and use some of the methods of the `String` class
- Use the JDK API documentation to search for and learn how to use a class
- Use the `StringBuilder` class to manipulate string data
- Create a constant by using the final keyword in the variable declaration
- Describe how the Java compiler can use promotion or casting to interpret expressions and avoid a compiler error

Practices Overview

- 7-1: Manipulating Text

8

Creating and Using Methods

Objectives

After completing this lesson, you should be able to:

- Add an argument to a method
- Instantiate a class and call a method
- Overload a method
- Work with static methods and variables
- Convert data values using `Integer`, `Double`, and `Boolean` object types

Topics

- Using methods and constructors
- Method arguments and return values
- Using static methods and variables
- Understanding how arguments are passed to a method
- Overloading a method

Basic Form of a Method

The void keyword indicates that the method does not return a value.

Empty parentheses indicate that no arguments are passed to the method.

```
public void display ()  {
      System.out.println("Shirt description:" + description);
      System.out.println("Color Code: " + colorCode);
      System.out.println("Shirt price: " + price);
} // end of display method
```


This is an example of a simple method that does not receive any arguments or return a value.

Calling a Method from a Different Class

```
public class ShoppingCart {
    public static void main (String[] args) {
        Shirt myShirt = new Shirt();
        myShirt.display();
    }
}
```

Method

Dot operator

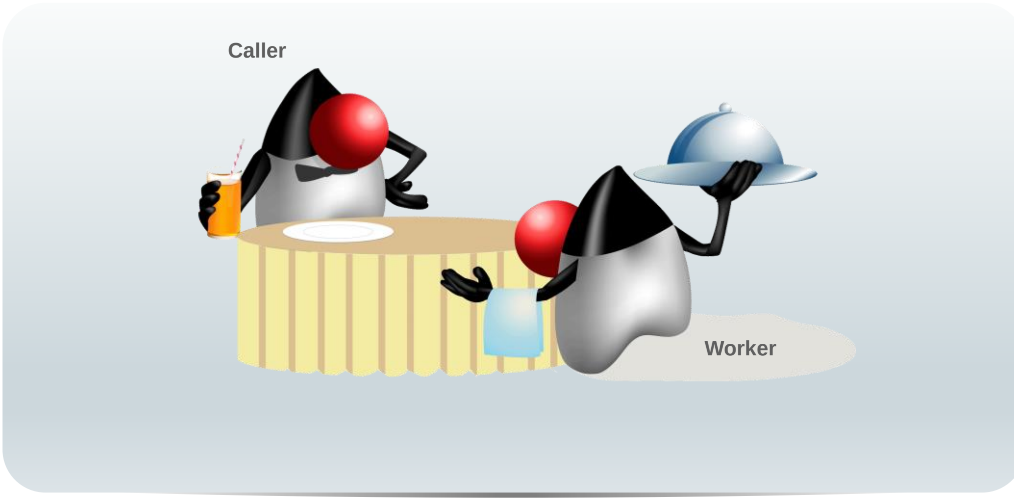
Reference variable

Output:

```
Item description:-description required-
Color Code: U
Item price: 0.0
```


In the example in this slide, `display` is called by typing the reference variable for the object, the dot operator, followed by the method to be called. The default values, as set in the `Shirt` constructor, are displayed.

Caller and Worker Methods



In the previous example, the `ShoppingCart` class calls the `display` method on a `Shirt` object from within the `main` method. The `main` method is referred to as the *calling method* because it is invoking or "calling" another method to do some work. Conversely, the `display` method is referred to as the *worker method* because it does some work for the `main` method.

When a calling method calls a worker method, the calling method stops execution until the worker method is done. After the worker method has completed, program flow returns to the point after the method invocation in the calling method.

A Constructor Method

A constructor method is a special method that is invoked when you create an object instance.

- It is called by using the `new` keyword.
- Its purpose is to instantiate an object of the class and store the reference in the reference variable.

```
Shirt myShirt = new Shirt();
```

Constructor method is called.

- It has a unique method signature.

  <modifier> ClassName()

A constructor is invoked using the `new` keyword. Its job is to instantiate an object of the class and to provide a reference to the new object. If you do not write your own constructor in a class, Java will provide one for you. The constructor's name is the same as the class name.

In the `Shirt` example above, the reference returned by the `Shirt` constructor is assigned to the `myShirt` reference variable.

Writing and Calling a Constructor

```
public static void main(String[] args){
  Shirt myShirt = new Shirt();
}
```

```
public class Shirt {
  //Fields
  public String description;
  public char colorCode;
  public double price;

  //Constructor
  public Shirt(){
      description = "--description required--";
      colorCode = 'U'
      price = 0.00;
  }

  //Methods
  public void display(){
     System.out.println("Shirt description:" + description);
     System.out.println("Color Code: " + colorCode);
     System.out.println("Shirt price: " + price);
  }…
```


The constructor is the first method called when an object is instantiated. Its purpose is primarily to set default values.

Calling a Method in the Same Class

```
public class Shirt {
  public String description;
  public char colorCode;
  public double price;

  public Shirt(){
     description = "--description required--";
     colorCode = 'U'
     price = 0.00;

     display();          //Called normally
     this.display();     //Called using the 'this' keyword
  }

  public void display(){
    System.out.println("Shirt description:" + description);
    System.out.println("Color Code: " + colorCode);
    System.out.println("Shirt price: " + price);
  }
…
```


Calling a method in the same class is very straightforward. You can simply use the method name without a reference. This is the same as when accessing a field; you can simply use the field name.

However, if you have local variables with similar names and you want to make it obvious that your code is accessing a field or method of the current object, you can use the `this` keyword with dot notation. `this` is a reference to the current object.

In this example, the display method is called twice from the constructor.

Topics

- Using constructors and methods
- Method arguments and return values
- Using static methods and variables
- Understanding how arguments are passed to a method
- Overloading a method

Method Arguments and Parameters

- An **argument** is a value that is passed during a method call:

```
Calculator calc = new Calculator();
double denominator = 2.0
                                Arguments
calc.calculate(3, denominator);        //should print 1.5
```

- A **parameter** is a variable defined in the method declaration:

```
                        3         2.0
public void calculate(int x, double y){
    System.out.println(x/y);   Parameters
}
```


Note: A value passed into the method when it is called is called an *argument*, whereas a variable that is defined in the method declaration is called a *method parameter*.

In this example, 3 and 2.0 are passed to be the values of x and y within the `calculate` method.

Method Parameter Examples

- Methods may have any number or type of parameters:

```
public void calculate0(){
    System.out.println("No parameters");
}
```

```
public void calculate1(int x){
    System.out.println(x/2.0);
}
```

```
public void calculate2(int x, double y){
    System.out.println(x/y);
}
```

```
public void calculate3(int x, double y, int z){
    System.out.println(x/y +z);
}
```


Methods can take any number of parameters and use these values within the method code block.

Method Return Types

- Variables can have values of many different types:

  `int` `double` `long` `char` `byte` `short` `String` `boolean` `int[]` `float` `Shirt`

- Method calls can also return values of many different types:

  `int` `double` `long` `char` `byte` `short` `String` `boolean` `int[]` `float` `Shirt`

- How to make a method return a value:
  - Declare the method to be a non-void return type.
  - Use the keyword `return` within a method, followed by a value.

