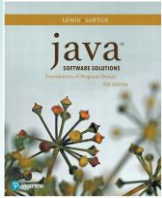


Chapter 3 Using Classes and Objects



Java Software Solutions
Foundations of Program Design
9th Edition

John Lewis
William Loftus

PEARSON

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Using Classes and Objects

- We can create more interesting programs using predefined classes and related objects
- Chapter 3 focuses on:
 - object creation and object references
 - the `String` class and its methods
 - the Java API class library
 - the `Random` and `Math` classes
 - formatting output
 - enumerated types
 - wrapper classes

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Outline

- ➔ **Creating Objects**
- The `String` Class**
- The `Random` and `Math` Classes**
- Formatting Output**
- Enumerated Types**
- Wrapper Classes**

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Creating Objects

- A variable holds either a primitive value or a *reference* to an object
- A class name can be used as a type to declare an *object reference variable*

```
String title;
```

- No object is created with this declaration
- An object reference variable holds the address of an object
- The object itself must be created separately

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Creating Objects

- Generally, we use the `new` operator to create an object
- Creating an object is called *instantiation*
- An object is an *instance* of a particular class

```
title = new String("Java Software Solutions");
```

This calls the *String constructor*, which is a special method that sets up the object

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Invoking Methods

- We've seen that once an object has been instantiated, we can use the *dot operator* to invoke its methods

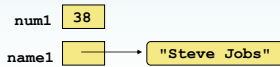
```
numChars = title.length();
```

- A method may *return a value*, which can be used in an assignment or expression
- A method invocation can be thought of as asking an object to perform a service

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References

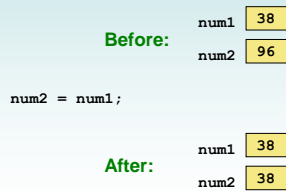
- Note that a primitive variable contains the value itself, but an object variable contains the address of the object
- An object reference can be thought of as a pointer to the location of the object
- Rather than dealing with arbitrary addresses, we often depict a reference graphically



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Assignment Revisited

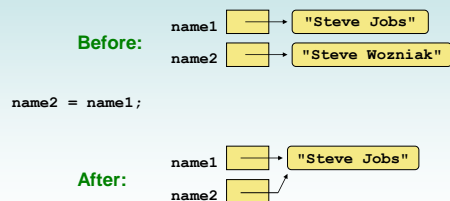
- The act of assignment takes a copy of a value and stores it in a variable
- For primitive types:



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Reference Assignment

- For object references, assignment copies the address:



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Aliases

- Two or more references that refer to the same object are called *aliases* of each other
- That creates an interesting situation: one object can be accessed using multiple reference variables
- Aliases can be useful, but should be managed carefully
- Changing an object through one reference changes it for all of its aliases, because there is really only one object

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Garbage Collection

- When an object no longer has any valid references to it, it can no longer be accessed by the program
- The object is useless, and therefore is called *garbage*
- Java performs *automatic garbage collection* periodically, returning an object's memory to the system for future use
- In other languages, the programmer is responsible for performing garbage collection

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Outline

- Creating Objects
- ➡ The String Class
- The Random and Math Classes
- Formatting Output
- Enumerated Types
- Wrapper Classes

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The String Class

- Because strings are so common, we don't have to use the `new` operator to create a `String` object

```
title = "Java Software Solutions";
```

- This is special syntax that works only for strings
- Each string literal (enclosed in double quotes) represents a `String` object

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String Methods

- Once a `String` object has been created, neither its value nor its length can be changed
- Therefore we say that an object of the `String` class is *immutable*
- However, several methods of the `String` class return new `String` objects that are modified versions of the original

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String Indexes

- It is occasionally helpful to refer to a particular character within a string
- This can be done by specifying the character's numeric *index*
- The indexes begin at zero in each string
- In the string `"Hello"`, the character `'H'` is at index 0 and the `'o'` is at index 4
- See `StringMutation.java`

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```

//*****
// StringMutation.java      Author: Lewis/Loftus
//
// Demonstrates the use of the String class and its methods.
//*****

public class StringMutation
{
    //-----
    // Prints a string and various mutations of it.
    //-----
    public static void main(String[] args)
    {
        String phrase = "Change is inevitable";
        String mutation1, mutation2, mutation3, mutation4;

