



# CHAPTER 7

## Inheritance

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# Inheritance

- ❑ The sharing of attributes and operations among classes based on a hierarchical relationship
  - It allows code to be *reused*, without having to copy it into the definitions of the derived classes
- ❑ Each subclass inherits all of the properties of its superclass and adds its own unique properties (called extension)
- ❑ **Is-a** relationship



# Introduction to Inheritance

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- ❑ The original class is called the *base class*
- ❑ The new class is called a *derived class*
  - A derived class automatically has all the instance variables and methods that the base class has, and it can have additional methods and/or instance variables as well



# Examples of Derived Classes

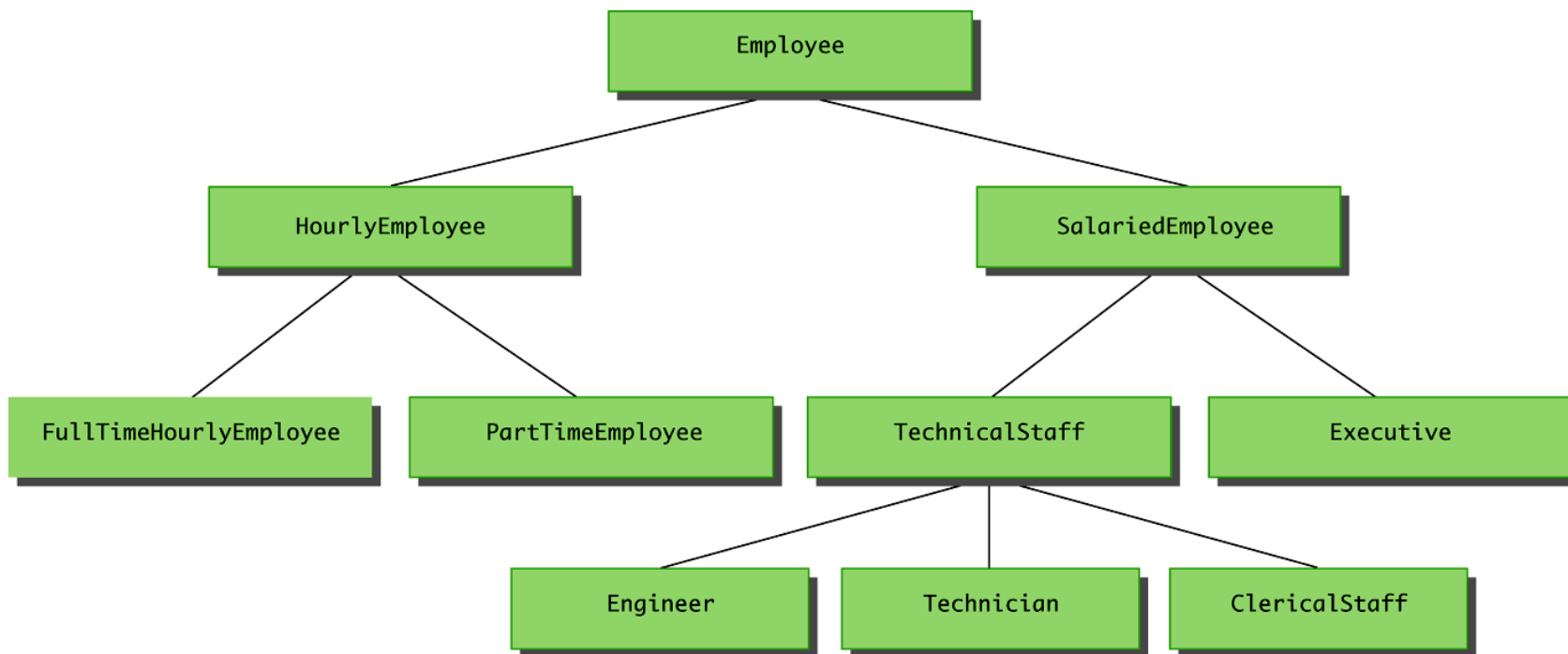
- ❑ Within Java, a class called **Employee** can be defined that includes all employees
- ❑ This class can then be used to define classes for hourly employees and salaried employees
  - In turn, the **HourlyEmployee** class can be used to define a **PartTimeHourlyEmployee** class, and so forth

```
public class HourlyEmployee extends Employee
```



# A Class Hierarchy

Display 7.1 A Class Hierarchy





# Derived Class (Subclass)

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- ☐ Members of a class that are declared **private** are not inherited by subclasses of that class.
- ☐ Only members of a class that are declared **protected** or **public** are inherited by subclasses declared in a package other than the one in which the class is declared.