Variables may have values of many different types, including primitive data types, objects, and arrays.

Likewise, methods may return values of many different types, including primitive data types, objects, and arrays.

Note: Constructors are special. They cannot have a return type, not even void.

Method Return Types Examples

- Methods must `return` data that matches their return type:

```
public void printString(){
    System.out.println("Hello");
}
```

Void methods cannot return values in Java.

```
public String returnString(){
    return("Hello");
}
```

```
public int sum(int x, int y){
    return(x + y);
}
```

```
public boolean isGreater(int x, int y){
    return(x > y);
}
```


Void methods and constructors should not have a `return` statement. Void methods are incapable of returning a value in Java. The type of value a method returns must match the return type you declare. For instance, a `boolean` type method must return a `boolean`. A `String` type method must return a `String`.

Method Return Animation

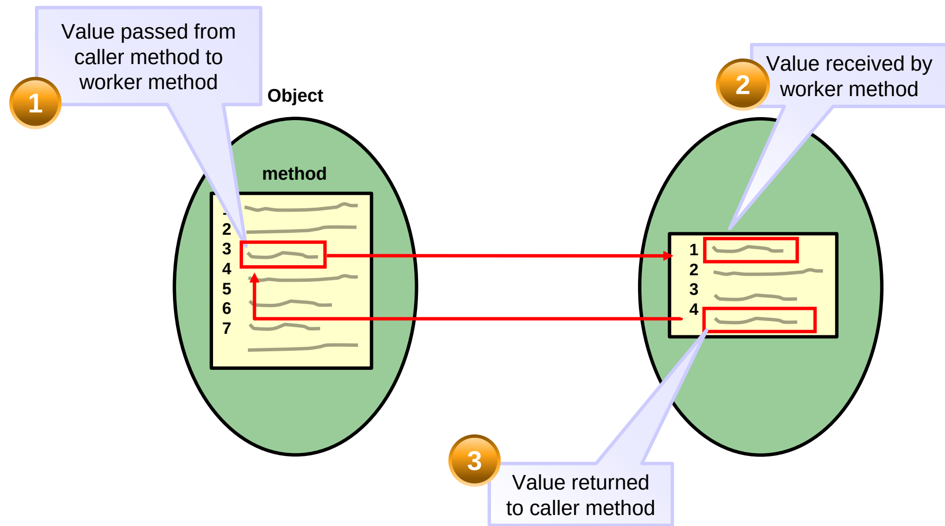
- The following code examples produce equivalent results:

```
public static void main(String[] args){
    int num1 = 1, num2 = 2;
    int result = num1 + num2;
    System.out.println(result);
}
```

```
public static void main(String[] args){
    int num1 = 1, num2 = 2;
    int result = sum(num1, num2);
    System.out.println(result);
}
public int sum(int x, int y){
    return(x + y);
}
```


In the top example, `num1` and `num2` are added together. In the bottom example, this logic is put into the `sum` method. Values are passed to the `sum` method and added, with the resulting integer value being passed back and assigned to the `result` variable.

Passing Arguments and Returning Values



More Examples

```
1 public void setCustomerServices() {
2     String message ="Would you like to hear about "
3           +"special deals in your area?";
4     if (cust.isNewCustomer()) {
5
6         cust.sendEmail(message);
7     }
8 }
```

```
public class Customer{
    public boolean isNew;

    public boolean isNewCustomer(){
        return isNew;
    }
    public void sendEmail(String message){
        // send email
    }
}
```

Return a boolean

String argument required

Here you see a caller method, `setCustomerServices`, invoking worker methods in the `Customer` class.

- The example at the bottom of the slide shows the `Customer` class, which defines two methods:
  - `isNewCustomer` is defined with a return value of type `boolean`, but it does not define any input parameters.
  - `sendEmail` is defined with an input parameter of type `String`, called message. This method does not return a value.
- The example at top of the slide shows the `setCustomerServices` method in the `ShoppingCart` class invoking the methods of a Customer object by using dot notation (`object_reference.method`).
  - In line 4, `isNewCustomer` is called on the `cust` object reference. Because the method returns a `boolean`, the method invocation becomes a `boolean` expression evaluated by the `if` statement.
  - In line 6, `sendEmail` is called on the `cust` object reference, passing the message string as an argument.

Code Without Methods

```
public static void main(String[] args){
  Shirt shirt01 = new Shirt();
  Shirt shirt02 = new Shirt();
  Shirt shirt03 = new Shirt();
  Shirt shirt04 = new Shirt();

  shirt01.description = "Sailor";
  shirt01.colorCode = 'B';
  shirt01.price = 30;

  shirt02.description = "Sweatshirt";
  shirt02.colorCode = 'G';
  shirt02.price = 25;

  shirt03.description = "Skull Tee";
  shirt03.colorCode = 'B';
  shirt03.price = 15;

  shirt04.description = "Tropical";
  shirt04.colorCode = 'R';
  shirt04.price = 20;
}
```


Why are methods useful? To answer that question, take a look at this code without methods. For every instance of the `Shirt` object that you want to create, you need many more lines of code to edit each object. Methods can help this code be more efficient and less cumbersome to work with.

Better Code with Methods

```
public static void main(String[] args){
  Shirt shirt01 = new Shirt();
  Shirt shirt02 = new Shirt();
  Shirt shirt03 = new Shirt();
  Shirt shirt04 = new Shirt();

  shirt01.setFields("Sailor", 'B', 30);
  shirt02.setFields("Sweatshirt", 'G', 25);
  shirt03.setFields("Skull Tee", 'B', 15);
  shirt04.setFields("Tropical", 'R', 20);
}
```

```
public class Shirt {
  public String description;
  public char colorCode;
  public double price;

  public void setFields(String desc, char color, double price){
      this.description = desc;
      this.colorCode = color;
      this.price = price;
  }
…
```


With a little bit of extra coding in the `Shirt` class, we can create a method that sets all the appropriate fields. This reduces the amount of code needed in the `main` method to create and edit `Shirt` objects.

Even Better Code with Methods

```
public static void main(String[] args){
  Shirt shirt01 = new Shirt("Sailor", "Blue", 30);
  Shirt shirt02 = new Shirt("SweatShirt", "Green", 25);
  Shirt shirt03 = new Shirt("Skull Tee", "Blue", 15);
  Shirt shirt04 = new Shirt("Tropical", "Red", 20);
}
```

```
public class Shirt {
  public String description;
  public char colorCode;
  public double price;

  //Constructor
  public Shirt(String desc, String color, double price){
      setFields(desc, price);
      setColor(color);
  }
  public void setColor (String theColor){
     if (theColor.length() > 0)
         colorCode = theColor.charAt(0);
     }
  }
}
```


Taking advantage of a `Shirt` constructor can further reduce the amount of code needed in the `main` method.

Another issue is maintenance. Imagine if you wanted to change the constructor so that the color passed in is a `String`, but the instance variable, `colorCode`, remains a `char` type. You could create a method `setColor` that receives a `String` as an argument and then modifies it so that it sets `colorCode` correctly.