        System.out.println("Original string: \" + phrase + "\"");
        System.out.println("Length of string: " + phrase.length());

        mutation1 = phrase.concat(", except from vending machines.");
        mutation2 = mutation1.toUpperCase();
        mutation3 = mutation2.replace('E', 'X');
        mutation4 = mutation3.substring(3, 30);
    }
}

```

continued

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```

continued

// Print each mutated string
System.out.println("Mutation #1: " + mutation1);
System.out.println("Mutation #2: " + mutation2);
System.out.println("Mutation #3: " + mutation3);
System.out.println("Mutation #4: " + mutation4);

System.out.println("Mutated length: " + mutation4.length());
}
}

```

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Output

```

Original string: "Change is inevitable"
Length of string: 20
Mutation #1: Change is inevitable, except from vending machines.
Mutation #2: CHANGE IS INEVITABLE, EXCEPT FROM VENDING MACHINES.
Mutation #3: CHANGX IS INXVITABLX, XXCXPT FROM VXNDING MACHINXS.
Mutation #4: NGX IS INXVITABLX, XXCXPT F
Mutated length: 27

```

```

        System.out.println("Mutated length: " + mutation4.length());
    }
}

```

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Quick Check

What output is produced by the following?

```
String str = "Space, the final frontier.";
System.out.println(str.length());
System.out.println(str.substring(7));
System.out.println(str.toUpperCase());
System.out.println(str.length());
```

```
26
the final frontier.
SPACE, THE FINAL FRONTIER.
26
```

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Outline

Creating Objects

The String Class

➡ The Random and Math Classes

Formatting Output

Enumerated Types

Wrapper Classes

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Class Libraries

- A *class library* is a collection of classes that we can use when developing programs
- The *Java standard class library* is part of any Java development environment
- Its classes are not part of the Java language per se, but we rely on them heavily
- Various classes we've already used (`System`, `Scanner`, `String`) are part of the Java standard class library

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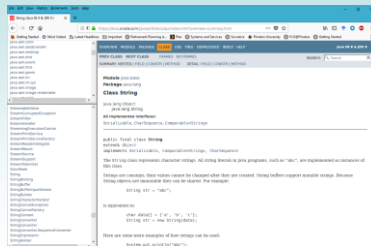
The Java API

- The Java class library is sometimes referred to as the Java API
- API stands for Application Programming Interface
- Clusters of related classes are sometimes referred to as specific APIs:
 - The Swing API
 - The Database API

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The Java API

- Get comfortable navigating the online Java API documentation



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Packages

- For purposes of accessing them, classes in the Java API are organized into *packages*
- These often overlap with specific APIs
- Examples:

Package	Purpose
java.lang	General support
java.applet	Creating applets for the web
java.awt	Graphics and graphical user interfaces
javax.swing	Additional graphics capabilities
java.net	Network communication
java.util	Utilities
javax.xml.parsers	XML document processing

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The import Declaration

- When you want to use a class from a package, you could use its *fully qualified name*

```
java.util.Scanner
```

- Or you can *import* the class, and then use just the class name

```
import java.util.Scanner;
```

- To import all classes in a particular package, you can use the *** wildcard character

```
import java.util.*;
```

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The import Declaration

- All classes of the `java.lang` package are imported automatically into all programs
- It's as if all programs contain the following line:

```
import java.lang.*;
```

- That's why we didn't have to import the `System` or `String` classes explicitly in earlier programs
- The `Scanner` class, on the other hand, is part of the `java.util` package, and therefore must be imported

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The Random Class

- The `Random` class is part of the `java.util` package
- It provides methods that generate pseudorandom numbers
- A `Random` object performs complicated calculations based on a *seed value* to produce a stream of seemingly random values
- See `RandomNumbers.java`

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```

//*****
// RandomNumbers.java      Author: Lewis/Loftus
//
// Demonstrates the creation of pseudo-random numbers using the
// Random class.
//*****

import java.util.Random;

public class RandomNumbers
{
    //-----
    // Generates random numbers in various ranges.
    //-----
    public static void main(String[] args)
    {
        Random generator = new Random();
        int num1;
        float num2;

        num1 = generator.nextInt();
        System.out.println("A random integer: " + num1);

        num1 = generator.nextInt(10);
        System.out.println("From 0 to 9: " + num1);
    }
}

```

continued

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```

continued

num1 = generator.nextInt(10) + 1;
System.out.println("From 1 to 10: " + num1);

num1 = generator.nextInt(15) + 20;
System.out.println("From 20 to 34: " + num1);

num1 = generator.nextInt(20) - 10;
System.out.println("From -10 to 9: " + num1);

num2 = generator.nextFloat();
System.out.println("A random float (between 0-1): " + num2);

num2 = generator.nextFloat() * 6; // 0.0 to 5.999999
num1 = (int)num2 + 1;
System.out.println("From 1 to 6: " + num1);
}

