Inheritance

Introduction to Programming and Computational Problem Solving II

CSE 8B

Lecture 12

Announcements

- Assignments 2-4 upgrades due today, 11:59 PM
- Assignment 5 is due Feb 24, 11:59 PM
  - Upgrade beginning Feb 27, 12:01 AM

Inheritance

- Suppose you define classes to model circles, rectangles, and triangles
- These classes have many common features
- What is the best way to design these classes so to avoid redundancy?
- Object-oriented programming allows you to define new classes from existing classes
- This is called *inheritance*

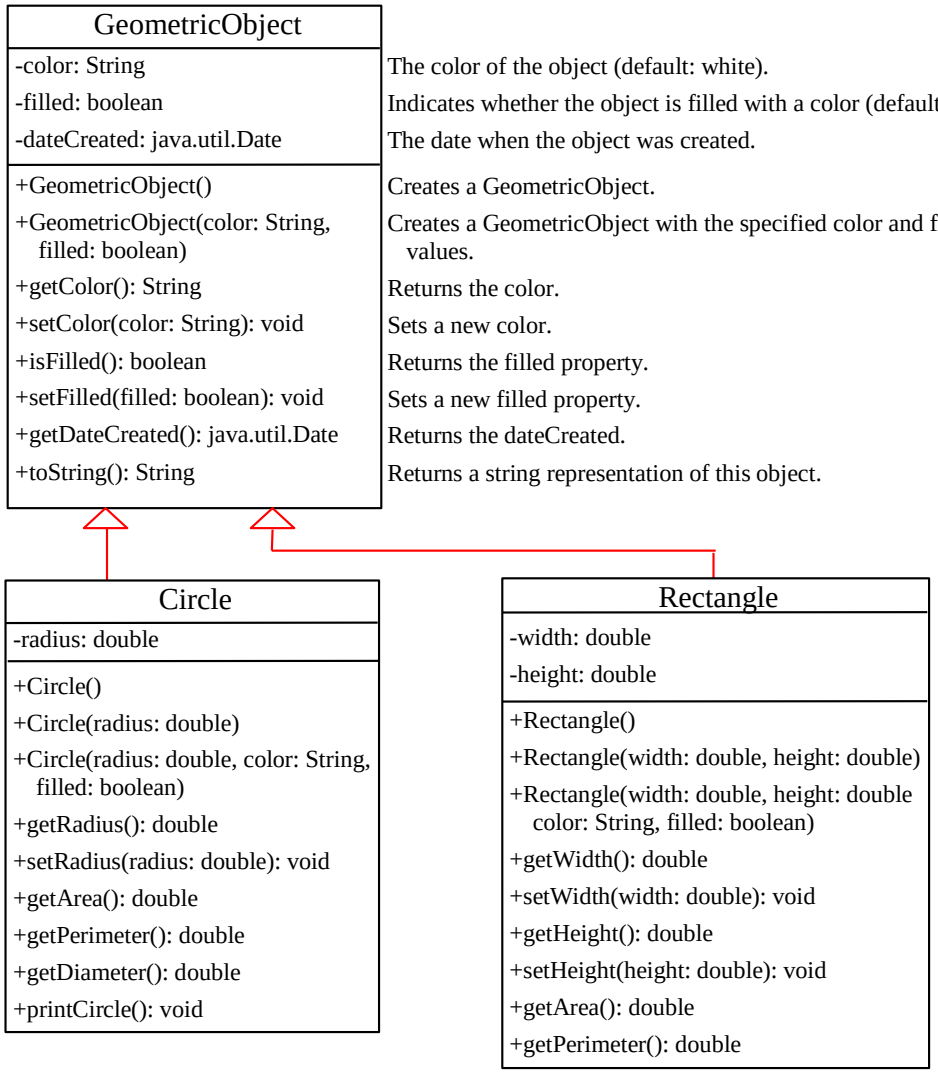
Superclasses and subclasses

- Inheritance enables you to define a general class (i.e., a *superclass*) and later extend it to more specialized classes (i.e., *subclasses*)
- A subclass inherits from a superclass
  - For example, both a circle and a rectangle are geometric objects
    - `GeometricObject` is a superclass
    - `Circle` is a subclass of `GeometricObject`
    - `Rectangle` is a subclass of `GeometricObject`
- Models **is-a** relationships
  - For example
    - Circle **is-a** GeometricObject
    - Rectangle **is-a** GeometricObject