Remember, methods can call other methods (as shown by the call to `setColor`).

Variable Scope

Instance variable (field)

```
public class Shirt {
   public String description;
   public char colorCode;
   public double price;

   public void setColor (String theColor){
      if (theColor.length() > 0)
         colorCode = theColor.charAt(0);
      }
   }

   public String getColor(){
     return theColor; //Cannot find symbol
   }

}
```

Local variable

Scope of theColor

Not scope of theColor

This code illustrates the scope of two different types of variables. Variables live in the block where they are defined. This is called “scope.” The scope of a variable determines its accessibility and also how long you can count on its value to persist.

- The `colorCode` variable is an instance variable, usually called a field. It is a member of the Shirt class. It is accessible from any code within this class. The value of fit is stored only during the lifespan of an instance.
- `theColor` is a local variable. It is accessible only from within the `setColor` method. The value of `theColor` is deleted from memory when the method ends. Another way of saying this is that its scope is the `setColor` method.
- Regardless of whether a local variable is declared within a method, a loop (discussed later), or an `if` statement, its scope is always the block within which it is declared.
- In the example above, the `setColor` method uses the `charAt` method of the `String` object to extract the first character in the `theColor String`. It assigns it to the `fit` instance variable, which is a char.

Note: Local variables are stored in short-term memory, called “the stack,” whereas instance variables (fields) are stored in a longer-term area of memory called “the heap.”

Advantages of Using Methods

Methods:

- Are reusable
- Make programs shorter and more readable
- Make development and maintenance quicker
- Allow separate objects to communicate and to distribute the work performed by the program

Exercise 8-1: Declare a `setColor` Method

1. Open the project `Exercise_08-1` in NetBeans.

In the `Item` class:

2. Declare a `setColor` method that takes a char as an argument (a color code) and returns a `boolean`. Return false if the `colorCode` is `' '` (a single space). Otherwise, assign the `colorCode` to the color field and return true.

In the `ShoppingCart` class:

3. Call the `setColor` method on `item1`. If it returns true, print `item1.color`. If it returns false, print an invalid color message.
4. Test the `setColor` method with both a valid color and an invalid one.

In this exercise, you declare a `setColor` method that takes a char as an argument, call the `setColor` method on `item1`, and test this method with both a valid color and invalid color.

Topics

- Using constructors and methods
- Method arguments and return values
- Using static methods and variables
- Understanding how arguments are passed to a method
- Overloading a method

Static Methods and Variables

The `static` modifier is applied to a method or variable.

It means the method/variable:

- Belongs to the *class* and is shared by all objects of that class
- Is *not unique* to an object instance
- Can be accessed without instantiating the class

Comparison:

- A **static variable** is shared by all objects in a class.
- An **instance variable** is unique to an individual object.

So far you learned how to access variables and methods by creating an object instance of the class that the variable or method belongs to. The Java language allows you to declare a variable or method as `static`. This means that you can access it *without* creating an object instance of the class. Sometimes these are referred to as *class variables* or *class methods.*

Example: Setting the Size for a New Item

```
public class ItemSizes {
    static final String mSmall = "Men's Small";
    static final String mMed = "Men's Medium";
}
```

Passing the static mMed variable to the setSize method

```
Item item1 = new Item();
item1.setSize(ItemSizes.mMed);
```

```
public class Item {
    public String size;
    public void setSize(String sizeArg){
        this.size = sizeArg;
    }
}
```


In the example above, the class `ItemSizes` contains two static variables of type `String`: `mSmall` and `mMed`. These are initialized to a description of a particular men's size. These values can be used without instantiating `ItemSizes`.

- The code snippet shown in the middle of the slide shows an Item object being instantiated and then the `setSize` method of the Item object is invoked, passing in `ItemSizes.mMed` as an argument.
- The code example at the bottom of the slide shows the `Item` class. It contains a `String` field, `size`. The `setSize` method requires a `String` parameter to set the `size` field.

Creating and Accessing Static Members

- To create a static variable or method:

```
static String mSmall;
static void setMSmall(String desc);
```

- To access a `static` variable or method:
  - From another class

```
ItemSizes.mSmall;
ItemSizes.setMSmall("Men's Small");
```

  - From within the class

```
mSmall;
setMSmall("Men's Small");
```


Variables and methods that are unique to an instance are referred to as *instance* variables or methods. If they are accessed from an object of another class, you qualify the reference with the object reference (`shirt01.size`).

- When accessing a static variable or method from an object of a different class, you qualify the reference with the class name as shown above: `ItemSizes.setMSmall("Men's Small")` or `ItemSizes.mSmall`
- If you are referencing the static variable or method from within the class, there is no need to qualify it.
- The `main` method is an example of a static method. As you know, it is used as the entry point to an application. Because the main method is static, the Java runtime can implicitly invoke it on the class without first instantiating the class.

When to Use Static Methods or Fields

- Performing the operation on an individual object or associating the variable with a specific object type is not important.
- Accessing the variable or method before instantiating an object is important.
- The method or variable does not logically belong to an object, but possibly belongs to a utility class, such as the `Math` class, included in the Java API.
- Using constant values (such as `Math.PI`)

Some Rules About Static Fields and Methods

- Instance methods can access static methods or fields.
- Static methods cannot access instance methods or fields. Why?

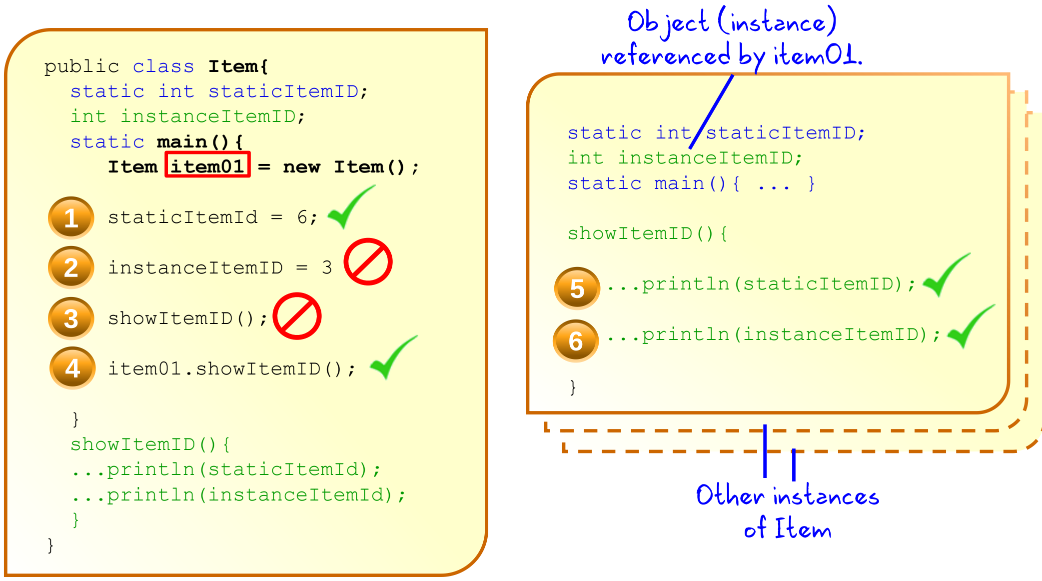
```
public class Item{
  int itemID;
  public Item(){
     setId();
  }
  static int getID(){
     // whose itemID??
  }
```


The code example above illustrates why a static method is not allowed to access an instance method or field.

