

Inheritance



**How did the Java
programmer's son get
rich?**

Because of inheritance.

Inheritance

► *inheritance*:

- one of the four pillars of OOP.
- an important and powerful object oriented technique that allows one to define new classes from existing classes.
- powerful feature for defining relationships between related classes and allowing a base class to reuse code written in the parent class.
- defines an *is - a* relationship between two classes.

► Example:

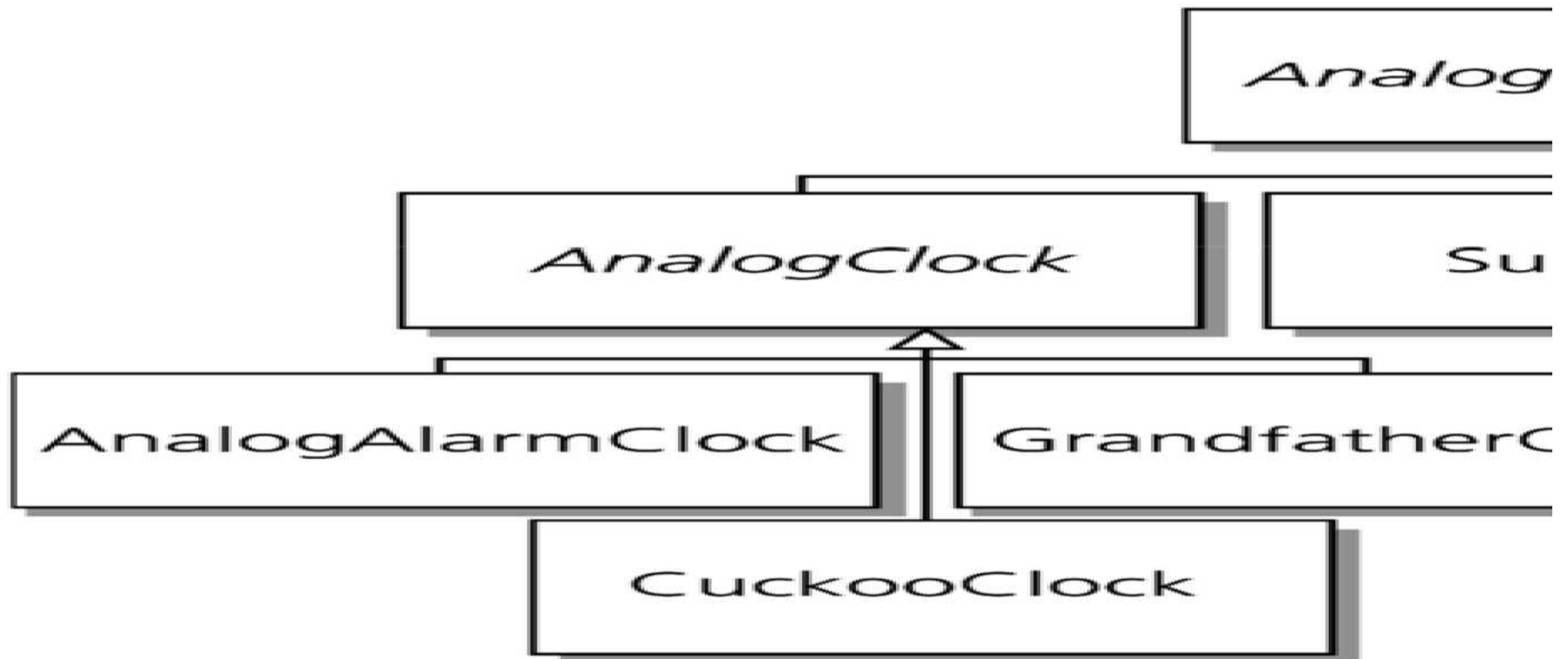
- Suppose you want to define a class to model various shapes (Circles, Rectangles, Triangles, etc.).
- these classes could have many common features.
- design the classes to avoid redundancy between them.

