CS112

Inheritance
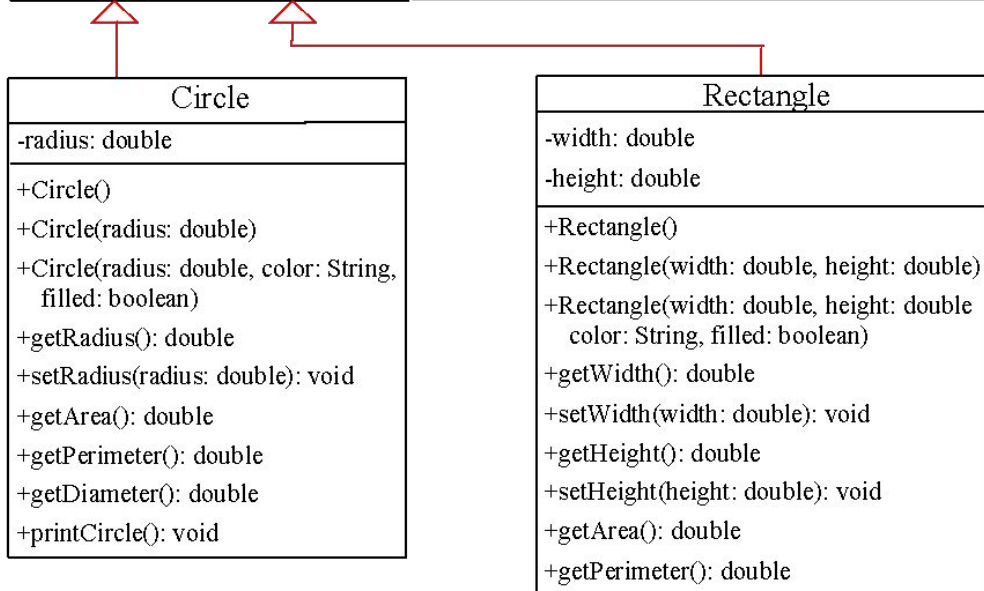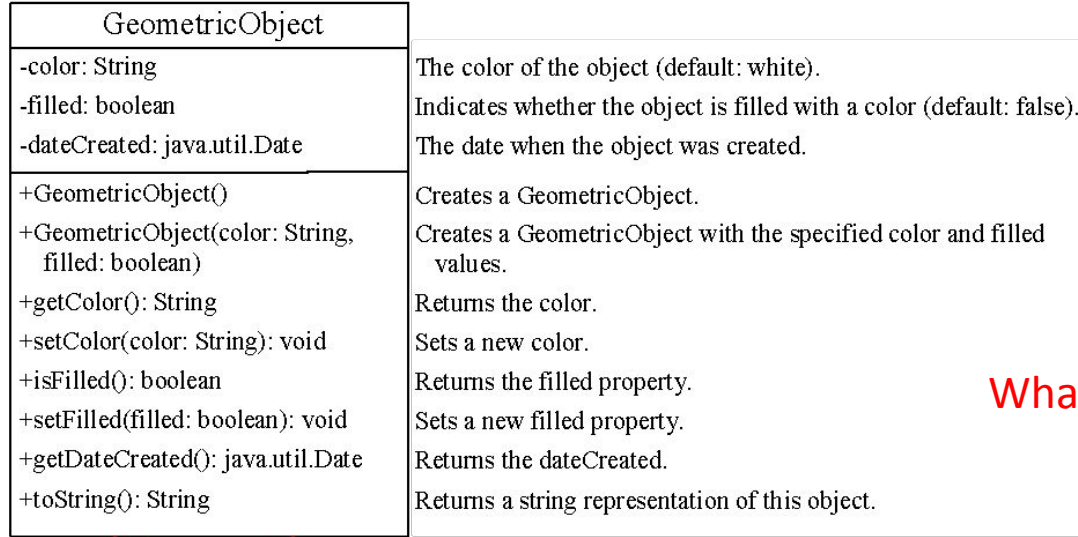
Lecture 05