- `itemID` is an instance variable. That means that each Item object has its own (presumably) unique `itemID`. In this example, its value is set in the constructor.
- The `getID` method is static, so it can be invoked even if there are no `Item` objects created.

Instance methods and fields are only available by referencing the individual object instance. \

Static Fields and Methods vs. Instance Fields and Methods



The code example above shows a more complex example of an `Item` class that has an instance variable `instanceItemID` and a static variable `staticItemID`. In its `main` method, it instantiates an object referenced by `item01`. Look at the six lines of code and see the explanations below for why some work and some do not.

1. `staticItemID` is a static variable, and referenced from within a static method, `main`, so it does not need to access an instance.
2. `instanceItemID` is an instance variable, and referenced from within a static method, `main`, so it cannot be accessed unless a reference points to the particular object whose instance variable needs to be set.
3. `showItemID()` is a call to an instance method, and referenced from within a static method, `main`, so it cannot be accessed without a reference.
4. `item01.showItemID()` is a call to an instance method, but in this case the reference points to the particular object whose instance method needs to be called.
5. `...println(staticItemID)` refers to a static variable, but it is referred to from an instance. Instances can always access static variables.
6. `...println(instanceItemID` refers to an instance variable, but it is referred to from an instance. No object reference is given, so it accesses the instance variable on the object itself.

Static Methods and Variables in the Java API

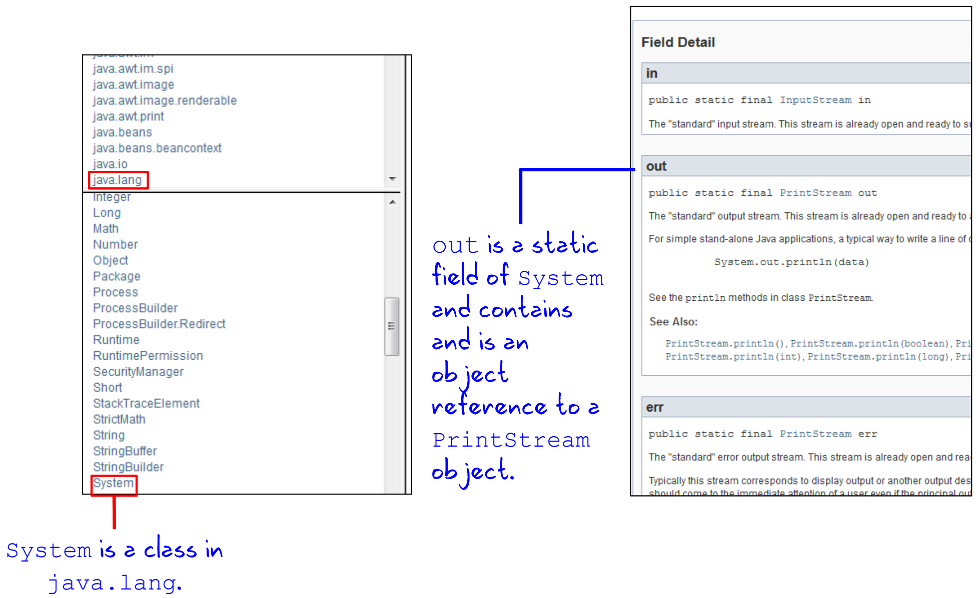
Examples:

- Some functionality of the `Math` class:
  - Exponential
  - Logarithmic
  - Trigonometric
  - Random
  - Access to common mathematical constants, such as the value PI (`Math.PI`)
- Some functionality of the `System` class:
  - Retrieving environment variables
  - Access to the standard input and output streams
  - Exiting the current program (`System.exit` method)

Certain Java class libraries, such as the `System` and the `Math` class, contain only static methods and variables. The `System` class contains utility methods for handling operating system–specific tasks. (They do not operate on an object instance.) For example, the `getProperties()` method of the `System` class gets information about the computer that you are using.

The `Math` class contains utility methods for math operations. Because these methods and variables are static, you do not need to create a new object every time you want your program to do some math.

Examining Static Variables in the JDK Libraries



The next few slides show how you might use the Java API documentation to find out more about `System.out.println()`. As you will see, this is a little unusual, because the class that has the methods that you need to investigate is not `System`. Rather, it is the class that is the type of the `out` field of the `System` object. Consider the following:

`System` is a class (in `java.lang`).

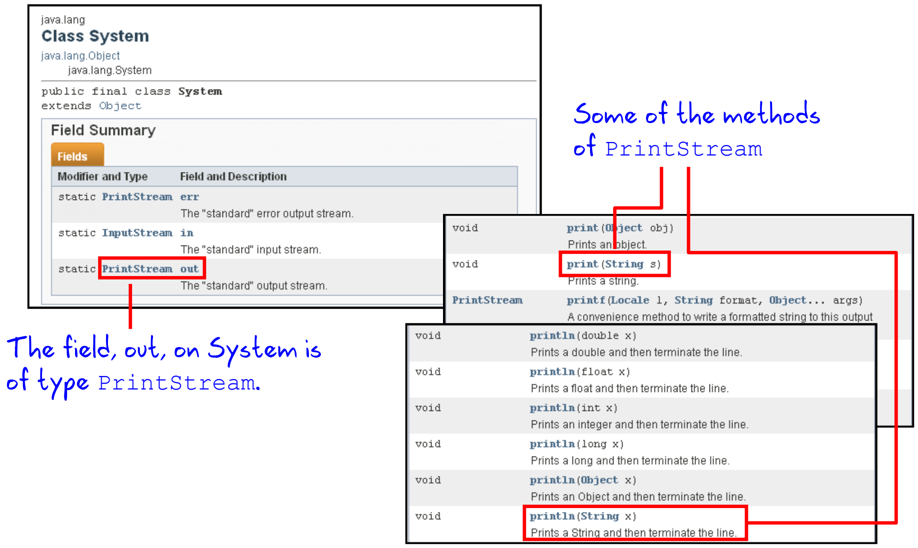
`out` is a static field of `System`. This is the reason that you reference it from the class name, not from an object instance: `System.out`

`out` is a reference type that allows calling `println()` on the object type it references.

To find the documentation:

1. Go to `System` class and find the type of the `out` field.
2. Go to the documentation for that field.
3. Review the methods available.

Using Static Variables and Methods: `System.out.println`



The diagram shows the Field Summary for the class `System`. Here, you can see that there is indeed a field called `out`, and it is of type `PrintStream`. By clicking `PrintStream`, you can now see the details for that class and, if you scroll down to the Method Summary, you will find (among many other methods) the `print` method and the `println` method. The `print` method is very similar to `println`, except that it does not create a new line after printing, like `println` does.