Inheritance

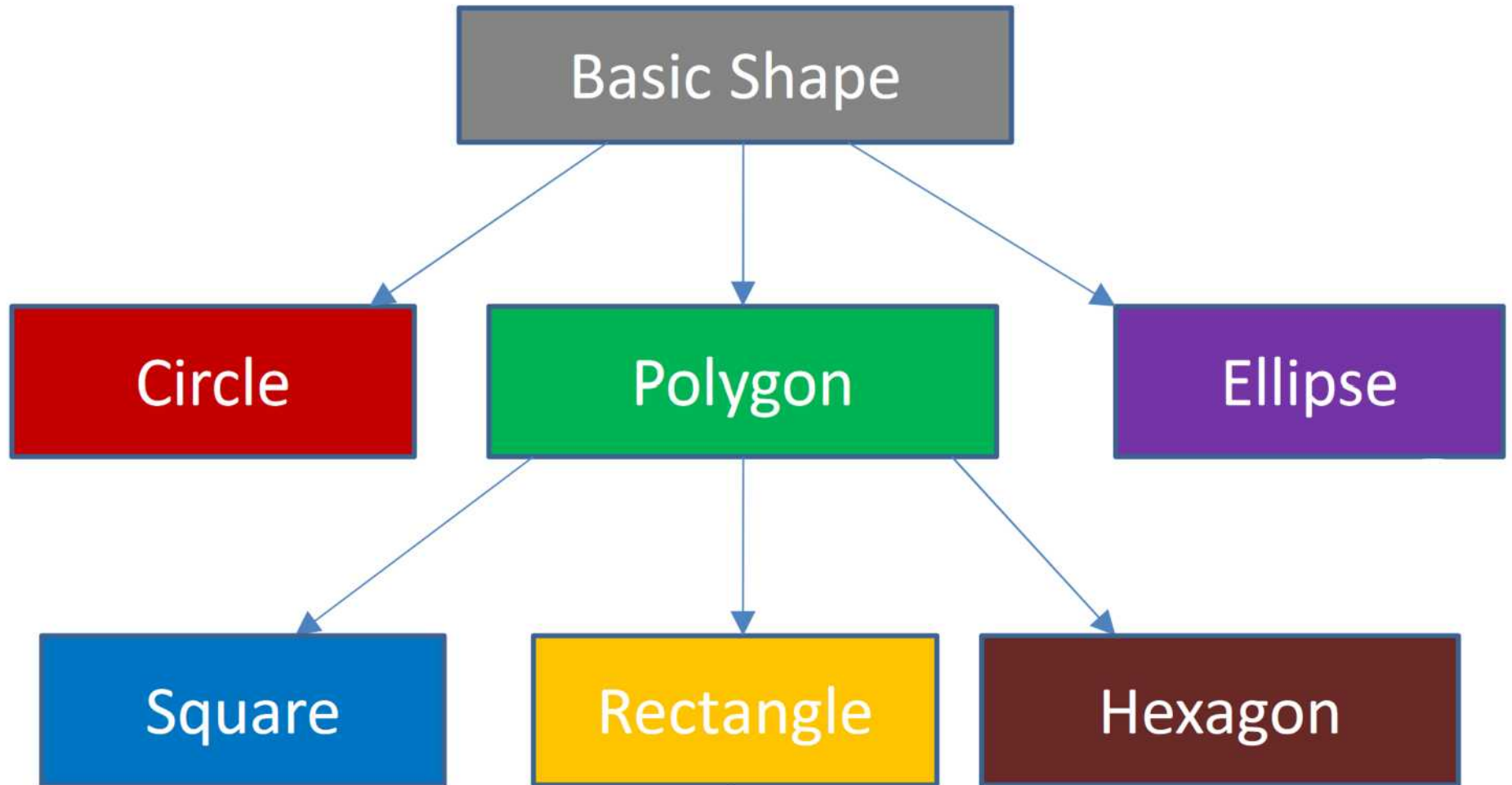
► Benefits of Inheritance:

- Break software into more manageable pieces
- Existing classes can be reused or reimplemented in new classes.
- Different object types can be grouped together and actions can be performed on all of them at the same time.
- Applications take less memory (less source code leads to less memory used once compiled.)
- Redundancy (repetition) of the code is reduced or minimized so that we get more consistent results.

Inheritance Example



Inheritance Example



Superclasses and Subclasses

Superclasses and Subclasses

- ▶ You can use a class to model objects of the same type.
- ▶ Even if classes are different, they can share common properties and behaviors
 - these can be generalized in a class and then shared by other classes.
- ▶ Assume there are two classes C1 and C2 where C2 "extends" C1.
 - in this case C1 is the **superclass**, **parent class**, or **base class**
 - and C2 is the **subclass**, **child class**, **extended class**, or **derived class**
- ▶ A subclass **inherits** all accessible data fields and methods from its superclass, and can even add new data fields and methods.

