CISC 3115 TY2

Inheritance

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Outline

- Recall we discussed
  - Relationships of classes
    - Association (Composition, and Aggregation)
    - There are more!
- Inheritance
  - Superclass/supertype, subclass/subtype
- Inheritance and constructors in Java
- Inheritance and instance methods in Java
- The Object class in Java

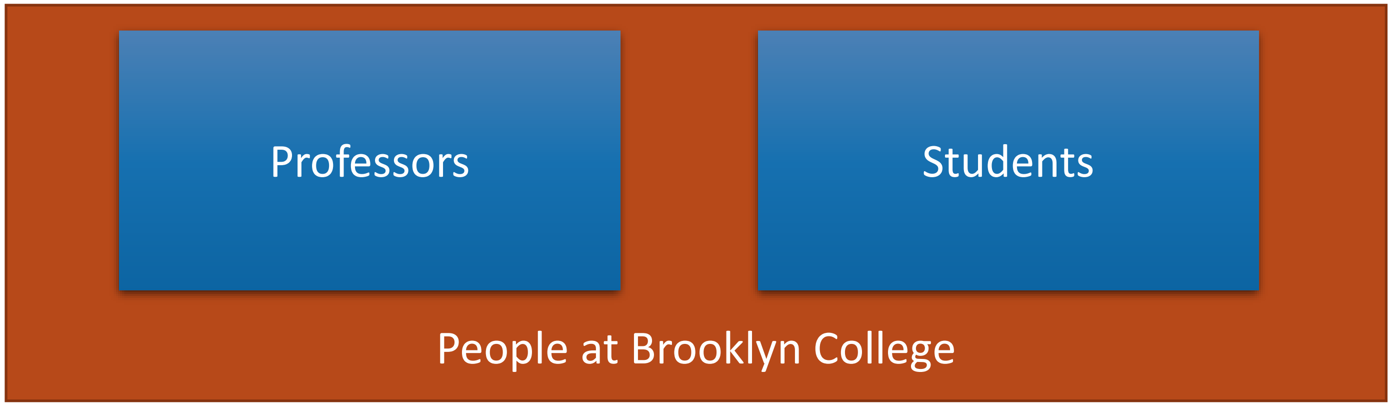
Class and Type

- A class defines a type, and often models a set of entities (or objects)
- Example: to build a system for managing business at Brooklyn College, we consider
  - People, a set of individuals (objects), modeled as a class that captures the essence of the set of objects
  - We have a *type* of objects, called People

People at Brooklyn College

Subtypes

- Some people at Brooklyn are different from the others in some way
- Professors and students are also types of Brooklyn College People, but professors and students are also People – they are subtypes of People



Type Hierarchy

- We have a hierarchy of types! They share a common set of characteristics and behavior, and also differ in some ways
    - What do Students and Professors have in common?
    - How are Students and Professors different?

What's in Common?

