Lab 9 - Inheritance

1.

A class called **Circle** contains:

- Two private instance variables: radius (of type double) and color (of type String), with default value of 1.0 and "red", respectively.
- Two *overloaded* constructors;
- Two public methods: getRadius() and getArea().

The source code for Circle is as follows:

```
public class Circle
{               // save as "Circle.java"
                // private instance variable, not accessible from outside this class
        private double radius;
        private String color;

                // 1st constructor, which sets both radius and color to default
        public Circle()
        {
                radius = 1.0;
                color = "red";
        }

                // 2nd constructor with given radius, but color default
        public Circle(double r)
        {
                radius = r;
                 color = "red";
         }

                // A public method for retrieving the radius
        public double getRadius()
        {
                 return radius;
         }

                // A public method for computing the area of circle
        public double getArea()
        {
                return radius*radius*Math.PI;
        }

        public String toString()
        {
                return "Circle: radius=" + radius + " color=" + color;
        }
```

```
}
```
The test program for circle:

```
public class TestCircle
{               // save as "TestCircle.java"
        public static void main(String[] args)
        {
                // Declare and allocate an instance of class Circle called c1
                //  with default radius and color
        Circle c1 = new Circle();
                // Use the dot operator to invoke methods of instance c1.
        System.out.println(c1.toString());

                // Declare and allocate an instance of class circle called c2
                //  with the given radius and default color
        Circle c2 = new Circle(2.0);
                // Use the dot operator to invoke methods of instance c2.
        System.out.println(c2);
        }
}
```

Compile and run **Circle** and **TestCircle**

2.
In this exercise, a subclass called Cylinder is derived from the superclass **Circle**. Study how the subclass Cylinder invokes the superclass' constructors (via super() and super(radius)) and inherits the variables and methods from the superclass Circle.

You can reuse the Circle class that you have created in the previous exercise. Make sure that you keep "Circle.class" in the same directory.

```
public class Cylinder extends Circle
{               //save as "Cylinder.java"
        private double height;  // private variable

                // Constructor with default color, radius and height
        public Cylinder()
        {
                super();        // call superclass no-arg constructor Circle()
                height = 1.0;
        }
                // Constructor with default radius, color but given height
        public Cylinder(double height)
        {
                super();        // call superclass no-arg constructor Circle()
                this.height = height;
        }
                // Constructor with default color, but given radius, height
```

```
    public Cylinder(double radius, double height)
    {
        super(radius);  // call superclass constructor Circle(r)
        this.height = height;
    }

        // A public method for retrieving the height
    public double getHeight()
    {
        return height;
    }

        // A public method for computing the volume of cylinder
        //  use superclass method getArea() to get the base area
    public double getVolume()
    {
        return getArea()*height;
    }
}
```

Write a test program (called TestCylinder) to test the Cylinder class created, as follows:

```
public class TestCylinder
{       // save as "TestCylinder.java"
    public static void main (String[] args)
    {
            // Declare and allocate a new instance of cylinder
            //   with default color, radius, and height
        Cylinder c1 = new Cylinder();
        System.out.println("Cylinder:"
            + " radius=" + c1.getRadius()
            + " height=" + c1.getHeight()
            + " base area=" + c1.getArea()
            + " volume=" + c1.getVolume());

            // Declare and allocate a new instance of cylinder
            //   specifying height, with default color and radius
        Cylinder c2 = new Cylinder(10.0);
        System.out.println("Cylinder:"
            + " radius=" + c2.getRadius()
            + " height=" + c2.getHeight()
            + " base area=" + c2.getArea()
            + " volume=" + c2.getVolume());

            // Declare and allocate a new instance of cylinder
            //   specifying radius and height, with default color
        Cylinder c3 = new Cylinder(2.0, 10.0);
```

```
                System.out.println("Cylinder:"
                        + " radius=" + c3.getRadius()
                        + " height=" + c3.getHeight()
                        + " base area=" + c3.getArea()
                        + " volume=" + c3.getVolume());
        }
}
```

Compile and run **Cylinder** and **TestCylinder**.