```

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```

continued

num1
Syst
From 0 to 9: 0
From 1 to 10: 3
num1
Syst
From 20 to 34: 30
From -10 to 9: -4
num1
Syst
A random float (between 0-1): 0.18538326
From 1 to 6: 3

num2 = generator.nextFloat();
System.out.println("A random float (between 0-1): " + num2);

num2 = generator.nextFloat() * 6; // 0.0 to 5.999999
num1 = (int)num2 + 1;
System.out.println("From 1 to 6: " + num1);
}

```

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Sample Run

```

A random integer: 672981683
From 0 to 9: 0
From 1 to 10: 3
From 20 to 34: 30
From -10 to 9: -4
A random float (between 0-1): 0.18538326
From 1 to 6: 3

```

Quick Check

Given a `Random` object named `gen`, what range of values are produced by the following expressions?

	<u>Range</u>
<code>gen.nextInt(25)</code>	0 to 24
<code>gen.nextInt(6) + 1</code>	1 to 6
<code>gen.nextInt(100) + 10</code>	10 to 109
<code>gen.nextInt(50) + 100</code>	100 to 149
<code>gen.nextInt(10) - 5</code>	-5 to 4
<code>gen.nextInt(22) + 12</code>	12 to 33

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Quick Check

Write an expression that produces a random integer in the following ranges:

<u>Range</u>	
0 to 12	<code>gen.nextInt(13)</code>
1 to 20	<code>gen.nextInt(20) + 1</code>
15 to 20	<code>gen.nextInt(6) + 15</code>
-10 to 0	<code>gen.nextInt(11) - 10</code>

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The Math Class

- The `Math` class is part of the `java.lang` package
- The `Math` class contains methods that perform various mathematical functions
- These include:
 - absolute value
 - square root
 - exponentiation
 - trigonometric functions

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The Math Class

- The methods of the `Math` class are *static methods* (also called *class methods*)
- Static methods are invoked through the class name – no object of the `Math` class is needed


```
value = Math.cos(90) + Math.sqrt(delta);
```
- We discuss static methods further in Chapter 7
- See `Quadratic.java`

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```

//*****
// Quadratic.java      Author: Lewis/Loftus
//
// Demonstrates the use of the Math class to perform a calculation
// based on user input.
//*****

import java.util.Scanner;

public class Quadratic
{
    //-----
    // Determines the roots of a quadratic equation.
    //-----
    public static void main(String[] args)
    {
        int a, b, c; // ax^2 + bx + c
        double discriminant, root1, root2;

        Scanner scan = new Scanner(System.in);

        System.out.print("Enter the coefficient of x squared: ");
        a = scan.nextInt();

continued

```

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continued

```

        System.out.print("Enter the coefficient of x: ");
        b = scan.nextInt();

        System.out.print("Enter the constant: ");
        c = scan.nextInt();

        // Use the quadratic formula to compute the roots.
        // Assumes a positive discriminant.

        discriminant = Math.pow(b, 2) - (4 * a * c);
        root1 = ((-1 * b) + Math.sqrt(discriminant)) / (2 * a);
        root2 = ((-1 * b) - Math.sqrt(discriminant)) / (2 * a);

        System.out.println("Root #1: " + root1);
        System.out.println("Root #2: " + root2);
    }
}

```

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continued

Sample Run

```

System.out.println("Enter the coefficient of x squared: 3");
b = sc.nextInt();
System.out.println("Enter the coefficient of x: 8");
c = sc.nextInt();
System.out.println("Enter the constant: 4");
Root #1: -0.6666666666666666
Root #2: -2.0

// Use the quadratic formula to compute the roots.
// Assumes a positive discriminant.

discriminant = Math.pow(b, 2) - (4 * a * c);
root1 = ((-1 * b) + Math.sqrt(discriminant)) / (2 * a);
root2 = ((-1 * b) - Math.sqrt(discriminant)) / (2 * a);

System.out.println("Root #1: " + root1);
System.out.println("Root #2: " + root2);
}

```

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Outline

Creating Objects

The String Class

The Random and Math Classes



Formatting Output

Enumerated Types

Wrapper Classes

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Formatting Output

- It is often necessary to format output values in certain ways so that they can be presented properly
- The Java standard class library contains classes that provide formatting capabilities
- The `NumberFormat` class allows you to format values as currency or percentages
- The `DecimalFormat` class allows you to format values based on a pattern
- Both are part of the `java.text` package