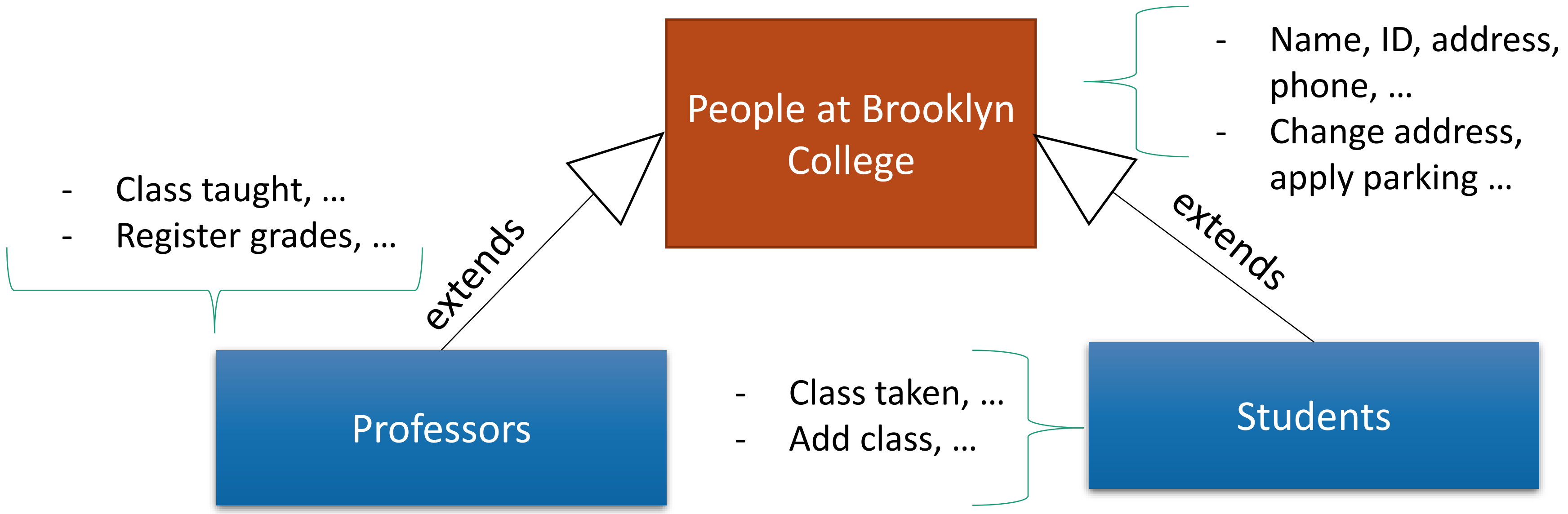
- What characteristics (attributes) and behavior (actions) do People at Brooklyn College have in common?
  - Characteristics (attributes, fields, or states): name, ID, address, email, phone, …
  - Behavior (actions, functions, or methods): change address, apply parking, …

What’s Special?

- What’s distinct about students?
  - Characteristics (attributes, fields, or states): classes taken, tuition and fees, …
  - Behavior (actions, functions, or methods): add class, drop class, pay tuition, …
- What’s distinct about professors?
  - Characteristics (attributes, fields, or states): course taught, rank, title, …
  - Behavior (actions, functions, or methods): register grade, apply promotion, …

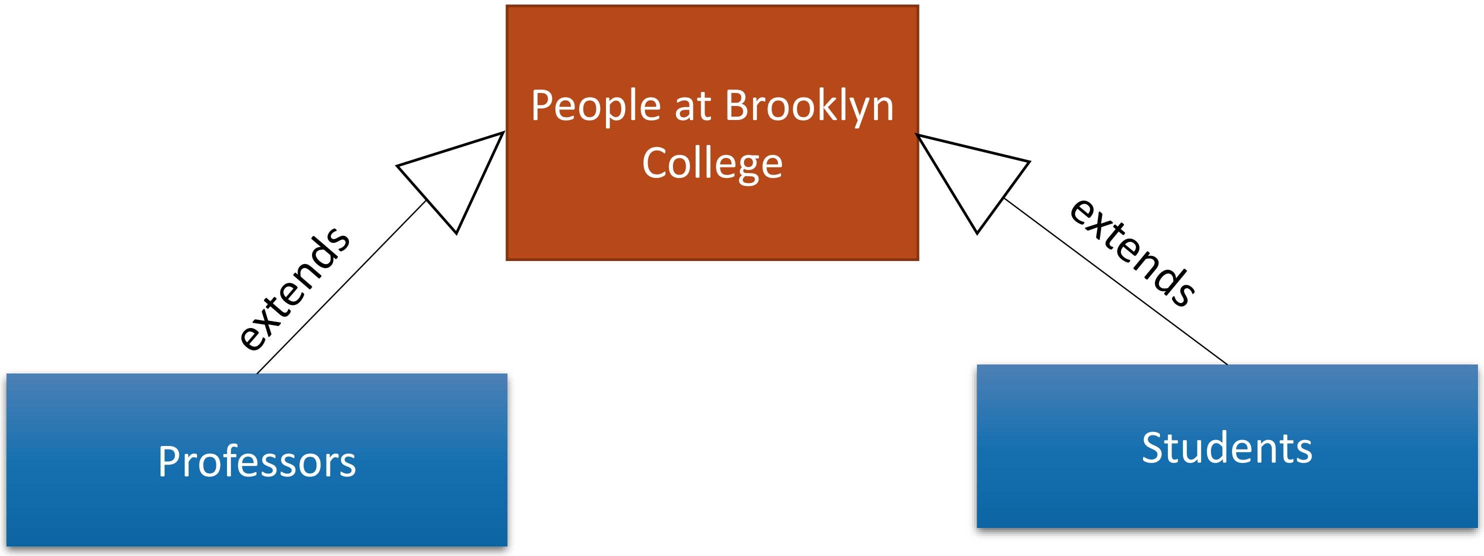
Inheritance & Type Hierarchy

- A subtype (child) inherits characteristics (data fields & methods) and behavior (actions) of its super/base type (parent)