# Lab

```
import java.util.Date;

public class Employee {

    protected String name;
    protected Date hireDate;

    public Employee(){}

    public Employee(String theName, Date theDate){
        name = theName;
        hireDate = theDate;
    }
    public Date getHireDate(){
        return hireDate;
    }

    public String getName(){
        return name;
    }
}
```



# Lab

---

```
import java.util.Date;

public class HourlyEmployee extends Employee{
    private double wageRate;

    public HourlyEmployee(String theName, Date theDate, double rate){
        name = theName;
        hireDate = theDate;
        wageRate = rate;
    }
}
```





# Lab

---

```
import java.util.Date;

public class Company {

    public static void main(String[] args){

        HourlyEmployee hourlyEmployee = new HourlyEmployee("Josephine",
            new Date(114,0,1), 100);

        System.out.println(hourlyEmployee.getName());

    }
}
```



# Parent and Child Classes

- ❑ A base class is often called the *parent class*
  - A derived class is then called a *child class*
- ❑ These relationships are often extended such that a class that is a parent of a parent . . . of another class is called an *ancestor class*
  - If class **A** is an ancestor of class **B**, then class **B** can be called a *descendent* of class **A**



# Overriding a Method Definition

- ❑ Although a derived class inherits methods from the base class, it can **change** or *override* an inherited method if necessary
  - In order to override a method definition, a new definition of the method is simply placed in the class definition



# Lab

```
import java.util.Date;

public class HourlyEmployee extends Employee{
    private double wageRate;

    public HourlyEmployee(String theName, Date theDate, double rate){
        name = theName;
        hireDate = theDate;
        wageRate = rate;
    }
    public String getName(){
        return "Hourly Employee:" + name;
    }
}
```

Then run Company again!



## Changing the Access Permission of an Overridden Method

- ❑ The access permission of an overridden method can be changed **from private** in the base class **to public** (or some other more permissive access) in the derived class
- ❑ However, the access permission of an overridden method **can not** be changed **from public** in the base class **to a more restricted** access permission in the derived class



# Changing the Access Permission of an Overridden Method

- ❑ Given the following method header in a base case:  
`private void doSomething()`
- ❑ The following method header is valid in a derived class:  
`public void doSomething()`
  
- ❑ Given the following method header in a base case:  
`public void doSomething()`
- ❑ The following method header is not valid in a derived class:  
`private void doSomething()`



## Pitfall: Overriding Versus Overloading

- ❑ When a method is **overridden**, the new method definition given in the derived class has the **exact same number and types of parameters** as in the base class
- ❑ When a method in a derived class has a **different signature** from the method in the base class, that is **overloading**



# The **final** Modifier

- ❑ If the modifier **final** is placed before the definition of a *method*, then that method may not be redefined in a derived class
- ❑ If the modifier **final** is placed before the definition of a *class*, then that class may not be used as a base class to derive other classes





# Lab

```
import java.util.Date;

public class Employee {
    protected String name;
    protected Date hireDate;

    public Employee(){}

    public Employee(String theName, Date theDate){
        name = theName;
        hireDate = theDate;
    }
    public Date getHireDate(){
        return hireDate;
    }
    final public String getName(){
        return name;
    }
}
```

Then see what happens in HourlyEmployee!



# The super Constructor

- ❑ A derived class uses a constructor from the base class to initialize all the data inherited from the base class

- In order to invoke a constructor from the base class, it uses a special syntax:

```
public derivedClass(int p1, int p2, double p3)
{
    super(p1, p2);
    instanceVariable = p3;
}
```

- In the above example, `super(p1, p2);` is a call to the base class constructor



# Lab

Step 1: remove the “final” added in the previous lab.

```
import java.util.Date;

public class HourlyEmployee extends Employee{
    private double wageRate;

    public HourlyEmployee(String theName, Date theDate, double rate){
        super(theName,theDate);
        wageRate = rate;
    }
    public String getName(){
        return "Hourly Employee:" + name;
    }
}
```

Step 2: revise code here

Step 3: then run the Company again!