Example:

`println("Hello"); println("Hello")` yields the following output:

```
Hello
Hello
```

`print("Hello"); print("Hello");` yields the following output:

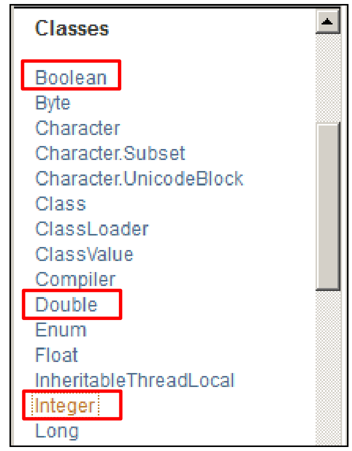
```
HelloHello
```

More Static Fields and Methods in the Java API

Java provides wrapper classes for each of the primitive data types.

- `Boolean`: Contains a single field of type `boolean`
- `Double`: Contains a single field of type `double`
- `Integer`: Contains a single field of type `int`

They also provide utility methods to work with the data.



A wrapper class is a class with the same name as one of the primitive data types. Wrapper classes are instantiated to contain a single value of the primitive type.

```
Integer myInt = new Integer(10);
```

These are very useful classes because they provide methods to help you work with the primitive values stored within.

Converting Data Values

- Methods often need to convert an argument to a different type.
- Most of the object classes in the JDK provide various conversion methods.

Examples:

- Converting a String to an `int`

```
int myInt1 = Integer.parseInt(s_Num);
```

- Converting a String to a `double`

```
double myDbl = Double.parseDouble(s_Num);
```

- Converting a String to `boolean`

```
boolean myBool = Boolean.valueOf(s_Bool);
```


The examples show static conversion methods for `Integer`, `Double`, and `Boolean`.

There are also some conversion methods for the object classes (`Integer`, `Double`, and so on) that are not static. These methods are invoked on an object reference for one of these classes and convert the value of that specific object.

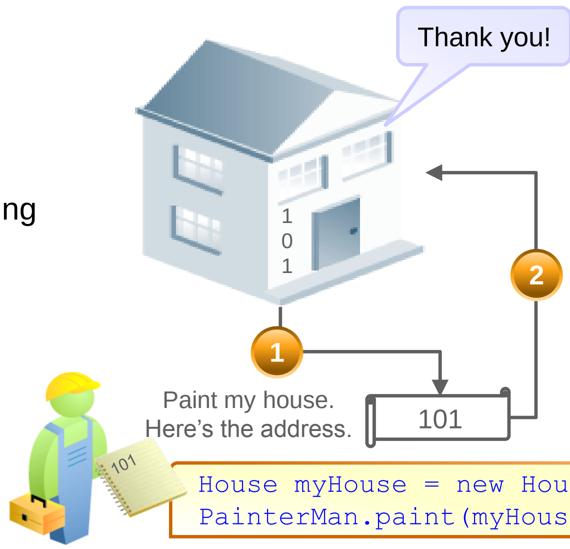
Topics

- Using constructors and methods
- Method arguments and return values
- Using static methods and variables
- Understanding how arguments are passed to a method
- Overloading a method

Passing an Object Reference

An object reference is similar to a house address. When it is passed to a method:

- The object itself is not passed
- The method can access the object using the reference
- The method can act upon the object




```
House myHouse = new House();
PainterMan.paint(myHouse);
```

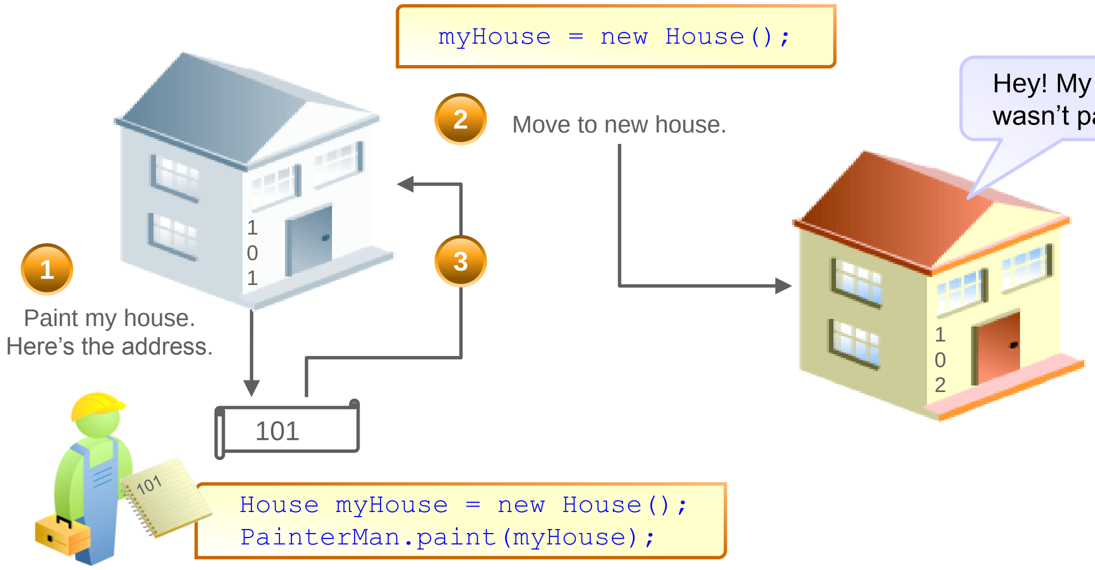

An object reference is not the same as the object. It simply provides a reference for access to that object. This is similar to the way a house address provides directions for finding a particular house.

In the graphic above, the house (call it `myHouse`) has an address (the `myHouse` reference) of `101`. When the painter gets this address, he jots it down in his notebook (he makes a copy of it). This enables the house painter to find the house and paint it.

When you send an object reference as an argument to a method, you are sending a *copy* of the reference—not the object nor the actual reference.

The receiving method has the information it needs to act directly upon the object itself.

What If There Is a New Object?



Suppose that the owner of the house moves to another house before the job is finished. Will the painter be able to find the owner's new house in order to paint it? The object reference (`myHouse`) has changed to point to a new house, but the notation in the painter's notebook still refers to the old house. If the owner expects the new house to be painted, he or she will be disappointed.

A Shopping Cart Code Example

```java
public class ShoppingCart {
    public static void main (String[] args) {
        Shirt myShirt = new Shirt();
        System.out.println("Shirt color: " + myShirt.colorCode);
        changeShirtColor(myShirt, 'B');
        System.out.println("Shirt color: " + myShirt.colorCode);
    }
    public static void changeShirtColor(Shirt theShirt, char color) {
        theShirt.colorCode = color;      }
}
```

theShirt is a new reference of type Shirt.