Remark: Graphing Type Hierarchy

- UML class diagrams

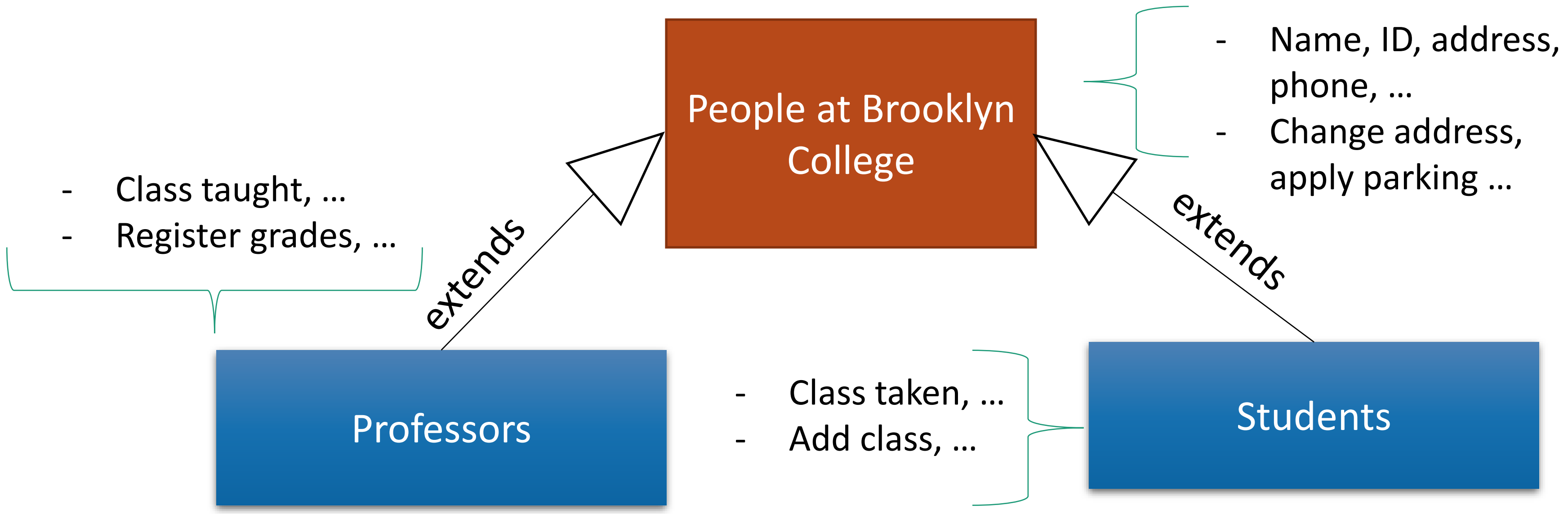


Terms of Choice

- Terms
  - Super type, Super class
  - Base type, Base class
  - Parent type, parent class
  - Child type, child class
  - Subtype, subclass
  - …
- In Java, we sometimes consider “type” and “class” are slightly different
  - In Java, a pure abstract class is called an “interface” (to be discussed in the future)

Example: Realizing the Type Hierarchy

- Classes: Person, Student, Professor



Super Type (Super Class): Person

```
public class Person {
        private String name;
        private String id;
        private String address;
        public Person(String name, String id, String address) {
                this.name = name;  this.id = id;  …
        }
        public void changeAddress(String address) {  …          }
… }
```

Subtype (Subclass): Student

```
public class Student extends Person {
        public final static int MAX_NUM_COURSES = 10;
        private String[] classesTaken;
        public Student(String name, String id, String address) {
                ......  // initializing inherited data fields
                classesTaken = new String[MAX_NUM_COURSES];
        }
        public void haveTakenClass(String className) { … }
        public void showClassesTaken() { … }
…}
```