Superclasses and subclasses

Superclass

Subclasses



Superclasses and subclasses

- A subclass *inherits* accessible data fields and methods from its superclass and may also add *new* data fields and methods
  - **A subclass is not a subset of its superclass**
    - A subclass usually contains *more* information and methods than its superclass
  - For example
    - A rectangle has a width and height
    - A circle has a radius
    - Both have a color

Superclasses and subclasses

- A **superclass** is also called a *parent class* or *base class*
- A **subclass** is also called a *child class*, *extended class*, or *derived class*
  - A child class inherits from a parent class
  - A subclass extends a superclass
  - A derived class derives from a base class

Superclasses and subclasses

- Remember, a class defines a type
- A type defined by a subclass is called a *subtype*, and a type defined by its superclass is called a *supertype*
  - For example
    - `Circle` is a subtype of `GeometricObject`, and `GeometricObject` is a supertype for `Circle`

Inheritance

- The keyword `extends` tells the compiler that the (sub)class extends another (super)class
- A Java class may inherit directly from only one superclass
  - This restriction is known as *single inheritance*
  - Some other programming languages allow classes to inherit from one or more classes
    - This is known as *multiple inheritance*

`extends` keyword

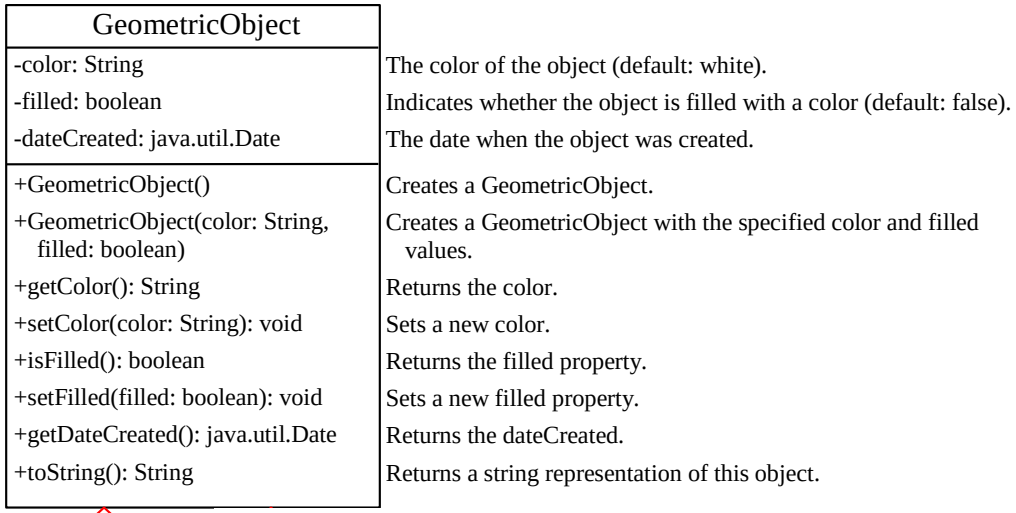
- The keyword `extends` tells the compiler that the (sub)class extends another (super)class
- For example
  - The `Circle` class extends the `GeometricObject` class using the syntax

```
public class Circle extends GeometricObject
```

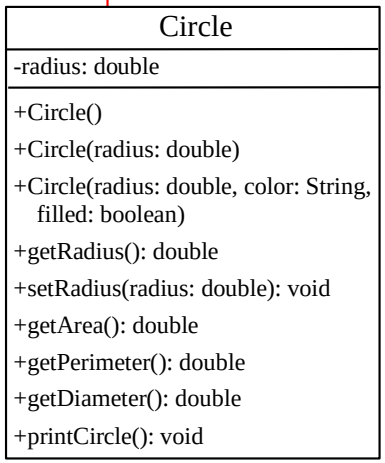
  - The `Circle` class inherits the **accessible** data fields and methods of `GeometricObject`

Circle extends GeometricObject

Superclass



Subclass




```
public class Circle extends GeometricObject {
  private double radius;

  public Circle() {
  }

  public Circle(double radius) {
    this.radius = radius;
  }
```