A First Example

- ▶ Let's design a class to model geometric objects like circles and triangles.
- ▶ Geometric objects have many common properties and behaviors.
- ▶ `GeometricObject` Class:
 - a general class that can be used to model all geometric objects.
 - has properties `color` and `filled` and their getters / setters
 - also has `dateCreated` property and its getter
 - also has a `toString()` method to return a string representation of the object.

A First Example

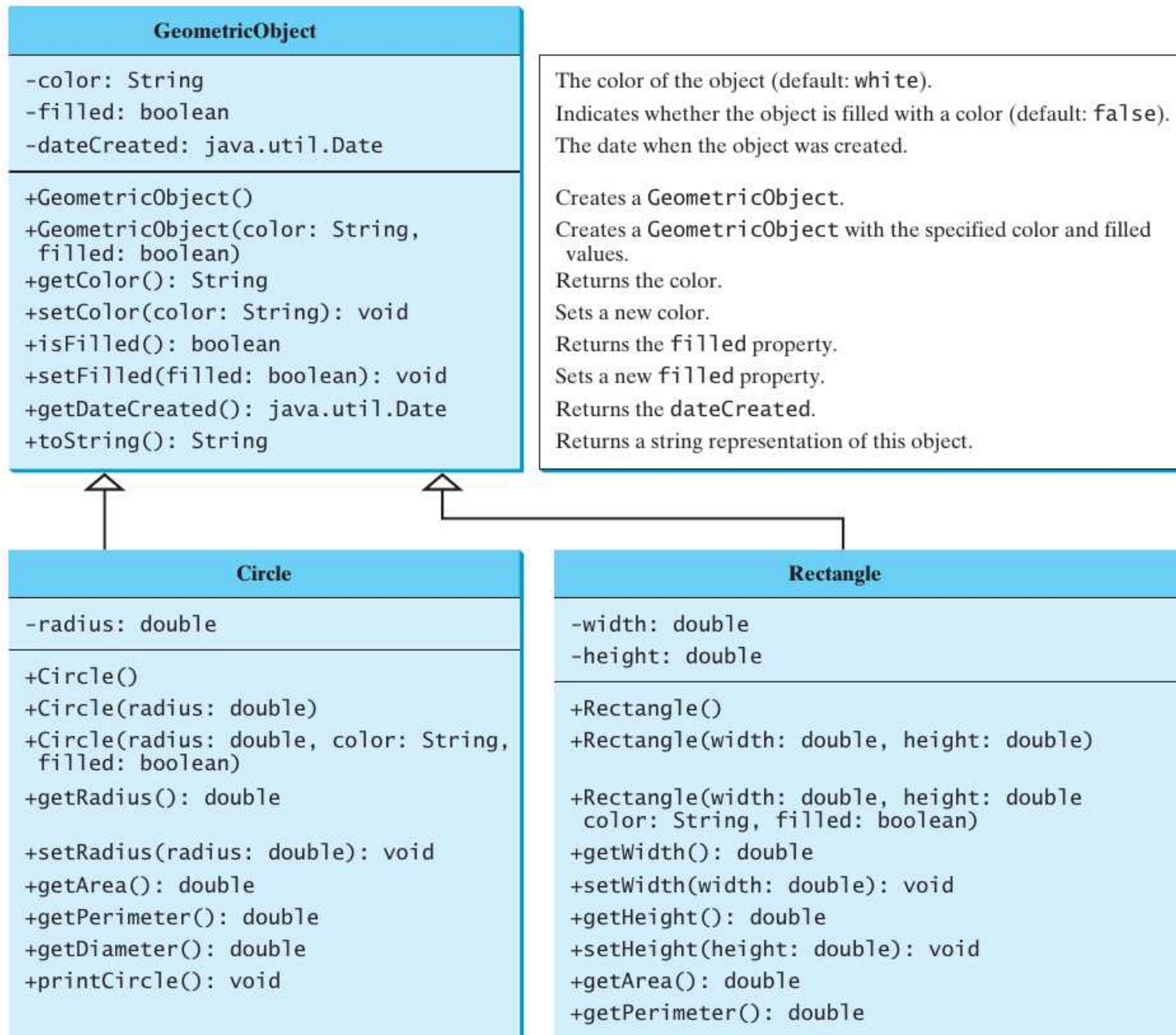
► The Circle class:

- a special type of geometric object
- shares common properties and methods with other geometric objects
- define `Circle` to "extend" the `GeometricObject` class
- inherits everything from `GeometricObject`
- adds some of its own methods.