Subtype (Subclass): Professor

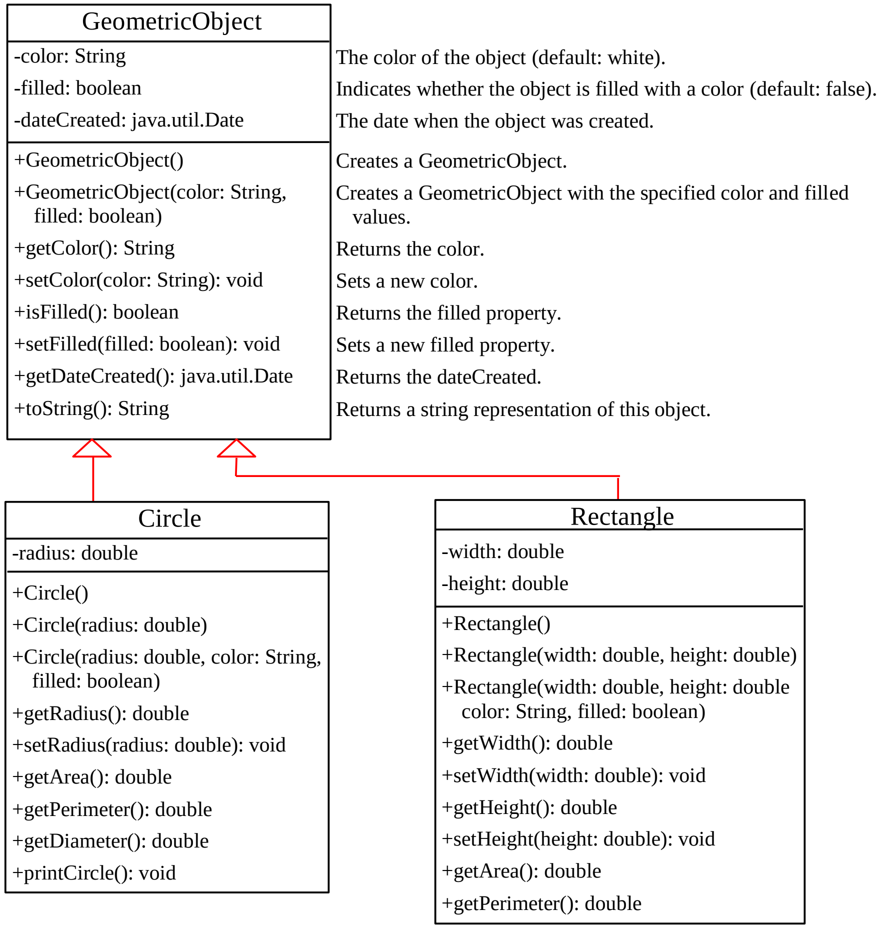
```
public class Professor extends Person {
        public final static int SABATTICAL_LEAVE_INTERVAL = 7;
        private int yearStarted;
        public Professor(String name, String id, String address, int yearStarted) {
                ......  // initializing inherited data fields
                this.yearStarted = yearStarted;
        }
        public void applySabbatical(int applicationYear) { …
        }
…}
```

Questions

- Concepts
  - Type, subtype, class, subclass
  - Inheritance

UML Diagram and Type Hierarchy

- UML diagram for showing class hierarchy
- Example: GeometricObject, Circle, Rectangle


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

Exercise (Part 1 of 3)

- Complete the following,
    - Implement 3 classes: Shape, Circle, and Rectangle with ***minimal coding (don't write more than asked)***
        - The Shape class is the superclass of the Circle and Rectangle class
        - Shape objects have a name. We add the name data field to the Shape class
        - We add a getName():String method to the Shape class
        - Write a ShapeClient class and create a Shape, a Circle, and a Rectangle object, and print out their names.
        - Make sure you can compile your classes
    - We shall do more with these classes (later)