# The **super** Constructor

- ❑ If a derived class constructor does not include an invocation of **super**, then the no-argument constructor of the base class will automatically be invoked
- ❑ Since the inherited instance variables should be initialized, and the base class constructor is designed to do that, then an explicit call to **super** should always be used



# Lab

```
class A
{
    int a;
    public A()
    {
        a = 7;
        System.out.println("Step 1");
    }
}
```

```
class B extends A
{
    public B()
    {
        System.out.println("Step 2");
    }

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



# The `this` Constructor

- ❑ Often, a no-argument constructor uses `this` to invoke an explicit-value constructor
  - No-argument constructor (invokes explicit-value constructor using `this` and default arguments):

```
public ClassName()  
{  
    this(argument1, argument2);  
}
```

- Explicit-value constructor (receives default values):

```
public ClassName(type1 param1, type2 param2)  
{  
    . . .  
}
```



## **Tip: An Object of a Derived Class Has More than One Type**

- ❑ More generally, an object of a derived class has the type of every one of its ancestor classes**
  - Therefore, an object of a derived class can be assigned to a variable of any ancestor type**
  
- ❑ An ancestor type can never be used in place of one of its derived types**



# Lab

```
import java.util.Date;

public class Company {

    public static void main(String[] args){

        HourlyEmployee hourlyEmployee = new HourlyEmployee("Josephine",
            new Date(114,0,1), 100);

        System.out.println(hourlyEmployee.getName());

        Employee someEmploy = hourlyEmployee;
        printHireDate(someEmploy);
    }

    public static void printHireDate(Employee someEmploy){
        System.out.println(someEmploy.getHireDate());
    }
}
```





# Modifiers

Modifier	Class	Package	Subclass	World
public	V	V	V	V
protected	V	V	V	X
default (package access)	V	V	X	X
private	V	X	X	X



# Protected and Package Access

- ❑ The **protected** modifier provides very weak protection compared to the **private** modifier
  - It allows direct access for any programmer who defines a suitable derived class
  - Therefore, instance variables should normally not be marked **protected**



# Lab

```
import java.util.Date;

public class Employee {

    private String name;
    private Date hireDate;

    public Employee(){}

    public Employee(String theName, Date theDate){
        name = theName;
        hireDate = theDate;
    }

    public Date getHireDate(){
        return hireDate;
    }

    public String getName(){
        return name;
    }

}
```



# Lab

```
import java.util.Date;

public class HourlyEmployee extends Employee{
    private double wageRate;