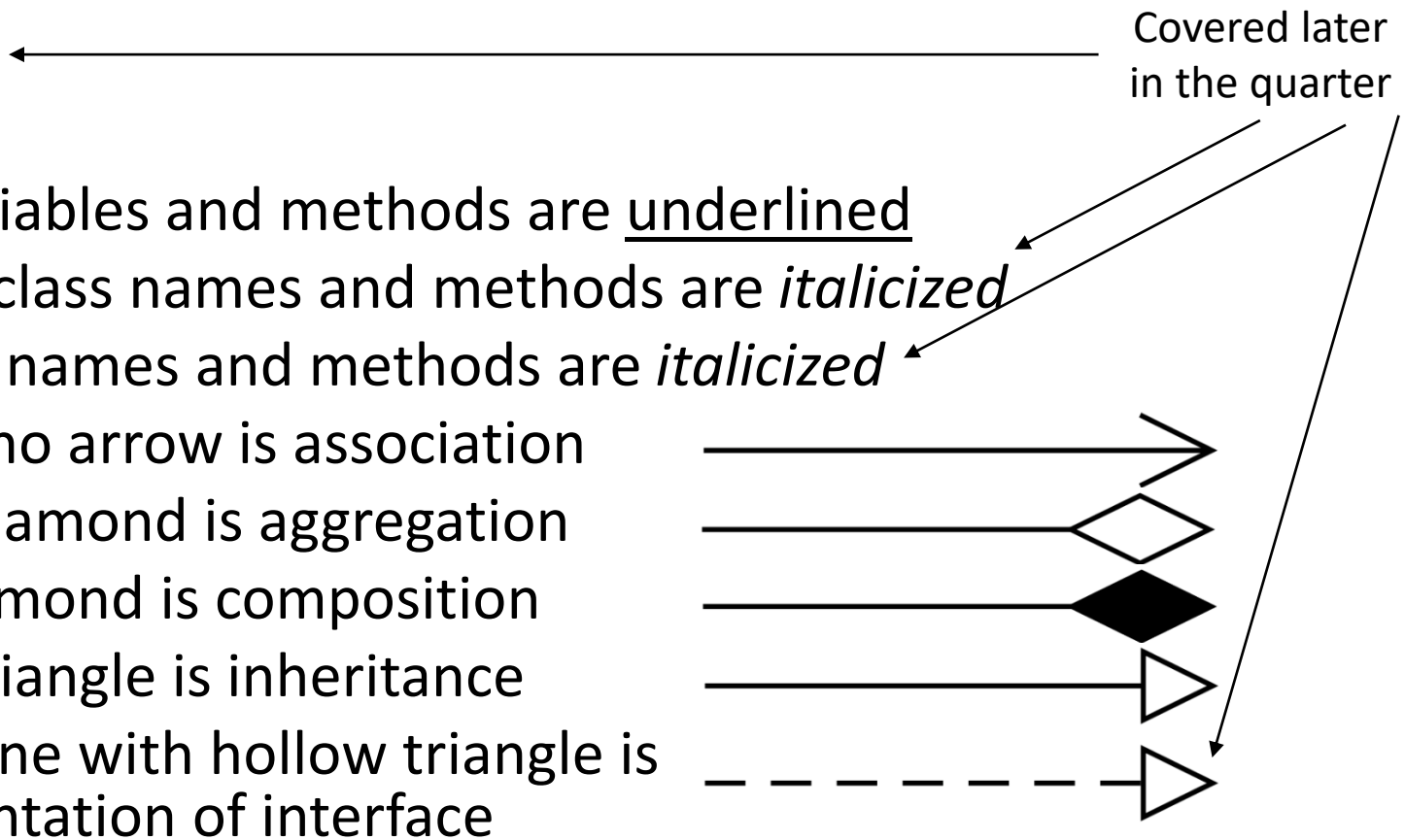
Unified Modeling Language (UML)