الفصل الدراسي الثاني 1442 -Spring 2021

College of Computer Science and Engineering

Superclasses and Subclasses
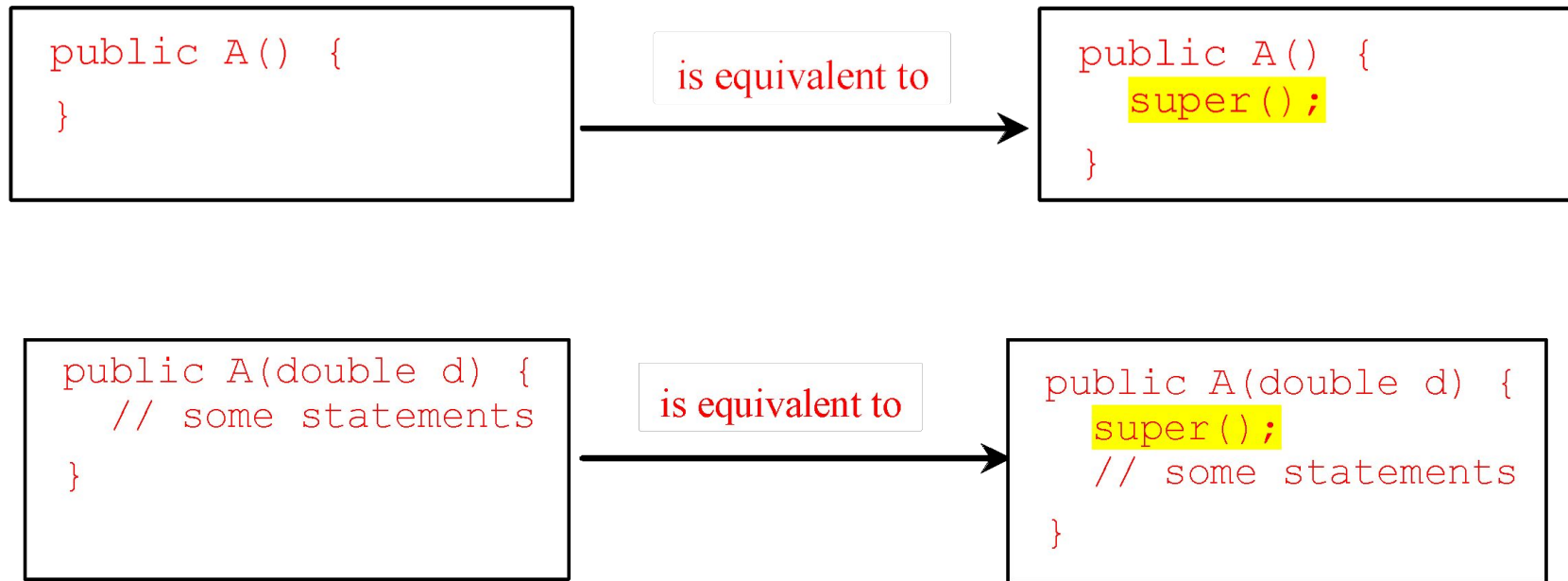
GeometricObject	
-color: String	The color of the object (default: white).
-filled: boolean	Indicates whether the object is filled with a color (default: false).
-dateCreated: java.util.Date	The date when the object was created.
+GeometricObject()	Creates a GeometricObject.
+GeometricObject(color: String, filled: boolean)	Creates a GeometricObject with the specified color and filled values.
+getColor(): String	Returns the color.
+setColor(color: String): void	Sets a new color.
+isFilled(): boolean	Returns the filled property.
+setFilled(filled: boolean): void	Sets a new filled property.
+getDateCreated(): java.util.Date	Returns the dateCreated.
+toString(): String	Returns a string representation of this object.

What is the relation between the three classes if there is no inheritance?