3.

Method Overriding and "Super": The subclass C**ylinder** inherits getArea() method from its superclass **Circle**. Try *overriding* the getArea() method in the subclass **Cylinder** to compute the surface area (=2π×radius×height + 2×base-area) of the cylinder instead of base area. That is, if getArea() is called by a **Circle** instance, it returns the area. If getArea() is called by a **Cylinder** instance, it returns the surface area of the cylinder.

If you override the getArea() in the subclass **Cylinder**, the getVolume() no longer works. This is because the getVolume() uses the *overridden* getArea() method found in the same class. (Java runtime will search the superclass only if it cannot locate the method in this class). Fix the getVolume().

Hints: After overridding the getArea() in subclass **Cylinder**, you can choose to invoke the getArea() of the superclass **Circle** by calling super.getArea().

Test to see that it works.

4.

Provide a toString() method to the **Cylinder** class, which overrides the toString() inherited from the superclass **Circle**.
Test to see that it works.

5.
See the hierarchy diagram below.

a) Write a superclass called **Shape**, which contains:

- Two instance variables color (String) and filled (boolean).
- Two constructors: a no-arg (no-argument) constructor that initializes the color to "green" and filled to true, and a constructor that initializes the color and filled to the given values.
- Getter and setter for all the instance variables. By convention, the getter for a boolean variable xxx is called isXXX() (instead of getXxx() for all the other types).
- A toString() method that returns "A Shape with color of xxx and filled/Not filled".

Write a test program to test all the methods defined in **Shape**.

b) Write two subclasses of **Shape** called **Circle** and **Rectangle**, as shown in the class

diagram.

The **Circle** class contains:

- An instance variable radius (double).
- Three constructors as shown. The no-arg constructor initializes the radius to 1.0.
- Getter and setter for the instance variable radius.
- Methods getArea() and getPerimeter().
- Override the toString() method inherited, to return "A Circle with radius=xxx, which is a subclass of yyy", where yyy is the output of the toString() method from the superclass.

The **Rectangle** class contains:

- Two instance variables width (double) and length (double).
- Three constructors as shown. The no-arg constructor initializes the width and length to 1.0.
- Getter and setter for all the instance variables.
- Methods getArea() and getPerimeter().
- Override the toString() method inherited, to return "A Rectangle with width=xxx and length=zzz, which is a subclass of yyy", where yyy is the output of the toString() method from the superclass.

c) Write a class called **Square**, as a subclass of **Rectangle**. Convince yourself that **Square** can be modeled as a subclass of **Rectangle**. **Square** has no instance variable, but inherits the instance variables width and length from its superclass **Rectangle**.