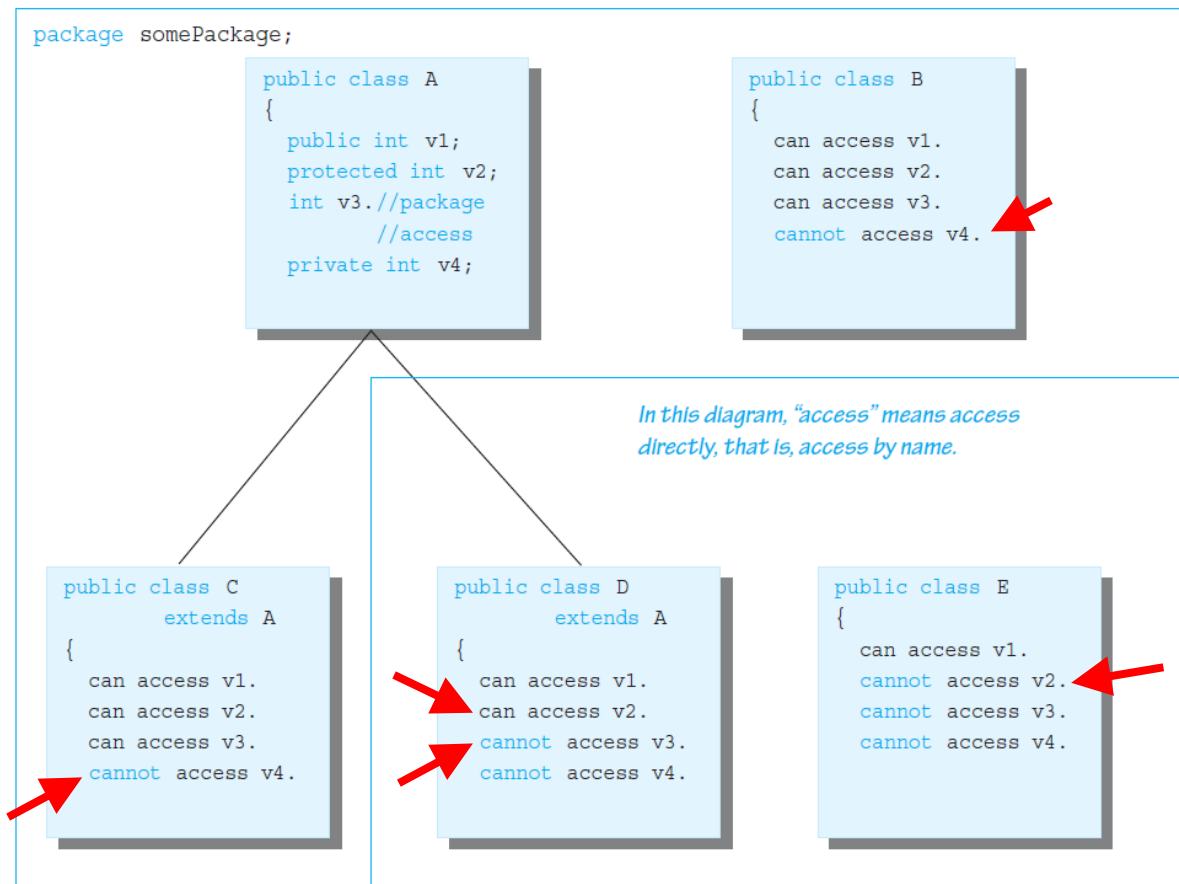
    public HourlyEmployee(String theName, Date theDate, double rate){
        super(theName,theDate);
        wageRate = rate;
    }
    public String getName(){
        return "Hourly Employee:" + super.getName();
    }
}
```

Then run Company again!



# Access Modifiers

Display 7.9 Access Modifiers





## Tip: "Is a" Versus "Has a"

- ❑ A derived class demonstrates an *"is a"* relationship between it and its base class
  - Forming an "is a" relationship is one way to make a more complex class out of a simpler class
  - For example, an **HourlyEmployee** *"is an"* **Employee**
  - **HourlyEmployee** is a more complex class compared to the more general **Employee** class



## Tip: "Is a" Versus "Has a"

- ❑ Another way to make a more complex class out of a simpler class is through a *"has a"* relationship
  - This type of relationship, called *composition*, occurs when a class contains an instance variable of a class type
  - The **Employee** class contains an instance variable, **hireDate**, of the class **Date**, so therefore, an **Employee** *"has a"* **Date**



## Tip: "Is a" Versus "Has a"

- ❑ Both kinds of relationships are commonly used to create complex classes, often within the same class
  - Since **HourlyEmployee** is a derived class of **Employee**, and contains an instance variable of class **Date**, then **HourlyEmployee** *"is an"* **Employee** and *"has a"* **Date**





# You Cannot Use Multiple supers

- ❑ It is only valid to use **super** to invoke a method from a direct parent
  - Repeating **super** will not invoke a method from some other ancestor class
- ❑ For example, if the **Employee** class were derived from the class **Person**, and the **HourlyEmployee** class were derived from the class **Employee**, it would not be possible to invoke the **toString** method of the **Person** class within a method of the **HourlyEmployee** class

**super.super.toString() // ILLEGAL!**



# The Class Object

- ❑ In Java, every class is a descendent of the class *Object*
  - Every class has *Object* as its ancestor
  - Every object of every class is of type *Object*, as well as being of the type of its own class
- ❑ If a class is defined that is not explicitly a derived class of another class, it is still automatically a derived class of the class *Object*



# The Class `Object`

- ❑ The class `Object` is in the package `java.lang` which is always imported automatically
- ❑ Having an `Object` class enables methods to be written with a parameter of type `Object`
  - A parameter of type `Object` can be replaced by an object of any class
  - For example, some library methods accept an argument of type `Object` so they can be used with an argument that is an object of any class



# The Class Object

- ❑ The class **Object** has some methods that every Java class inherits
  - For example, the **equals** and **toString** methods
- ❑ Every object inherits these methods from some ancestor class
  - Either the class **Object** itself, or a class that itself inherited these methods (ultimately) from the class **Object**
- ❑ However, these inherited methods should be overridden with definitions more appropriate to a given class
  - Some Java library classes assume that every class has its own version of such methods



# Methods of Object

Modifier and Type	Method and Description
protected <a href="#">Object</a>	<a href="#">clone()</a> Creates and returns a copy of this object.
boolean	<a href="#">equals(<a href="#">Object</a> obj)</a> Indicates whether some other object is "equal to" this one.
protected void	<a href="#">finalize()</a> Called by the garbage collector on an object when garbage collection determines that there are no more references to the object.
<a href="#">Class</a> <?>	<a href="#">getClass()</a> Returns the runtime class of this Object.
int	<a href="#">hashCode()</a> Returns a hash code value for the object.
void	<a href="#">notify()</a> Wakes up a single thread that is waiting on this object's monitor.
void	<a href="#">notifyAll()</a> Wakes up all threads that are waiting on this object's monitor.
<a href="#">String</a>	<a href="#">toString()</a> Returns a string representation of the object.
void	<a href="#">wait()</a> Causes the current thread to wait until another thread invokes the <a href="#">notify()</a> method or the <a href="#">notifyAll()</a> method for this object.
void	<a href="#">wait(long timeout)</a> Causes the current thread to wait until either another thread invokes the <a href="#">notify()</a> method or the <a href="#">notifyAll()</a> method for this object, or a specified amount of time has elapsed.
void	<a href="#">wait(long timeout, int nanos)</a> Causes the current thread to wait until another thread invokes the <a href="#">notify()</a> method or the <a href="#">notifyAll()</a> method for this object, or some other thread interrupts the current thread, or a certain amount of real time has elapsed.



# The Right Way to Define equals

- ❑ Since the `equals` method is always inherited from the class `Object`, methods like the following simply overload it:

```
public boolean equals(Employee otherEmployee)
{ . . . }
```



# Lab

```
import java.util.Date;

public class Employee {
    private String name;
    private Date hireDate;

    public Employee(){}

    public Employee(String theName, Date theDate){
        name = theName;
        hireDate = theDate;
    }
    public Date getHireDate(){
        return hireDate;
    }

    public String getName(){
        return name;
    }

    public boolean equals(Employee otherone){
        if(otherone.getName().equals(this.name) && otherone.getHireDate().equals(this.hireDate)){
            return true;
        }else{
            return false;
        }
    }
}
```



# Lab

```
import java.util.Date;

public class CompareTest {

    public static void main(String[] args) {
        Employee employeeA = new Employee("Josephine", new Date(114,0,1));
        Employee employeeB = new Employee("Josephine", new Date(114,0,1));

        System.out.println(employeeA.equals(employeeB));

        System.out.println(employee == employeeB);
    }
}
```





# instanceof and getClass

- ❑ Both the **instanceof** operator and the **getClass()** method can be used to check the class of an object
- ❑ However, the **getClass()** method is more exact
  - The **instanceof** operator simply tests the class of an object
  - The **getClass()** method used in a test with **==** or **!=** tests if two objects *were created with* the same class



# The `instanceof` Operator

- ❑ The `instanceof` operator checks if an object is of the type given as its second argument

`Object instanceof ClassName`

- This will return `true` if `Object` is of type `ClassName`, and otherwise return `false`
- Note that this means it will return `true` if `Object` is the type of *any descendent class* of `ClassName`



# The `getClass()` Method

- ❑ Every object inherits the same `getClass()` method from the `Object` class
  - This method is marked `final`, so it cannot be overridden
- ❑ An invocation of `getClass()` on an object returns a representation *only* of the class that was used with `new` to create the object
  - The results of any two such invocations can be compared with `==` or `!=` to determine whether or not they represent the exact same class

`(object1.getClass() == object2.getClass())`



# Lab