Circle
-radius: double
+Circle()
+Circle(radius: double)
+Circle(radius: double, color: String, filled: boolean)
+getRadius(): double
+setRadius(radius: double): void
+getArea(): double
+getPerimeter(): double
+getDiameter(): double
+printCircle(): void

Rectangle
-width: double
-height: double
+Rectangle()
+Rectangle(width: double, height: double)
+Rectangle(width: double, height: double color: String, filled: boolean)
+getWidth(): double
+setWidth(width: double): void
+getHeight(): double
+setHeight(height: double): void
+getArea(): double
+getPerimeter(): double

Are superclass's Constructor Inherited?

- No. They are not inherited

- They are invoked explicitly or implicitly

- Explicitly using the super keyword

- A constructor is used to construct an instance of a class.

- Unlike properties and methods, a superclass's constructors are not inherited in the subclass.

- They can only be invoked from the subclasses' constructors, using the keyword <u>super</u>. *If the keyword <u>super</u> is not explicitly used, the superclass's no-arg constructor is automatically invoked.*

Superclass's Constructor Is Always Invoked

- A constructor may invoke an overloaded constructor or its superclass's constructor. If none of them is invoked explicitly, the compiler puts <u>super()</u> as the first statement in the constructor. For example,

```
public A() {

}
```

is equivalent to

```
public A() {
    super();

}
```

```
public A(double d) {
    // some statements
}
```

is equivalent to

```
public A(double d) {
    super();
    // some statements

}
```

Using the Keyword `super`

- The keyword `super` refers to the superclass of the class in which `super` appears. This keyword can be used in two ways:

  - To call a superclass constructor

  - To call a superclass method

CAUTION

You must use the keyword <u>super</u> to call the superclass constructor. Invoking a superclass constructor's name in a subclass causes a syntax error. Java requires that the statement that uses the keyword <u>super</u> appear first in the constructor.

Constructor Chaining

- Constructing an instance of a class invokes all the superclasses' constructors along the inheritance chain.

This is known as *constructor chaining*.

```java
public class Faculty extends Employee {
  public static void main(String[] args) {
    new Faculty();
  }

  public Faculty() {
    System.out.println("(4) Faculty's no-arg constructor is invoked");
  }
}

class Employee extends Person {
  public Employee() {
    this("(2) Invoke Employee's overloaded constructor");
    System.out.println("(3) Employee's no-arg constructor is invoked");
  }

  public Employee(String s) {
    System.out.println(s);
  }
}

class Person {
  public Person() {
    System.out.println("(1) Person's no-arg constructor is invoked");
  }
}
```

Trace Execution (1)

```java
public class Faculty extends Employee {
    public static void main(String[] args) {
        new Faculty();
    }

    public Faculty() {
        System.out.println("(4) Faculty's no-arg constructor is invoked");
    }
}

class Employee extends Person {
    public Employee() {
        this("(2) Invoke Employee's overloaded constructor");
        System.out.println("(3) Employee's no-arg constructor is invoked");
    }

    public Employee(String s) {
        System.out.println(s);
    }
}

class Person {
    public Person() {
        System.out.println("(1) Person's no-arg constructor is invoked");
    }
}
```

1. Start from the main method

Trace Execution (2)

```java
public class Faculty extends Employee {
  public static void main(String[] args) {
    new Faculty();
  }

  public Faculty() {
    System.out.println("(4) Faculty's no-arg constructor is invoked");
  }
}

class Employee extends Person {
  public Employee() {
    this("(2) Invoke Employee's overloaded constructor");
    System.out.println("(3) Employee's no-arg constructor is invoked");
  }

  public Employee(String s) {
    System.out.println(s);
  }
}

class Person {
  public Person() {
    System.out.println("(1) Person's no-arg constructor is invoked");
  }
}
```