Constructors

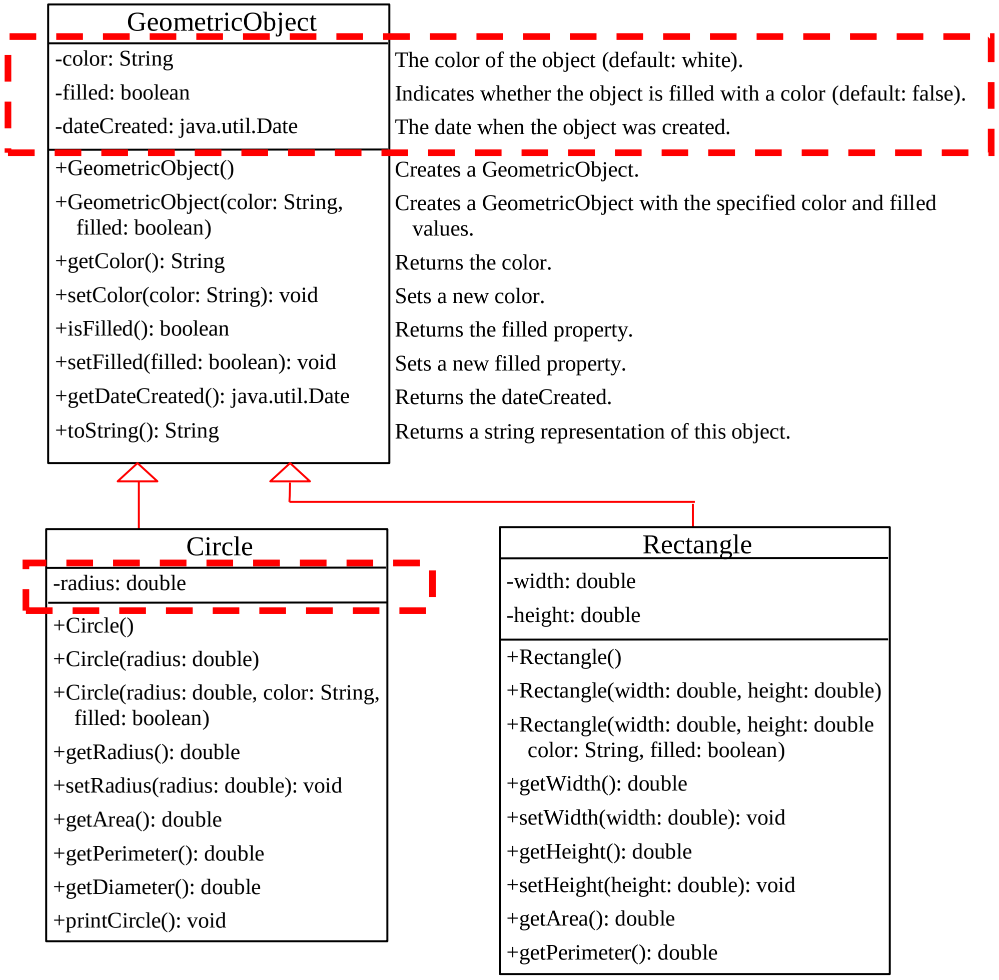
- Let us consider
  - Circle c = new Circle();
- Are superclass's constructor inherited?
  - No. They are not inherited.
  - They are invoked explicitly or implicitly.
  - Explicitly using the super keyword.

Constructors

- Let us consider

  Circle c = new Circle();

- Are superclass's Constructor Inherited?
- In other words, how are the data fields initialized?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+setWidth(width: double): void
+getHeight(): double
+setHeight(height: double): void
+getArea(): double
+getPerimeter(): double

Constructors in Super- and Sub-Classes

- Are superclass's Constructor Inherited?
    - No. They are not inherited, but one is always invoked
    - They are invoked explicitly or implicitly.
    - Explicitly using the super keyword
    - Implicitly *the superclass's no-arg constructor is automatically invoked if the keyword super is not explicitly used.*

Implicit Invocation of Superclass's Constructor

- A superclass's constructor is always invoked even if it isn't invoked explicitly using super.
- Which constructor is invoked implicitly?