+ public

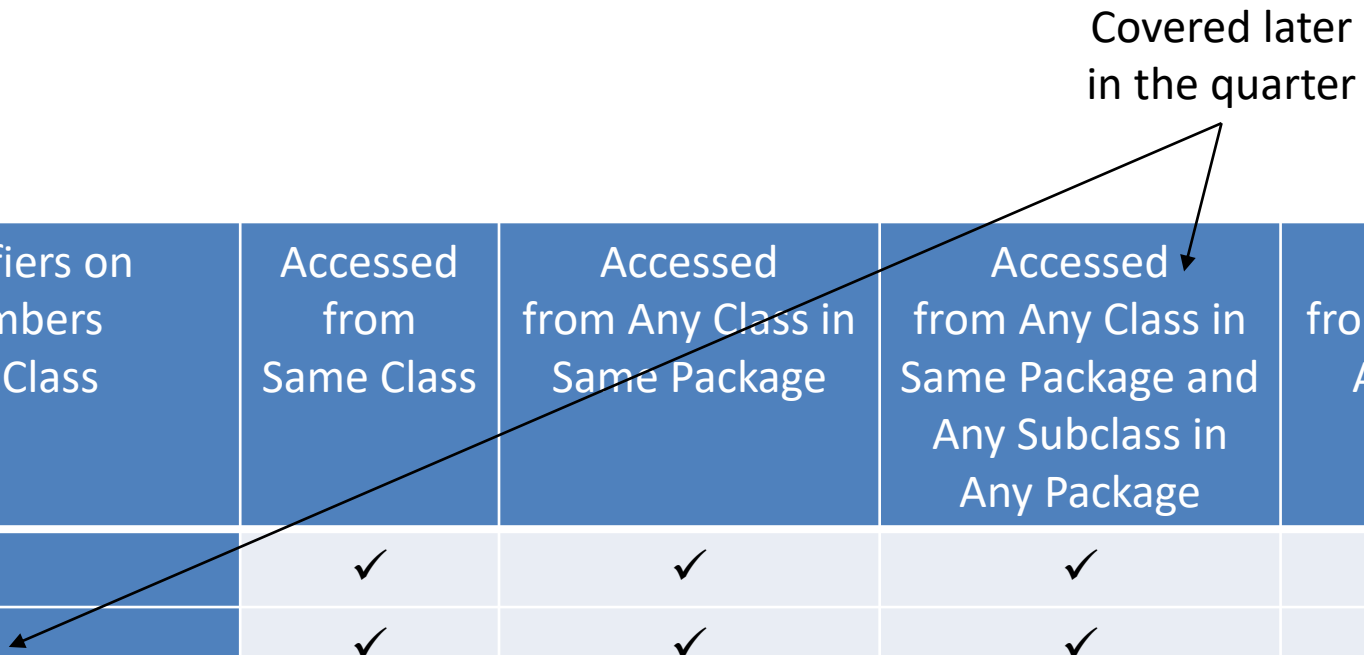
protected

- private

- Static variables and methods are underlined
- Abstract class names and methods are *italicized*
- Interface names and methods are *italicized*
- Open or no arrow is association
- Hollow diamond is aggregation
- Filled diamond is composition
- Hollow triangle is inheritance
- Dashed line with hollow triangle is implementation of interface



Methods and data fields visibility



Modifiers on Members in a Class	Accessed from Same Class	Accessed from Any Class in Same Package	Accessed from Any Class in Same Package and Any Subclass in Any Package	Accessed from Any Class in Any Package
Public	✓	✓	✓	✓
Protected	✓	✓	✓	
Default (no modifier)	✓	✓		
Private	✓			

Methods and data fields visibility

- **Private members cannot be accessed outside of a class, including one of its subclasses**
  - Use accessor (getter) and mutator (setter) methods

```
public class Circle extends GeometricObject {
  private double radius;

  public Circle() {
  }

  public Circle(double radius) {
    this.radius = radius;
  }

  public Circle(double radius, String color, boolean filled) {
    this.radius = radius;
    setColor(color);
    setFilled(filled);
  }
```

Superclass constructors and the `super` keyword

- Remember, 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 `super`
- **If the keyword `super` is not explicitly used, the superclass's no-arg constructor is automatically invoked**