► The Rectangle Class:

- can also be defined as a subclass of `GeometricObject`
- inherits everything from `GeometricObject`
- adds some of its own methods.

A First Example



A First Example

- ▶ The `Circle` class uses the following syntax:

Subclass Superclass



```
public class Circle extends GeometricObject
```

- ▶ `extends` is a keyword which tells the compiler that `Circle` is a subclass of `GeometricObject`, thus inheriting from the superclass.
- ▶ the constructor for `Circle` is implemented by invoking `setColor()`, and `setFilled()` which reside in the parent class inherited by `Circle`.
- ▶ You may be tempted to do something like this:

```
public CircleFromSimpleGeometricObject(  
    double radius, String color, boolean filled) {  
    this.radius = radius;  
    this.color = color; // Illegal  
    this.filled = filled; // Illegal  
}
```

- ▶ However, `color` and `filled` are private in the `GeometricObject` class and are only accessible in that class (so not accessible to `Circle`)

Other Inheritance Facts

- ▶ Despite its naming, a subclass is not a subset of its superclass.
 - Usually a subclass contains more information and methods than its superclass.
- ▶ Private data fields in the superclass are never accessible outside of the class.
 - They cannot be used directly in a subclass.
 - They can be accessed / mutated through public getters / setters if these are defined in the superclass.
- ▶ Not all *is-a* relationships should be modeled using inheritance
 - a square is a rectangle, but you should not extend Square from Rectangle
 - width and height properties are not appropriate for a square
 - better option is to define a Square class to extend GeometricObject and define a side property.

Other Inheritance Facts

- ▶ Inheritance models the is-a relationship
 - don't start extending classes all the time just to reuse methods.
 - it doesn't make sense for a Tree class to extend a Person class even if they share common properties like height and weight.
 - subclasses and superclasses should always have the is-a relationship.
- ▶ Two things to ask for whether or not to use inheritance?
 - do the two classes share common properties (data fields) and behaviors (methods)?
 - does the is-a relationship make sense in the real world?

Other Inheritance Facts

- ▶ Example 1: Tree extends Person
 - do the two classes share something in common
 - ♦ yes, they both have a height
 - does the is-a relationship make sense?
 - ♦ no, because a Tree is not a Person
- ▶ Example 2: Student extends Person
 - do the two classes share something in common
 - ♦ yes, they can have common properties
 - does the is-a relationship make sense?
 - ♦ yes, because a Student is-a Person

Other Inheritance Facts

- ▶ Unlike other languages, Java does not allow you to have ***multiple inheritance***
 - inheriting from more than one class
 - Java classes can only inherit directly from one superclass. (***single inheritance***)
 - (we will come back to multiple inheritance when we talk about interfaces.)

The super Keyword

The super Keyword

- ▶ super is a keyword which refers to the superclass of the class in which super is used
- ▶ super can be used in two ways:
 - call a superclass constructor.
 - call a superclass method.

Calling Superclass Constructors

- ▶ Constructors are not inherited by a subclass and can only be invoked using the `super` keyword.
- ▶ Examples:
 - `super () ;` //call the no-arg super constructor
 - `super (parameters) ;` //call the super constructor with the given parameters
- ▶ NOTE: the use of `super` to call the superclass constructor **MUST** be the first statement in the subclass constructor. invoking the superclass constructor with its class name in the subclass is a syntax error

Constructor Chaining

- ▶ A constructor can invoke an overloaded constructor or its superclass constructor. if neither is invoked explicitly, the compiler automatically puts `super ()` as first statement in the constructor.

```
public ClassName() {  
    // some statements  
}
```

Equivalent

```
public ClassName() {  
    super();  
    // some statements  
}
```