2. Invoke Faculty constructor

Trace Execution (3)

```java
public class Faculty extends Employee {
  public static void main(String[] args) {
    new Faculty();
  }

  public Faculty() {
    System.out.println("(4) Faculty's no-arg constructor is invoked");
  }
}

class Employee extends Person {
  public Employee() {
    this("(2) Invoke Employee's overloaded constructor");
    System.out.println("(3) Employee's no-arg constructor is invoked");
  }

  public Employee(String s) {
    System.out.println(s);
  }
}

class Person {
  public Person() {
    System.out.println("(1) Person's no-arg constructor is invoked");
  }
}
```

3. Invoke Employee's no-arg constructor

Trace Execution (4)

```java
public class Faculty extends Employee {
  public static void main(String[] args) {
    new Faculty();
  }

  public Faculty() {
    System.out.println("(4) Faculty's no-arg constructor is invoked");
  }
}

class Employee extends Person {
  public Employee() {
    this("(2) Invoke Employee's overloaded constructor");
    System.out.println("(3) Employee's no-arg constructor is invoked");
  }

  public Employee(String s) {
    System.out.println(s);
  }
}

class Person {
  public Person() {
    System.out.println("(1) Person's no-arg constructor is invoked");
  }
}
```

> 4. Invoke Employee(String) constructor

Trace Execution (5)

```java
public class Faculty extends Employee {
  public static void main(String[] args) {
    new Faculty();
  }

  public Faculty() {
    System.out.println("(4) Faculty's no-arg constructor is invoked");
  }
}

class Employee extends Person {
  public Employee() {
    this("(2) Invoke Employee's overloaded constructor");
    System.out.println("(3) Employee's no-arg constructor is invoked");
  }

  public Employee(String s) {
    System.out.println(s);
  }
}

class Person {
  public Person() {
    System.out.println("(1) Person's no-arg constructor is invoked");
  }
}
```

5. Invoke Person() constructor

Trace Execution (6)

```java
public class Faculty extends Employee {
    public static void main(String[] args) {
        new Faculty();
    }

    public Faculty() {
        System.out.println("(4) Faculty's no-arg constructor is invoked");
    }
}

class Employee extends Person {
    public Employee() {
        this("(2) Invoke Employee's overloaded constructor");
        System.out.println("(3) Employee's no-arg constructor is invoked");
    }

    public Employee(String s) {
        System.out.println(s);
    }
}

class Person {
    public Person() {
        System.out.println("(1) Person's no-arg con...
    }
}
```

6. Execute println

Trace Execution (7)

```java
public class Faculty extends Employee {
  public static void main(String[] args) {
    new Faculty();
  }

  public Faculty() {
    System.out.println("(4) Faculty's no-arg constructor is invoked");
  }
}

class Employee extends Person {
  public Employee() {
    this("(2) Invoke Employee's overloaded constructor");
    System.out.println("(3) Employee's no-arg constructor is invoked");
  }

  public Employee(String s) {
    System.out.println(s);
  }
}

class Person {
  public Person() {
    System.out.println("(1) Person's no-arg con
  }
}
```

7. Execute println

Trace Execution (8)

```java
public class Faculty extends Employee {
  public static void main(String[] args) {
    new Faculty();
  }

  public Faculty() {
    System.out.println("(4) Faculty's no-arg constructor is invoked");
  }
}

class Employee extends Person {
  public Employee() {
    this("(2) Invoke Employee's overloaded constructor");
    System.out.println("(3) Employee's no-arg constructor is invoked");
  }

  public Employee(String s) {
    System.out.println(s);
  }
}

class Person {
  public Person() {
    System.out.println("(1) Person's no-arg con
  }
}
```

8. Execute println

Trace Execution (9)

```java
public class Faculty extends Employee {
    public static void main(String[] args) {
        new Faculty();
    }

    public Faculty() {
        System.out.println("(4) Faculty's no-arg constructor is invoked");
    }
}

class Employee extends Person {
    public Employee() {
        this("(2) Invoke Employee's overloaded constructor");
        System.out.println("(3) Employee's no-arg constructor is invoked");
    }

    public Employee(String s) {
        System.out.println(s);
    }
}

class Person {
    public Person() {
        System.out.println("(1) Person's no-arg constructor is invoked");
    }
}
```

9. Execute println

Example on the Impact of a Superclass without no-arg Constructor

- Find out the errors in the program:

```java
public class Apple extends Fruit {
}

class Fruit {
  public Fruit(String name) {
    System.out.println("Fruit's constructor is invoked");
  }
}
```

Defining a Subclass

- A subclass inherits from a superclass.