Superclass constructors and the super keyword

- For example, replace this

```
public class Circle extends GeometricObject {
  private double radius;

  public Circle(double radius, String color, boolean filled) {
    this.radius = radius;
    setColor(color);
    setFilled(filled);
  }
```

with this

```
public class Circle extends GeometricObject {
  private double radius;

  public Circle(double radius, String color, boolean filled) {
    super(color, filled);
    this.radius = radius;
  }
```

Invoking the superclass constructor using super must be the first statement in the subclass's constructor

Superclass constructors and the `super` keyword

- If the keyword `super` is not explicitly used, the superclass's no-arg constructor is automatically invoked (as the **first** statement in the constructor)

```
public A() {
}
```

is equivalent to

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

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

is equivalent to

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

- When used in a constructor, both `this` and `super` must be the first statement in the constructor. If `this` is the first statement in the constructor, then an implied `super` is not called in that constructor because it is (directly or indirectly) called in the constructor called by `this`.

Constructor chaining

- Constructing an instance of a class invokes **all** the superclasses' constructors along the inheritance chain
- This is known as *constructor chaining*

Constructor chaining

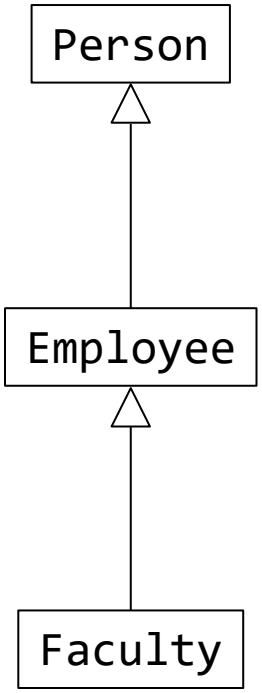
```
public class Faculty extends Employee {
  public static void main(String[] args) {
    new Faculty();
  }

  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 code

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

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class Employee extends Person {
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  public Employee(String s) {
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}

class Person {
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  }
}
```
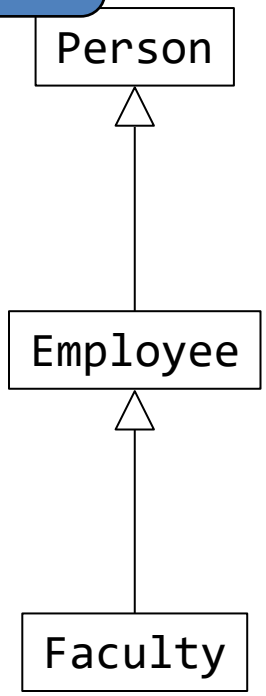