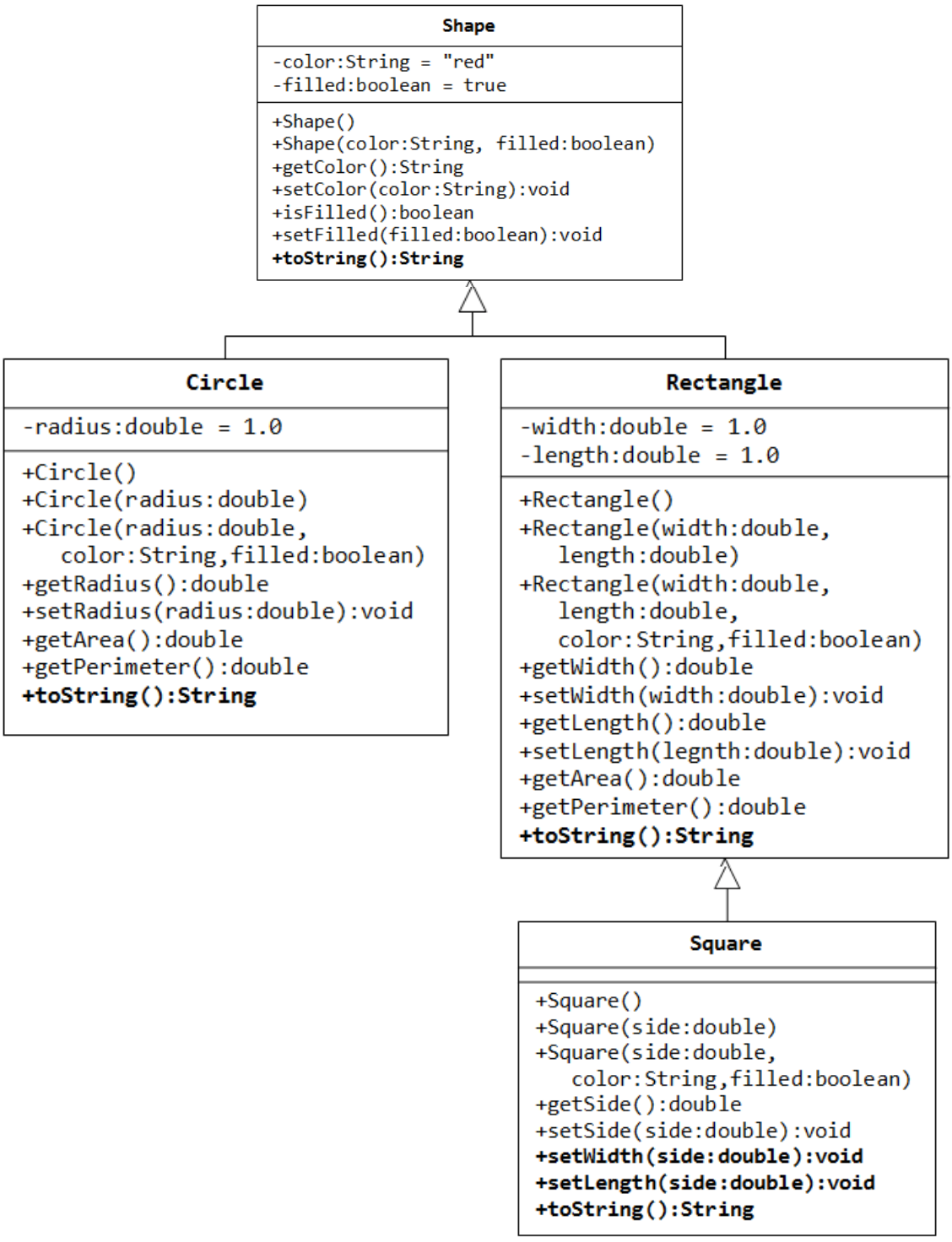
- Provide the appropriate constructors (as shown in the class diagram).

Hint:

```
public Square(double side)
   {
   super(side, side);  // Call superclass Rectangle(double, double)
   }
```

- Override the toString() method to return "A Square with side=xxx, which is a subclass of yyy", where yyy is the output of the toString() method from the superclass.
- Do you need to override the getArea() and getPerimeter()? Try them out.
- Override the setLength() and setWidth() to change both the width and length, so as to maintain the square geometry.

Test the classes.


Shape
-color:String = "red"
-filled:boolean = true
+Shape()
+Shape(color:String, filled:boolean)
+getColor():String
+setColor(color:String):void
+isFilled():boolean
+setFilled(filled:boolean):void
+toString():String
Circle
-radius:double = 1.0
+Circle()
+Circle(radius:double)
+Circle(radius:double,
color:String,filled:boolean)
+getRadius():double
+setRadius(radius:double):void
+getArea():double
+getPerimeter():double
+toString():String
Rectangle
-width:double = 1.0
-length:double = 1.0
+Rectangle()
+Rectangle(width:double,
length:double)
+Rectangle(width:double,
length:double,
color:String,filled:boolean)
+getWidth():double
+setWidth(width:double):void
+getLength():double
+setLength(legnth:double):void
+getArea():double
+getPerimeter():double
+toString():String
Square
+Square()
+Square(side:double)
+Square(side:double,
color:String,filled:boolean)
+getSide():double
+setSide(side:double):void
+setWidth(side:double):void
+setLength(side:double):void
+toString():String