- You can also:
  - Add new properties
  - Add new methods
  - Override the methods of the superclass

Calling Superclass Methods

- You could rewrite the <u>printCircle()</u> method in the <u>Circle</u> class as follows:

```java
public void printCircle() {
    System.out.println("The circle is created " +
        super.getDateCreated() + " and the radius is " + radius);
}
```

Overriding Methods in the Superclass

- A subclass inherits methods from a superclass. Sometimes it is necessary for the subclass to modify the implementation of a method defined in the superclass. This is referred to as *method overriding*.

```java
public class Circle extends GeometricObject {
  // Other methods are omitted


  /** Override the toString method defined in GeometricObject */
  public String toString() {
    return super.toString() + "\nradius is " + radius;
  }

}
```

NOTE

An instance method can be overridden only if it is accessible. Thus a private method cannot be overridden, because it is not accessible outside its own class. If a method defined in a subclass is private in its superclass, the two methods are completely unrelated.

NOTE

Like an instance method, a static method can be inherited. However, a static method cannot be overridden. If a static method defined in the superclass is redefined in a subclass, the method defined in the superclass is hidden.

Overriding vs. Overloading

```java
public class Test {
  public static void main(String[] args) {
    A a = new A();
    a.p(10);
    a.p(10.0);
  }
}


class B {
  public void p(double i) {
    System.out.println(i * 2);
  }
}


class A extends B {
  // This method overrides the method in B
  public void p(double i) {
    System.out.println(i);
  }
}
```

```java
public class Test {
  public static void main(String[] args) {
    A a = new A();
    a.p(10);
    a.p(10.0);
  }
}


class B {
  public void p(double i) {
    System.out.println(i * 2);
  }
}


class A extends B {
  // This method overloads the method in B
  public void p(int i) {
    System.out.println(i);
  }
}
```

The <u>Object</u> Class and Its Methods

- Every class in Java is descended from the java.lang.Object class. If no inheritance is specified when a class is defined, the superclass of the class is Object.

```
public class Circle {
   ...
}
```

Equivalent

```
public class Circle extends Object {
   ...
}
```
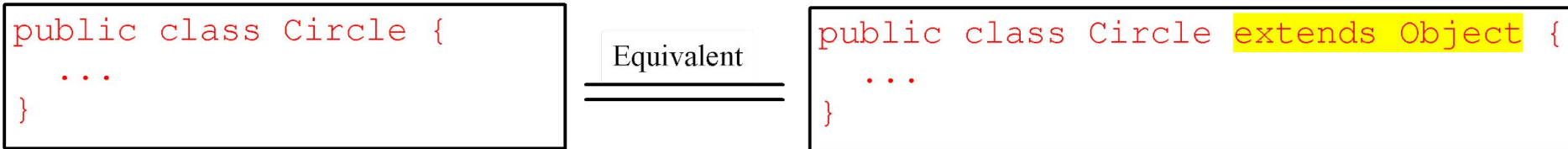
The toString() method in Object

- The toString() method returns a string representation of the object. The default implementation returns a string consisting of a class name of which the object is an instance, the at sign (@), and a number representing this object.

```
Loan loan = new Loan();
System.out.println(loan.toString());
```

- The code displays something like Loan@15037e5 . This message is not very helpful or informative. Usually you should override the toString method so that it returns a digestible string representation of the object.