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

is equivalent to

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

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

is equivalent to

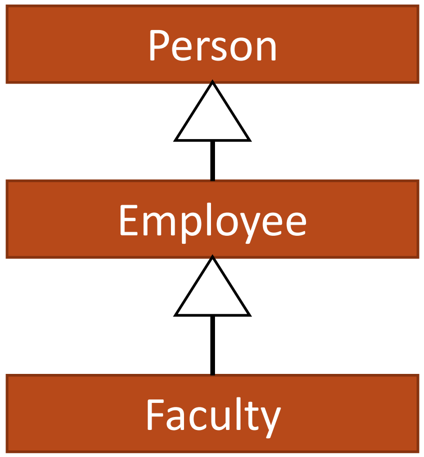
```
public A(double d) {
   super();
   // some statements
}
```

Explicit Invocation of Superclass's Methods

- super refers to the superclass
- Use it
    - To call a superclass constructor
        - Java requires that the statement that uses the keyword <u>super</u> appear first in the constructor.
    - To call a superclass method

Constructor Chaining

- Invocation of superclass's constructor (along the inheritance chain)
- Example
  - Consider classes: Person, Employee, Faculty



Constructor Chaining: Example

```
class Person {
  public Person() {
    System.out.println("(1) Person'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");
  }
```

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

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");
  }
}
```

Discussion: No-Arg Constructor

- Is there an error in the code below, and why?

```
public class Apple extends Fruit {
}


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

Questions?

- Constructors in superclass
  - Explicit and implicit invocation
- Constructor chaining

Exercise (Part 2 of 3)

- We continue to work on the share classes (Shape, Circle, Rectangle)
- Add the following,
  - Add a default constructor in each of the 3 classes
    - In each constructor, write a statement to print out something like,
      - "In the default constructor of ______ class." (fill the blank with right class name)
  - Add the instance variable radius to the Circle class, and width and length to the Rectangle class
  - Add parameterized constructors in the Circle and Rectangle class.
    - Initialize the instance variables from the parameters
    - Write a statement to print out something like, "In the constructor _____ of ______ class".
  - Revise the ShapeClient to call the parameterized constructors instead.
  - Make sure your program compiles and runs

Defining a Subclass

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

Overriding Methods in Superclass

- Modify the implementation of a method defined in the superclass

```
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;
  }
}
```

Invoking Superclass’s Instance Method

- Example
  - One could rewrite the printCircle() method in the Circle class as follows:

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

Discussion: Method Overriding

- Can you override a private method in the superclass?

Discussion: Method Overriding

- Can you override a private method in the superclass?
  - No
- An instance method can be overridden only if it is accessible.
- A private method is not accessible outside its own class.
- A private method in the superclass can only be accessible in the superclass itself, is inaccessible in the subclass.
- Thus a private method cannot be overridden.

Discussion: Unrelated Methods

- Can you have a method whose <u>signature</u> is identical to a private method in the superclass?

Discussion: Unrelated Methods

- Can you have a method whose <u>signature</u> is identical to a <u>private</u> method in the superclass?
    - Yes
- However, this isn’t method overriding. The two methods are unrelated, but happen to have the identical name.

Discussion: Static Method

- 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

- Overriding is to redefine the method with the identical signature in the superclass

```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) {
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    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);
```

Two methods with identical name but different signature

Questions?

- Defining subclasses
- A few topics
  - Invoking superclass's methods (constructors and instance methods)
  - Overriding
  - Overriding and overloading

Exercise (Part 3 of 3)

- We continue to work on the share classes (Shape, Circle, Rectangle)
- Add the following,
  - Add a getArea():double method to the Circle and Rectangle class
  - Override getName():String method in the Circle and Rectangle class to include the instance variables and their values, e.g.,, returning something like,
    - Rectangle[width="10.0", length="5.0"]
  - In the ShapeClient class, make you called getName() and getArea() methods on each Circle and Rectangle object you create
  - Make sure your program compiles and runs

Exercise

- Listings 11.1 - 11.3 in the textbook define 3 classes (that we discussed): GeometricObject, Circle, and Rectangle.
- In this exercise you are to add two classes to the hierarchy, Triangle and EquilateralTriangle, and write a client class to use the Triangle and EquilateralTriangle classes.
  - The Triangle class is a subclass to GeometricObject, and the EquilateralTriangle isa subclass to Triangle. An EquilateralTriangle is a triangles whose sides are equal.
  - Your program should include 6 files (6 classes): GeometricObject.java, Circle.java, Rectangle.java, Triangle.java, EquilateralTriangle, and TriangleClient.java