```
import java.util.Date;

public class CompareTest {

    public static void main(String[] args) {
        Employee employeeA = new Employee("Josephine", new Date(114,0,1));
        Employee employeeB = new Employee("Josephine", new Date(114,0,1));

        System.out.println(employeeA.equals(employeeB));

        System.out.println(employeeA == employeeB);

        if(employeeA instanceof Employee){
            System.out.println(employeeA.getName() + " is an object of Employee");
        }

        System.out.println(employeeA.getClass().getName());

    }

}
```



# Lab

---

Inheritance is the process by which a new class – known as a \_\_\_\_\_ - is created from another class, called the \_\_\_\_\_.

- (a) base class, derived class
- (b) derived class, base class
- (c) inherited class, base class
- (d) base class, inherited class



# Lab

---

Inheritance promotes code \_\_\_\_\_.

- (a)reinvention
- (b)reuse
- (c)repeats
- (d)all of the above



# Lab

---

The keyword **extends** indicates:

- (a)encapsulation
- (b)polymorphism
- (c)inheritance
- (d)none of the above



# Lab

---

A derived class is also called a

- (a) sub class
- (b) super class
- (c) base class
- (d) all of the above





# Lab

---

A super class is also called a

- (a) derived class
- (b) dominant class
- (c) sub class
- (d) base class



# Lab

---

What does a derived class automatically inherit from the base class?

- (a)instance variables
- (b)static variables
- (c)public methods
- (d)all of the above



# Lab

---

If the final modifier is added to the definition of a method, this means:

- (a) The method may be redefined in the derived class.
- (b) The method may be redefined in the sub class.
- (c) The method may not be redefined in the derived class.
- (d) None of the above.



# Lab

---

The special syntax for invoking a constructor of the base class is:

- (a) `super()`
- (b) `base()`
- (c) `parent()`
- (d) `child()`



# Lab

---

If an instance variable is not modified by public, protected or private then it is said to have:

- (a)Package access
- (b)Default access
- (c)Friendly access
- (d)All of the above



# Lab

---

The class \_\_\_\_\_ is an ancestor class of all Java classes.

- (a)String
- (b)Object
- (c)Math
- (d)JFrame



# Lab

Consider the classes below, declared in the same file:

```
class A
{
    int a;
    public A()
    {
        a = 7;
    }
}
```

```
class B extends A
{
    int b;
    public B()
    {
        b = 8;
    }
}
```

```
public class ABTest {
    public static void main
        (String[] args){
        B obj1 = new B();

        System.out.println(obj1.a);
        System.out.println(obj1.b);
    }
}
```

Which of the statements below is *false*?

- a. Both variables **a** and **b** are instance variables.
- b. After the constructor for **class B** executes, the variable **a** will have the value 7.
- c. After the constructor for **class B** executes, the variable **b** will have the value 8.
- d. A reference of type **A** can be treated as a reference of type **B**.



# Lab

```
public class Bicycle {  
  
    public int speed;  
  
    public Bicycle(int startSpeed) {  
        speed = startSpeed;  
    }  
  
    public void applyBrake(int decrement) {  
        speed -= decrement;  
    }  
  
    public void speedUp(int increment) {  
        speed += increment;  
    }  
  
}
```





# Lab

```
public class MountainBike extends Bicycle {  
  
    public int seatHeight;  
  
    public MountainBike(int startHeight,  
                        int startSpeed) {  
        super(startSpeed);  
        seatHeight = startHeight;  
    }  
  
    public void setHeight(int newValue) {  
        seatHeight = newValue;  
    }  
}
```



# Lab

```
public class BikeTest {  
  
    public static void main(String[] args) {  
        MountainBike myBike = new MountainBike(10,20);  
  
        for(int i=0;i<100;i++){  
            myBike.speedUp(1);  
        }  
        System.out.println(myBike.speed);  
  
        myBike.setHeight(10);  
        System.out.println(myBike.seatHeight);  
    }  
}
```



# Reference

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- ❑ “A Programmers Guide To Java SCJP Certification: A Comprehensive Primer 3rd Edition”. Khalid Mughal, Rolf Rasmussen. Addison-Wesley Professional. 2008