Output:

```
Shirt color: U
Shirt color: B
```

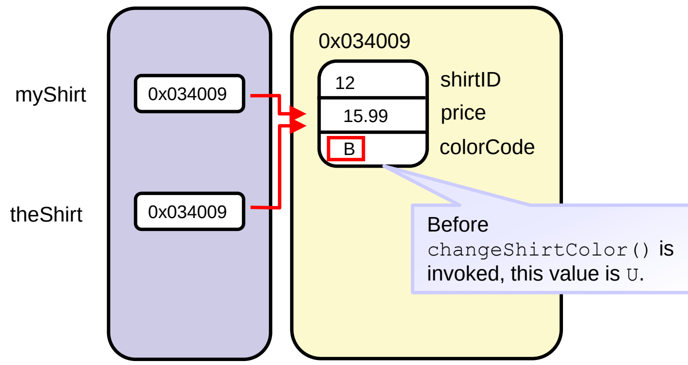

When a method is invoked, the values of the arguments are used to initialize the parameter variables before the body of the method is executed. This is true for both primitive types and reference types. (Objects are not passed to methods.)

In the example shown in the slide, the reference `myShirt` is passed by value into the `changeShirtColor` method. The reference, `theShirt` is assigned the value of the `myShirt` reference (the address). They now both point to the same object, so the change to the color made using `theShirt` is printed out by accessing `myShirt.color`.

Note: The call to the `changeShirtColor` method is made from the `main` method, which is static. Remember that a static method can only access other static methods. The `changeShirtColor` method is also static.

Passing by Value

```
Shirt myShirt = new Shirt();
changeShirtColor(myShirt, 'B');
```



The diagram in the slide shows how the value of the `myShirt` reference passed into the `changeShirtColor()` method is used to initialize a new `Shirt` reference (in this case, called `theShirt`). Remember that when a new `Shirt` is created, the `colorCode` is initialized to “U”.

Reassigning the Reference

```
1 public class ShoppingCart {
2     public static void main (String[] args) {
3         Shirt myShirt = new Shirt();
4         System.out.println("Shirt color: " + myShirt.colorCode);
5         changeShirtColor(myShirt, 'B');
6          System.out.println("Shirt color: " + myShirt.colorCode);
7     }
9     public static void changeShirtColor(Shirt theShirt, char color) {
10        theShirt = new Shirt();
11        theShirt.colorCode = color;
12 }
```

Output:

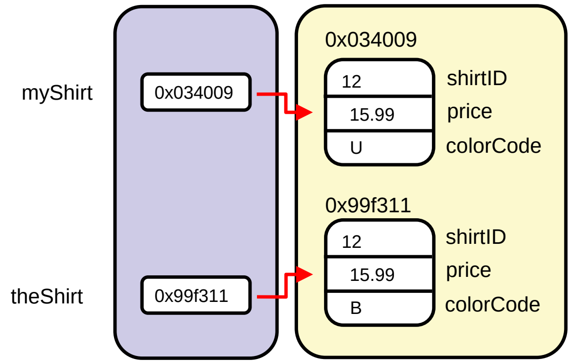
```
Shirt color: U
Shirt color: U
```


Here is another example with a small change in the code of the `changeShirtColor()` method. In this example, the reference value passed into the method is assigned to a *new* shirt. The reference now points to a different `Shirt` object than the `myShirt` reference does. As before, the `Shirt.color` is changed to '`B`'. The `println` method called on line 6 shows the color of the `myShirt` object still is '`U`' (Unset). These references point to two different Shirt objects.

This illustrates that the reference `myShirt` is indeed passed by value. Changes made to a reference passed into a worker method (reassignment to a different object, for instance) do not affect the references in the calling method.

Passing by Value

```
Shirt myShirt = new Shirt();
changeShirtColor(myShirt, 'B');
```



The diagram in the slide shows the situation that results from the code in the previous slide.

When `myShirt` is passed into the `changeShirtColor()` method, a new reference variable, `theShirt`, is initialized with the value of `myShirt`. Initially, this reference points to the object that the `myShirt` reference points to. But after a new `Shirt` is assigned to `theShirt`, any changes made using `theShirt` affect only this new `Shirt` object.

Topics

- Using constructors and methods
- Method arguments and return values
- Using static methods and variables
- Understanding how arguments are passed to a method
- Overloading a method

Method Overloading

Overloaded methods:

- Have the same name
- Have different signatures
  - The **number** of parameters
  - The **types** of parameters
  - The **order** of parameters
- May have different functionality or similar functionality
- Are widely used in the foundation classes

In the Java programming language, a class can contain several methods that have the same name but different arguments (so the method signature is different). This concept is called *method overloading*. Just as you can distinguish between two students named "Jim" in the same class by calling them "Jim in the green shirt" and "Jim with the beeper," you can distinguish between two methods by their name and arguments.

Using Method Overloading

The method type

The method signature

```
public final class Calculator {

    public static int sum(int num1, int num2){
        System.out.println("Method One");
        return num1 + num2;
    }

    public static float sum(float num1, float num2) {
        System.out.println("Method Two");
        return num1 + num2;
    }
    public static float sum(int num1, float num2) {
        System.out.println("Method Three");
        return num1 + num2;
     }
```


The example in the slide shows three methods to add two numbers, such as two `int` types or two `float` types. With method overloading, you can create several methods with the same name and different signatures.

The first `sum` method accepts two `int` arguments and returns an `int` value. The second `sum` method accepts two `float` arguments and returns a `float` value. The third `sum` method accepts an `int` and a `float` as arguments and returns a `float`.

The callout shows the part of the method declaration that is called the *method signature*.

The method signature of a method is the unique combination of the method name and the number, types, and order of its parameters. The method signature does not include the return type. To invoke any of the `sum` methods, the compiler compares the method signature in your method invocation against the method signatures in a class.

Using Method Overloading

```
public class CalculatorTest {

    public static void main(String[] args) {

        int totalOne = Calculator.sum(2, 3);
        System.out.println("The total is " + totalOne);

        float totalTwo = Calculator.sum(15.99F, 12.85F);
        System.out.println(totalTwo);

        float totalThree = Calculator.sum(2, 12.85F);
        System.out.println(totalThree);
    }
}
```


The code example in the slide has a `main` method that invokes each of the previous `sum` methods of the `Calculator` class.

Method Overloading and the Java API

Method	Use
`void println()`	Terminates the current line by writing the line separator string
`void println(boolean x)`	Prints a boolean value and then terminates the line
`void println(char x)`	Prints a character and then terminates the line
`void println(char[] x)`	Prints an array of characters and then terminates the line

Many methods in the Java API are overloaded, including the `System.out.println` method. The table in the slide shows four variations of the `println` method.

Exercise 8-2: Overload a `setItemFields` Method, Part 1

1. Open the project Practice_08-2 in NetBeans.

In the `Item` class:

2. Write a `setItemFields` method that takes three arguments and assigns them to the `desc`, `quantity`, and `price` fields. The method returns void.
3. Create an overloaded `setItemFields` method to take four arguments and return an int. The method assigns all four fields. A `' '` (a single space) is an invalid value for a colorCode argument.
   - If the `colorCode` argument is invalid, return -1 without assigning the value.
   - If the `colorCode` is valid, assign the `colorCode` field and then assign the remaining fields by calling the three-argument method.

.

In this exercise, you create an overloaded method in the Item class. Then, you invoke these from the ShoppingCart class.