1. Start from the main method



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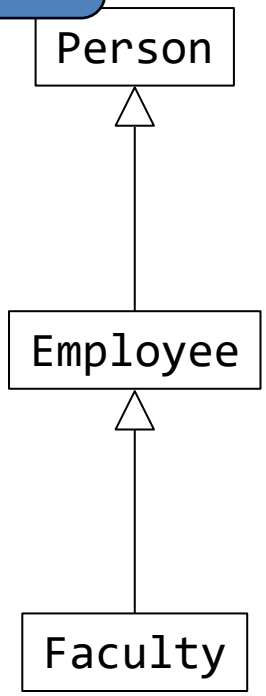
}
```

2. Invoke Faculty constructor



Trace code

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  public Employee(String s) {
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class Person {
  public Person() {
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```

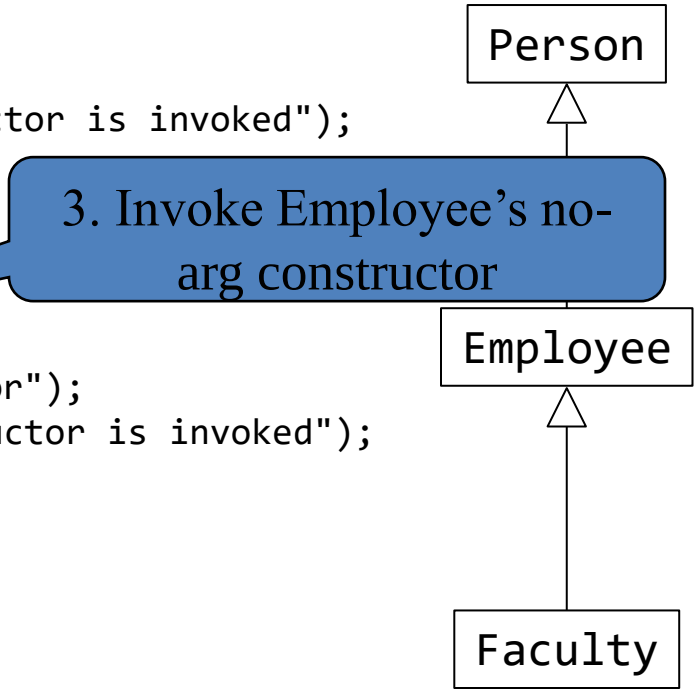

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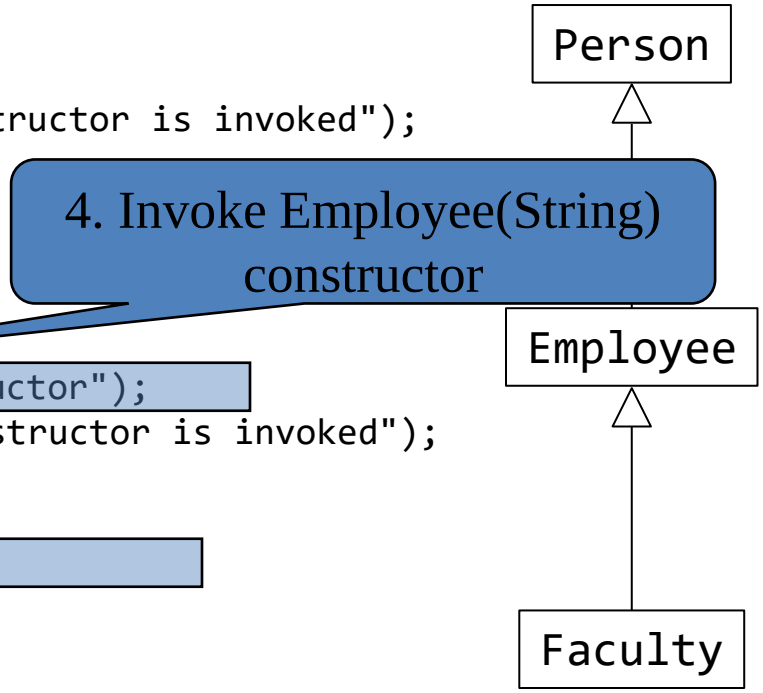

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  public Employee(String s) {
    System.out.println(s);
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}

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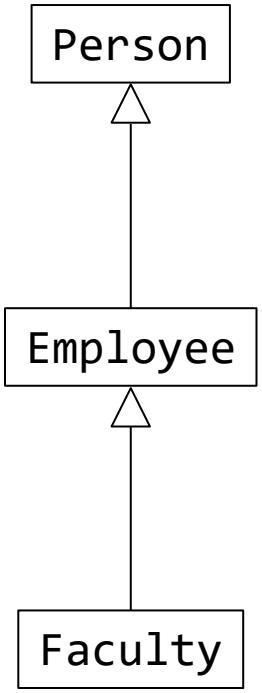

5. Invoke Person() constructor

Trace code

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  public static void main(String[] args) {
    new Faculty();
  }

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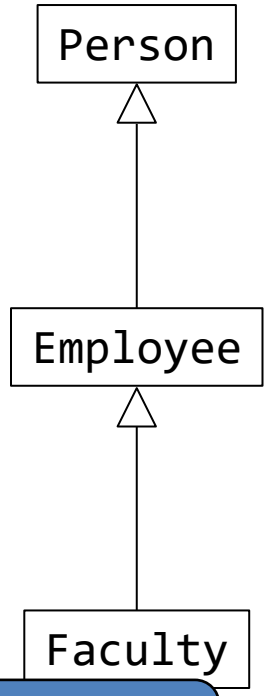

6. Execute println

Trace code

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  }

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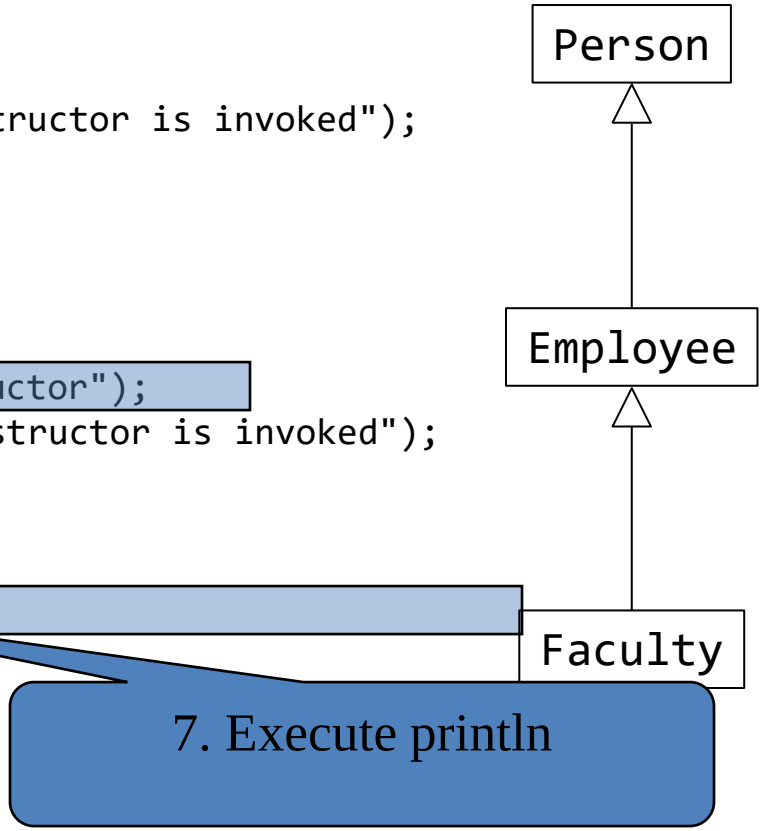

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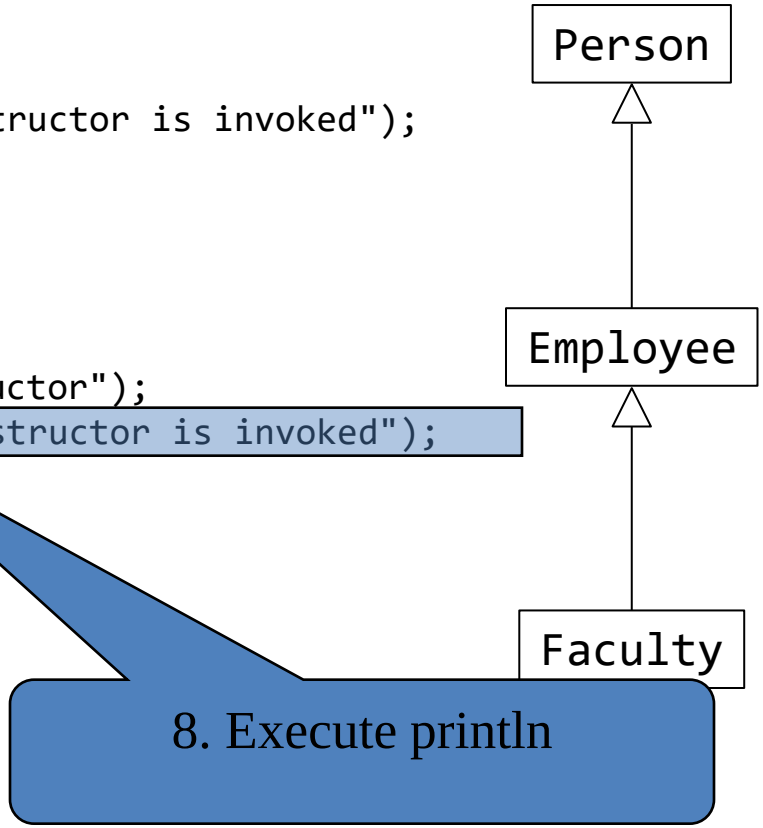

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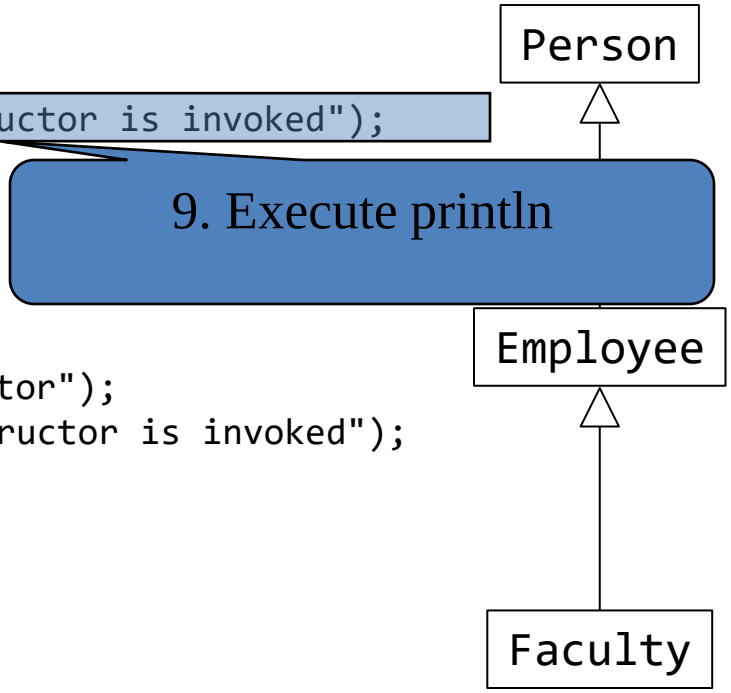


Default constructor

- Remember, a class may be defined without constructors
- In this case, a no-arg constructor with an empty body is *implicitly* defined in the class
- This constructor, called a *default constructor*, is provided automatically *only if no constructors are explicitly defined in the class*
- **Best practice is to provide (if possible) a no-arg constructor for every class to make the class easy to extend and avoid compile-time errors during constructor chaining**

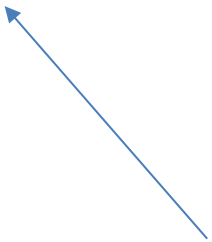
Defining a subclass

- A subclass inherits from a superclass
- You can also
  - Add new properties
  - Add new methods
  - Override the methods of the superclass

Add new methods

- For example
  - Add `printCircle()` method in the `Circle` class

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



Call superclass method

Override the methods of 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*

Override the methods of the superclass

- To override a method, the method must be defined in the subclass using **the same signature** as in its superclass, and **same or subtype of the overridden method's return type**
- A best practice to avoid mistakes is to use a special Java syntax, called *override annotation*
  - Annotated method is required to override a method in its superclass
    - If it does not, then there will be a compile-time error

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

  @Override
  public String toString() {
    return super.toString() + "\nradius is " + radius;
  }
}
```