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Formatting Output

- The `NumberFormat` class has static methods that return a formatter object

```
getCurrencyInstance()
```

```
getPercentInstance()
```

- Each formatter object has a method called `format` that returns a string with the specified information in the appropriate format
- See `Purchase.java`

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```

//*****
// Purchase.java      Author: Lewis/Loftus
//
// Demonstrates the use of the NumberFormat class to format output.
//*****

import java.util.Scanner;
import java.text.NumberFormat;

public class Purchase
{
    //-----
    // Calculates the final price of a purchased item using values
    // entered by the user.
    //-----
    public static void main(String[] args)
    {
        final double TAX_RATE = 0.06; // 6% sales tax

        int quantity;
        double subtotal, tax, totalCost, unitPrice;

        Scanner scan = new Scanner(System.in);

        continued

```

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```

continued

NumberFormat fmt1 = NumberFormat.getCurrencyInstance();
NumberFormat fmt2 = NumberFormat.getPercentInstance();

System.out.print("Enter the quantity: ");
quantity = scan.nextInt();

System.out.print("Enter the unit price: ");
unitPrice = scan.nextDouble();

subtotal = quantity * unitPrice;
tax = subtotal * TAX_RATE;
totalCost = subtotal + tax;

// Print output with appropriate formatting
System.out.println("Subtotal: " + fmt1.format(subtotal));
System.out.println("Tax: " + fmt1.format(tax) + " at "
    + fmt2.format(TAX_RATE));
System.out.println("Total: " + fmt1.format(totalCost));
}

```

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continued

Sample Run

```

Enter the quantity: 5
Enter the unit price: 3.87
Subtotal: $19.35
Tax: $1.16 at 6%
Total: $20.51

System.out.print("Enter the unit price: ");
unitPrice = scan.nextDouble();

subtotal = quantity * unitPrice;
tax = subtotal * TAX_RATE;
totalCost = subtotal + tax;

// Print output with appropriate formatting
System.out.println("Subtotal: " + fmt1.format(subtotal));
System.out.println("Tax: " + fmt1.format(tax) + " at "
    + fmt2.format(TAX_RATE));
System.out.println("Total: " + fmt1.format(totalCost));
}

```

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Formatting Output

- The `DecimalFormat` class can be used to format a floating point value in various ways
- For example, you can specify that the number should be truncated to three decimal places
- The constructor of the `DecimalFormat` class takes a string that represents a pattern for the formatted number
- See `CircleStats.java`

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```

//*****
// CircleStats.java      Author: Lewis/Loftus
//
// Demonstrates the formatting of decimal values using the
// DecimalFormat class.
//*****

import java.util.Scanner;
import java.text.DecimalFormat;

public class CircleStats
{
    //-----
    // Calculates the area and circumference of a circle given its
    // radius.
    //-----
    public static void main(String[] args)
    {
        int radius;
        double area, circumference;

        Scanner scan = new Scanner(System.in);

continued

```

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continued

```

System.out.print ("Enter the circle's radius: ");
radius = scan.nextInt();

area = Math.PI * Math.pow(radius, 2);
circumference = 2 * Math.PI * radius;

// Round the output to three decimal places
DecimalFormat fmt = new DecimalFormat ("0.###");

System.out.println ("The circle's area: " + fmt.format(area));
System.out.println ("The circle's circumference: "
    + fmt.format(circumference));
}

```

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continued

Sample Run

```

Enter the circle's radius: 5
The circle's area: 78.54
The circle's circumference: 31.416

```

```

System.out
radius =

area = Math.PI * Math.pow(radius, 2);
circumference = 2 * Math.PI * radius;

// Round the output to three decimal places
DecimalFormat fmt = new DecimalFormat("0.###");

System.out.println("The circle's area: " + fmt.format(area));
System.out.println("The circle's circumference: "
    + fmt.format(circumference));
}

```

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Outline

Creating Objects
 The String Class
 The Random and Math Classes
 Formatting Output
 ➞ Enumerated Types
 Wrapper Classes

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Enumerated Types

- Java allows you to define an *enumerated type*, which can then be used to declare variables
- An enumerated type declaration lists all possible values for a variable of that type
- The values are identifiers of your own choosing
- The following declaration creates an enumerated type called `Season`

```
enum Season {winter, spring, summer, fall};
```
- Any number of values can be listed

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Enumerated Types

- Once a type is defined, a variable of that type can be declared:

```
Season time;
```
- And it can be assigned a value:

```
time = Season.fall;
```
- The values are referenced through the name of the type
- Enumerated types are *type-safe* – you cannot assign any value other than those listed

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Ordinal Values

- Internally, each value of an enumerated type is stored as an integer, called its *ordinal value*
- The first value in an enumerated type has an ordinal value of zero, the second one, and so on
- However, you cannot assign a numeric value to an enumerated type, even if it corresponds to a valid ordinal value

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Enumerated Types

- The declaration of an enumerated type is a special type of class, and each variable of that type is an object
- The `ordinal` method returns the ordinal value of the object
- The `name` method returns the name of the identifier corresponding to the object's value
- See `IceCream.java`

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```

//*****
// IceCream.java      Author: Lewis/Loftus
//
// Demonstrates the use of enumerated types.
//*****

public class IceCream
{
    enum Flavor {vanilla, chocolate, strawberry, fudgeRipple, coffee,
                 rockyRoad, mintChocolateChip, cookieDough}

    //-----
    // Creates and uses variables of the Flavor type.
    //-----
    public static void main (String[] args)
    {
        Flavor cone1, cone2, cone3;

        cone1 = Flavor.rockyRoad;
        cone2 = Flavor.chocolate;

        System.out.println("cone1 value: " + cone1);
        System.out.println("cone1 ordinal: " + cone1.ordinal());
        System.out.println("cone1 name: " + cone1.name());
    }
}

```

continued

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```

continued

    System.out.println();
    System.out.println("cone2 value: " + cone2);
    System.out.println("cone2 ordinal: " + cone2.ordinal());
    System.out.println("cone2 name: " + cone2.name());

    cone3 = cone1;

    System.out.println();
    System.out.println("cone3 value: " + cone3);
    System.out.println("cone3 ordinal: " + cone3.ordinal());
    System.out.println("cone3 name: " + cone3.name());
}
}

```

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continued

```

System.out.println("cone1 value: " + cone1.value());
System.out.println("cone1 ordinal: " + cone1.ordinal());
System.out.println("cone1 name: " + cone1.name());
System.out.println("cone2 value: " + cone2.value());
System.out.println("cone2 ordinal: " + cone2.ordinal());
System.out.println("cone2 name: " + cone2.name());
System.out.println("cone3 value: " + cone3.value());
System.out.println("cone3 ordinal: " + cone3.ordinal());
System.out.println("cone3 name: " + cone3.name());
System.out.println("cone3 name: " + cone3.name());
}

```

Output

```

cone1 value: rockyRoad
cone1 ordinal: 5
cone1 name: rockyRoad
cone2 value: chocolate
cone2 ordinal: 1
cone2 name: chocolate
cone3 value: rockyRoad
cone3 ordinal: 5
cone3 name: rockyRoad
cone3 name: rockyRoad

```

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Outline

- Creating Objects
- The String Class
- The Random and Math Classes
- Formatting Output
- Enumerated Types
- ➔ Wrapper Classes

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Wrapper Classes

- The `java.lang` package contains *wrapper classes* that correspond to each primitive type:

Primitive Type	Wrapper Class
byte	Byte
short	Short
int	Integer
long	Long
float	Float
double	Double
char	Character
boolean	Boolean

Wrapper Classes

- The following declaration creates an `Integer` object which represents the integer 40 as an object

```
Integer age = new Integer(40);
```

- An object of a wrapper class can be used in any situation where a primitive value will not suffice
- For example, some objects serve as containers of other objects
- Primitive values could not be stored in such containers, but wrapper objects could be

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Wrapper Classes

- Wrapper classes also contain static methods that help manage the associated type
- For example, the `Integer` class contains a method to convert an integer stored in a `String` to an `int` value:

```
num = Integer.parseInt(str);
```

- They often contain useful constants as well
- For example, the `Integer` class contains `MIN_VALUE` and `MAX_VALUE` which hold the smallest and largest `int` values

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Autoboxing

- Autoboxing* is the automatic conversion of a primitive value to a corresponding wrapper object:

```
Integer obj;  
int num = 42;  
obj = num;
```

- The assignment creates the appropriate `Integer` object
- The reverse conversion (called *unboxing*) also occurs automatically as needed

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Quick Check

Are the following assignments valid? Explain.

```
Double value = 15.75;
```

Yes. The double literal is autoboxed into a `Double` object.

```
Character ch = new Character('T');  
char myChar = ch;
```

Yes, the char in the object is unboxed before the assignment.

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Summary

- Chapter 3 focused on:
 - object creation and object references
 - the `String` class and its methods
 - the Java standard class library
 - the `Random` and `Math` classes
 - formatting output
 - enumerated types
 - wrapper classes

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