Exercise 8-2: Overload a `setItemFields` Method, Part 2

In the `ShoppingCart` class:

4. Call the 3-argument `setItemFields` method and then call `item1.displayItem()`.
5. Call the 4-argument `setItemFields` method. Check the return value.
   - If the return value < 0, print an invalid color code message.
   - Otherwise, call `displayItem()`.

In this exercise, you create an overloaded method in the Item class. Then, you invoke these from the ShoppingCart class.

Quiz

Which method corresponds to the following method call?

`myPerson.printValues(100, 147.7F, "lavender");`

a. `public void printValues (int i, float f)`
b. `public void printValues (i, float f, s)`
c. `public void printValues (int i, float f, String s)`
d. `public void printValues (float f, String s, int i)`

Answer: c

Summary

In this lesson, you should have learned how to:

- Add an argument to a method
- Instantiate a class and call a method
- Overload a method
- Work with static methods and variables
- Convert data values using `Integer`, `Double`, and `Boolean` object types

Practices Overview

- 8-1: Using Methods
- 8-2: Creating Game Data Randomly
- 8-3: Creating Overloaded Methods

9

Using Encapsulation

ORACLE

Interactive Quizzes

Before you start today's lessons, test your knowledge by answering some quiz questions that relate to yesterday's lessons. Open the Quiz files by clicking the quizzes.html shortcut from the desktop of your VM. In the welcome page, JavaSEProgrammingI.html, click the links for Lessons 6, 7, and 8.

Objectives

After completing this lesson, you should be able to:

- Use public and private access modifiers
- Restrict access to fields and methods using encapsulation
- Implement encapsulation in a class
- Overload a constructor by adding method parameters to a constructor

Topics

- Access control
- Encapsulation
- Overloading constructors

What Is Access Control?

Access control allows you to:

- Hide fields and methods from other classes
- Determine how internal data gets changed
- Keep the implementation separate from the public interface
  - Public interface:

```
setPrice( Customer cust)
```

  - Implementation:

```
public void setPrice(Customer cust){
   // set price discount relative to customer
}
```


Access control allows you to hide internal data and functionality in a class. In this lesson, you distinguish between the public interface of a class and the actual implementation of that interface.

- The public interface is what you see when you look up a class in the JDK API documentation. You get just the information you need in order to use a class. That is, the signatures for public methods, and data types of any public fields.
- The implementation of a class is the code itself, and also any private methods or fields that are used by that class. These are the internal workings of a class and it is not necessary to expose them to another class.

Access Modifiers

- `public`: Accessible by anyone
- `private`: Accessible only within the class

```
public class Item {
   // Base price
  private double price = 15.50;

  public void setPrice(Customer cust){
      if (cust.hasLoyaltyDiscount()){
         price = price*.85; }
  }
}
```

When a field is declared as public, any other class can access and potentially change the field's value. This is often problematic. It could be that the field represents sensitive data, such as a social security number, or that some type of logic or manipulation of the data may be required in order to safely modify the data. In the code example, the shirt price is declared in a private method. You would not want outside objects, such as a customer, to be able to freely manipulate the price of an item.

Access from Another Class

```
public class Item {
   private double price = 15.50;

   public void setPrice(Customer cust){
     if (cust.hasLoyaltyDiscount()){
        price = price*.85; }
   }
}
```

```
public class Order{
   public static void main(String args[]){
     Customer cust = new Customer(int ID);
     Item item = new Item();
     item.price = 10.00;
     item.setPrice(cust);
   }
}
```

Won't compile

You don't need to know how setPrice works in order to use it.

Another Example

The data type of the field does not match the data type of the data used to set the field.

```
private int phone;
public void setPhoneNumber(String s_num){
    //  parse out the dashes and parentheses from the
    //  String first
    this.phone = Integer.parseInt(s_num);
}
```


It may be that the data representing someone's phone number may be collected as a string, including spaces, dashes, and parentheses. If the phone number is represented internally as an `int`, then the setter method for the phone number will need to parse out spaces, dashes, and parentheses first, and then convert the `String` to an `int`. The `parseInt` method of `Integer` is covered in the "Using Encapsulation" lesson.

Using Access Control on Methods

```
public class Item {
    private int id;
    private String desc;
    private double price;
    private static int nextId = 1;

    public Item(){
        setId();
        desc = "--description required--";
        price = 0.00;
    }

    private void setId() {
        id = Item.nextId++;
    }
```

Called from within a public method

Private method

Here you see a private method that sets a new unique ID for an item. It is not necessary to expose this functionality to another class. The `setId` method is called from the public constructor method as part of its implementation.

Topics

- Access control
- Encapsulation
- Overloading constructors

Encapsulation

- Encapsulation means hiding object fields. It uses access control to hide the fields.
  - Safe access is provided by getter and setter methods.
  - In setter methods, use code to ensure that values are valid.
- Encapsulation mandates programming to the interface:
  - A method can change the data type to match the field.
  - A class can be changed as long as interface remains same.
- Encapsulation encourages good object-oriented (OO) design.

Get and Set Methods

```java
public class Shirt {
   private int shirtID = 0;            // Default ID for the shirt
   private String description = "-description required-"; // default
   private char colorCode = 'U';      //R=Red, B=Blue, G=Green, U=Unset
   private double price = 0.0;        // Default price for all items

   public char getColorCode() {
       return colorCode;
   }
   public void setColorCode(char newCode) {
       colorCode = newCode;
   }
       // Additional get and set methods for shirtID, description,
       // and price would follow

} // end of class
```


If you make attributes private, how can another object access them? One object can access the private attributes of a second object if the second object provides public methods for each of the operations that are to be performed on the value of an attribute.

For example, it is recommended that all fields of a class should be private, and those that need to be accessed should have public methods for setting and getting their values.

This ensures that, at some future time, the actual field type itself could be changed, if that were advantageous. Or the getter or setter methods could be modified to control how the value could be changed, such as the value of the `colorCode`.

Why Use Setter and Getter Methods?

```
1 public class ShirtTest {
2       public static void main (String[] args) {
3               Shirt theShirt = new Shirt();
4               char colorCode;
5       // Set a valid colorCode
6               theShirt.setColorCode('R');
7               colorCode = theShirt.getColorCode();
8               System.out.println("Color Code:  " + colorCode);
9       // Set an invalid color code
10              theShirt.setColorCode('Z');
11              colorCode = theShirt.getColorCode();
12              System.out.println("Color Code:  " + colorCode);
13    }
14 …
```

Not a valid color code

Output:

```
Color Code: R
Color Code: Z
```


Though the code for the `Shirt` class is syntactically correct, the `setcolorCode` method does not contain any logic to ensure that the correct values are set.

The code example in the slide successfully sets an invalid color code in the `Shirt` object.

However, because `ShirtTest` accesses a private field on `Shirt` using a setter method, `Shirt` can now be recoded without modifying any of the classes that depend on it.

In the code example above, starting with line 6, the `ShirtTest` class is setting and getting a valid `colorCode`. Starting with line 10, the `ShirtTest` class is setting an invalid `colorCode` and confirming that invalid setting.