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

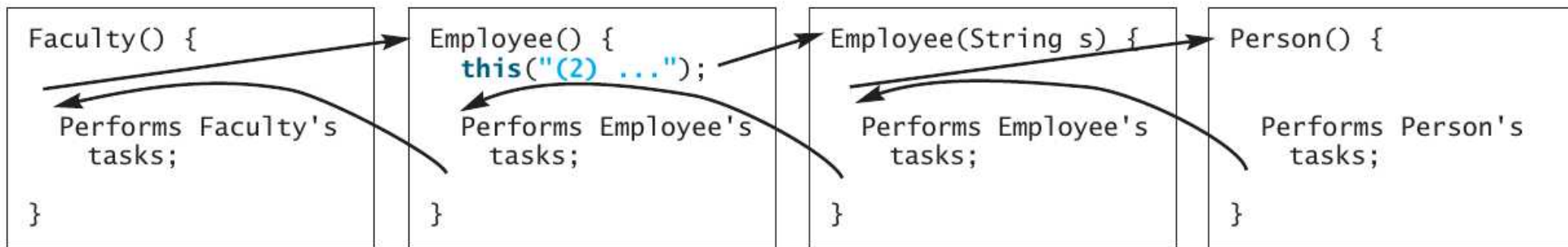
Equivalent

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

- ▶ Constructing an instance of a class invokes the constructors of all the superclasses along the inheritance chain.
- ▶ subclass constructors always invoke the superclass constructors before performing their own tasks even if there are multiple levels of inheritance

Constructor Chaining Example

- ▶ See Code: Faculty.java, Employee.java, and Person.java



Constructor Chaining Caution

- ▶ Classes should always define a no-arg constructor to avoid programming errors. Consider:

```
1  public class Apple extends Fruit {  
2  }  
3  
4  class Fruit {  
5      public Fruit(String name) {  
6          System.out.println("Fruit's constructor is invoked");  
7      }  
8  }
```

- ▶ Why does this cause compile errors?

Calling Superclass Methods

- ▶ `super` can be used to call other methods from the superclass.
- ▶ Syntax:
 - `super.method(parameters);`
- ▶ `printCircle()` from the `Circle` class could be rewritten as follows:

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

Caution: No ~~super.super.methodName()~~

- ▶ Assume there are three classes A, B, and C.
- ▶ Assume C inherits from B and B inherits from A
 - A ► B ► C
- ▶ Assume A has a method `myMethod()` which is implemented in B and C
- ▶ Question: if you can use `super.myMethod()` in B to call A's version of `myMethod()`, can you also use `super.super.myMethod()` to call A's version of `myMethod()` in C?
 - No, this is a syntax error.
 - Only allowed one level of method chaining with `super`.

Overriding Methods

Overriding Methods

- ▶ ***override a method***: when a subclass modifies the implementation of a method defined in the super class
 - you have already seen this when you "override" the `toString()` method.
 - `toString()` is defined in the `Object` class, and can be given a more specific implementation in any class in Java (since all classes are subclasses of `Object`).

Overriding Methods

► Rules for Overriding:

- instance methods can only be overridden if it is accessible (public). if a method defined in the subclass is private in the superclass, the two methods are unrelated.
- static methods can be inherited, but a static method cannot be overridden
 - ♦ if a static method defined in the superclass is redefined in a subclass, the superclass version is "hidden". to access it you need to use `SuperClassName.staticMethodName`

Overriding vs Overloading

Overriding vs. Overloading

- ▶ **overloading**: define multiple methods with the same name, but different method signatures.
 - overloaded methods can be either in the same class or different classes related by inheritance
 - overloaded methods have the same name but different parameter lists
- ▶ **overriding**: providing a completely new implementation for a method in a subclass.
 - overridden methods are in different classes related by inheritance
 - overridden methods have the exact same signature and return type.

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);  
    }  
}
```

(a)

```
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);  
    }  
}
```

(b)

Override Annotation

- ▶ To avoid any confusion / mistakes, you can use a special Java syntax called the override annotation to indicate that a method is an override of another method.
 - annotation is `@Override` and is placed before the method in the subclass.
 - the annotation denotes that the annotated method is required to override a method in the superclass
 - if the method with this annotation does not override its superclass method, the compiler will report an error.
- ▶ Example: if `toString()` is mistyped `tostring()` a compile error is reported if the annotation is present, no compile error reported if the annotation is omitted.

Override Annotation Example

```
1  public class CircleFromSimpleGeometricObject
2      extends SimpleGeometricObject {
3      // Other methods are omitted
4
5      @Override
6      public String toString() {
7          return super.toString() + "\nradius is " + radius;
8      }
9  }
```

References

- ▶ Liang, Chapter 11