Overriding vs overloading

- Overridden methods
  - Have the same signature
  - Are in different classes related by inheritance
- Overloaded methods
  - Have the same name, but different parameter lists
  - Can be either
    - In the same class
    - In different classes related by inheritance

Overriding vs overloading

```
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);
  }
}
```

```
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);
  }
}
```

Remember to use @Override annotation
(not shown so lines align)

Private methods of the superclass

- An instance method can be overridden only if it is accessible
- As such, **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, then the two methods are completely unrelated**

Static methods of the superclass

- 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**

`this` and `super` keywords

- Similar to using `this` to reference the calling object, the keyword `super` refers to the superclass of the class which `super` appears
- The keyword `this` is the name of a reference that refers to an object itself
  - One common use of the `this` keyword is to reference a hidden *class* member
- The keyword `super` refers to the superclass of the class in which `super` appears
  - One common use of the `super` keyword is to reference a hidden *superclass* member

`this` keyword

- The keyword `this` refers to an object itself
- The keyword `this` can be used to
  - Call another constructor of the same class
    - Syntax

      ```
      this(arguments);
      ```
  - Reference a hidden class variable
    - Syntax

      ```
      this.variableName
      ```

super keyword

- The keyword super refers to the superclass of the class in which super appears
- The keyword super can be used to
  - Call a superclass constructor
    - Syntax

      ```
      super(arguments);
      ```
  - Call a superclass method
    - Syntax

      ```
      super.methodName(arguments);
      ```

The `Object` 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
- For example

```
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

Next Lecture

- Polymorphism