Setter Method with Checking

```
public void setColorCode(char newCode) {
    if (newCode == 'R'){
        colorCode = newCode;
          return;
      }
    if (newCode == 'G') {
        colorCode = newCode;
          return;
      }
    if (newCode == 'B') {
        colorCode = newCode;
          return;
      }
      System.out.println("Invalid colorCode. Use R, G, or B");
 }
}
```


In the slide is another version of the `Shirt` class. However, in this class, before setting the value, the setter method ensures that the value is valid. If it is not valid, the `colorCode` field remains unchanged and an error message is printed.

Note: Void type methods can have return statements. They just cannot return any values.

Using Setter and Getter Methods

```
public class ShirtTest {
    public static void main (String[] args) {
        Shirt theShirt = new Shirt();
        System.out.println("Color Code: " + theShirt.getColorCode());

        // Try to set an invalid color code
        theShirt.setColorCode('Z');      Not a valid color code
        System.out.println("Color Code: " + theShirt.getColorCode());
    }
```

Output:

```
Color Code: U          Before call to setColorCode() – shows default value
Invalid colorCode. Use R, G, or B      call to setColorCode prints error message
Color Code: U      colorCode not modified by invalid argument passed to setColorCode()
```


Building on the previous slides, before the call to `setColorCode`, the default color value of U (unset) is printed. If you call `setColorCode` with an invalid code, the color code is not modified and the default value, U, is still the value. Additionally, you receive an error message that tells you to use the valid color codes, which are R, G, and B.

Exercise 9-1: Encapsulate a Class

In this exercise, you encapsulate the `Customer` class.

1. Open **`Exercise_09-1`** project in NetBeans.
2. Change access modifiers so that fields must be read or modified through public methods.
3. Allow the `name` field to be read and modified.
4. Allow the `ssn` field to be read but not modified (read only).

In this exercise, you encapsulate the Customer class.

Topics

- Access control
- Encapsulation
- Overloading constructors

Initializing a Shirt Object

Explicitly:

```
public class ShirtTest {
    public static void main (String[] args) {
        Shirt theShirt = new Shirt();

        // Set values for the Shirt
        theShirt.setColorCode('R');
        theShirt.setDescription("Outdoors shirt");
        theShirt.price(39.99);
    }
}
```

Using a constructor:

```
Shirt theShirt = new Shirt('R', "Outdoors shirt", 39.99);
```


Assuming that you now have setters for all the private fields of `Shirt`, you could now instantiate and initialize a `Shirt` object by instantiating it and then setting the various fields through the setter methods.

However, Java provides a much more convenient way to instantiate and initialize an object by using a special method called a *constructor*.

Constructors

- Constructors are usually used to initialize fields in an object.
  - They can receive arguments.
  - When you create a constructor with arguments, it removes the default no-argument constructor.

All classes have at least one constructor.

If the code does not include an explicit constructor, the Java compiler automatically supplies a no-argument constructor. This is called the default constructor.

`Shirt` Constructor with Arguments

```
public class Shirt {
  public int shirtID = 0;                      // Default ID for the shirt
  public String description = "-description required-"; // default
  private char colorCode = 'U’;                // R=Red, B=Blue, G=Green, U=Unset
  public double price = 0.0;                   // Default price all items

 // This constructor takes three argument
  public Shirt(char colorCode, String desc, double price ) {
      setColorCode(colorCode);
      setDescription(desc);
      setPrice(price);
  }
```

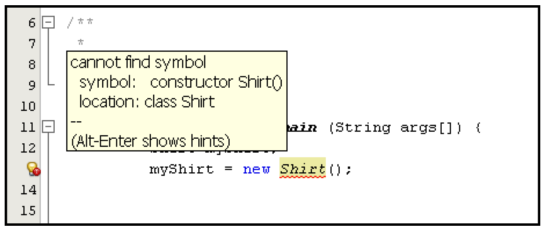

The `Shirt` example shown in the slide has a constructor that accepts three values to initialize three of the object’s fields. Because `setColorCode` ensures that an invalid code cannot be set, the constructor can just call this method.

Default Constructor and Constructor with Args

When you create a constructor with arguments, the default constructor is no longer created by the compiler.

```
// default constructor
public Shirt()

// Constructor with args
public Shirt (char color, String desc, double price)
```

This constructor is not in the source code. It only exists if no constructor is explicitly defined.



When you explicitly create an overloaded constructor, it replaces the default no-argument constructor.

You may be wondering why you have been able to instantiate a Shirt object with `Shirt myShirt = new Shirt()` even if you did not actually create that no-argument constructor. If there is no explicit constructor in a class, Java assumes that you want to be able to instantiate the class, and gives you an *implicit* default no-argument constructor. Otherwise, how could you instantiate the class?

The example above shows a new constructor that takes arguments. When you do this, Java removes the implicit default constructor. Therefore, if you try to use `Shirt myShirt = new Shirt()`, the compiler cannot find this constructor because it no longer exists.

Overloading Constructors

```
public class Shirt {
  ... //fields

  // No-argument constructor
  public Shirt() {
      setColorCode('U');
  }
  // 1 argument constructor
  public Shirt(char colorCode ) {
      setColorCode(colorCode);
  }
  // 2 argument constructor
  public Shirt(char colorCode, double price) {
      this(colorCode);
      setPrice(price);
  }
```

If required, must be added explicitly

Calling the 1 argument constructor

The code in the slide shows three overloaded constructors:

- A default no-argument constructor
- A constructor with one parameter (a `char`)
- A constructor with two parameters (a `char` and a `double`)

This third constructor sets both the `colorCode` field and the `price` field. Notice, however, that the syntax where it sets the `colorCode` field is one that you have not seen yet. It would be possible to set `colorCode` with a simple call to `setColorCode()` just as the previous constructor does, but there is another option, as shown here.

You can chain the constructors by calling the second constructor in the first line of the third constructor using the following syntax:

```
this(argument);
```

The keyword `this` is a reference to the current object. In this case, it references the constructor method from this class whose signature matches.

This technique of chaining constructors is especially useful when one constructor has some (perhaps quite complex) code associated with setting fields. You would not want to duplicate this code in another constructor and so you would chain the constructors.

Quiz

What is the default constructor for the following class?

```
public class Penny {
    String name = "lane";
}
```

a. `public Penny(String name)`
b. `public Penny()`
c. `class()`
d. `String()`
e. `private Penny()`

Answer: b

Exercise 9-2: Create an Overloaded Constructor

1. Continue editing **`Exercise_09-1`** or open **`Exercise_09-2`** in NetBeans.

In the `Customer` class:

2. Add a custom constructor that initializes the fields.

In the `ShoppingCart` class:

3. Declare, instantiate, and initialize a new `Customer` object by calling the custom constructor.
4. Test it by printing the `Customer` object name (call the `getName` method).

In this exercise, you add a constructor to the Customer class and create a new Customer object by calling the constructor.

Summary

In this lesson, you should have learned how to:

- Use public and private access modifiers
- Restrict access to fields and methods using encapsulation
- Implement encapsulation in a class
- Overload a constructor by adding method parameters to a constructor

Practices Overview

- 9-1: Encapsulating Fields
- 9-2: Creating Overloaded Constructors