Tutorial of Inheritance

> Based on the tutorial of "2020S-Java-A" designed by teaching group in SUSTech
>
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Objective

- Understand what is polynorphism.
- Learn abstract class.
- Learn how to define and implement an interface.
- Learn how to use the interface `java.long.Comparable<T>`.

Part 1: Polymorphism

1. Before Exercise

1.1 Create a PolymorphismTest class

```java
public class PolymorphismTest {
    public static void main(String[] args) {
        ArrayList<Shape> shapeList = new ArrayList<Shape>();

        Shape.setScreenSize(9);
        StdDraw.setXscale(-Shape.getScreenSize(), Shape.getScreenSize());
        StdDraw.setYscale(-Shape.getScreenSize(), Shape.getScreenSize());

        for (int i = 0; i < 3; i++) {
            shapeList.add(new Circle(1, 4 * i + 1, 1));
            shapeList.add(new Rectangle(4 * i + 1, -1, 1,1));
        }

        for (int i = 0; i < shapeList.size(); i++) {
            shapeList.get(i).checkColor();
            System.out.print(shapeList.get(i));
            shapeList.get(i).draw();
        }
    }
}
```

Obviously, two errors would arise in `checkColor()` and `draw()`. Although we understand that those two methods have been defined in both Circle and Rectangle class, we cannot invoke them directly if they haven't been defined in their super class Shape. It is because we are using subclass to instantiate their super class.

Define these two methods in Shape:

```
public void checkColor(){}
public void draw(){}
```

Run above code, observe the result:

```
Circle{radius=1.0 x=1.0, y=1.0, color=GREEN}
Rectangle{width=1.0, height=1.0 x=1.0, y=-1.0, color=GREEN}
Circle{radius=1.0 x=5.0, y=1.0, color=GREEN}
Rectangle{width=1.0, height=1.0 x=5.0, y=-1.0, color=GREEN}
Circle{radius=1.0 x=9.0, y=1.0, color=RED}
Rectangle{width=1.0, height=1.0 x=9.0, y=-1.0, color=RED}
```
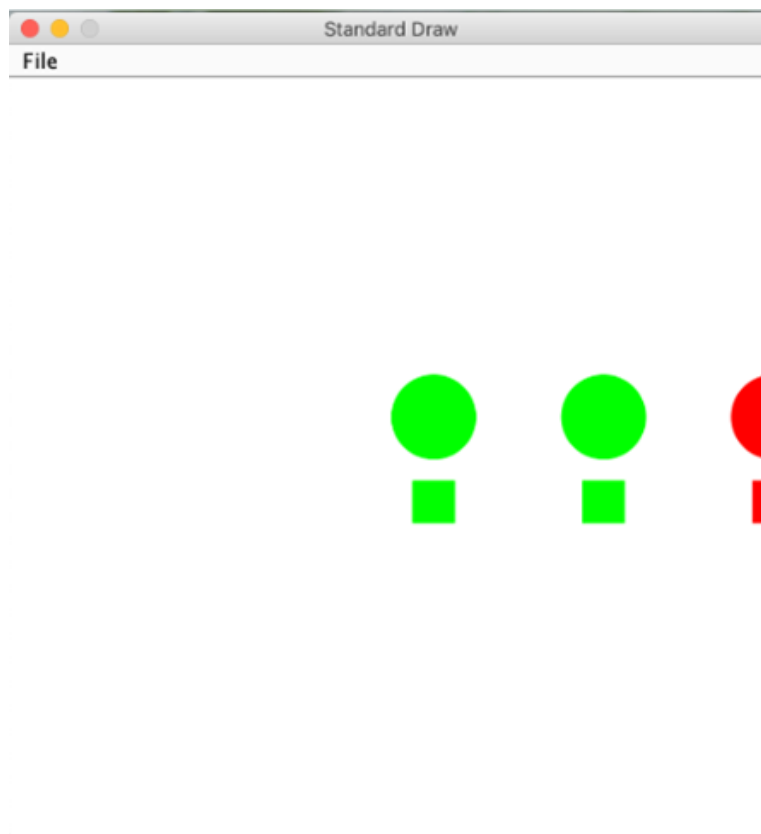

Part 2: Abstract Class

1. Before Exercise

Start from the codes you finished in the previous task, we can see that there are two public methods, which have no statement in it.

```
public void checkColor(){}
public void draw(){}
```

 Other than that, instead of instanitate Shape class, we only instanitate the subclasses of Shape is enough. In this case, we can change the `Shape` class to an `abstract` class.

1.1 Refactoring Shape class to abstract class

- add the keyword `abstract` before `class`

```
public abstract class Shape
```

- Change `draw()` and `checkColor()` method to abstarct

```
public abstract void checkColor();
public abstract void draw();
```

1.2 In `ShapeTest` , try to write the following code in main method:

```
Shape shape = new Shape()
```

There will be an error: Cannot instantiate the type Shape

Part 3: interface.

1. Before Exercise

1.1 Comparable Interface

Comparable is very useful. This interface imposes a total ordering on the objects of each class that implements it. This ordering is referred to as the class's *natural ordering*, and the `compareTo` method in it is referred to as its *natural comparison method*.

Lists (and arrays) of objects that implement this interface can be sorted automatically by `Collections.sort` (and `Arrays.sort`).

- Let **Circle** implements **Comparable**

```
public class Circle extends Shape implements Comparable<Circle>
```

  After implements the interface Comparable, it arise a mistake that if a class implements an interface, it must override all abstract methods in it.

- Override the method **compareTo** defined in **Comparable.**

```
@Override
public int compareTo(Circle o) {
    if(this.radius < o.radius){
        return 1;
    }else if(this.radius > o.radius){
        return -1;
    }
    return 0;
}
```

Normally, this method compares current object with the parameter object to determine a sort order. The return value of the method can be a negative integer, zero, or a positive integer, which means current object would in former place, all equal, or in latter place than parameter respectively. However, in this case, we want to sort the Circles in descending order of its radius, so that when the radius of current object is less than the parameter object, the return value would be 1(a positive integer)

- Rewrite the **ShapeTest**, using the following code:

```
public static void main(String[] args) {
    List<Circle> circleList = new ArrayList<>();
    Circle.setScreenSize(14);
    StdDraw.setScale(-Shape.getScreenSize(), Shape.getScreenSize());
    for (int i = 0; i < Shape.getScreenSize(); i += 2) {
        circleList.add(new Circle(i, 0, -Shape.getScreenSize()));
    }
    Collections.sort(circleList);
    for (int i = 0; i < circleList.size(); i++) {
        circleList.get(i).setColor(ShapeColor.values()[i%3]);
        circleList.get(i).draw();
    }
}
```

Run result:
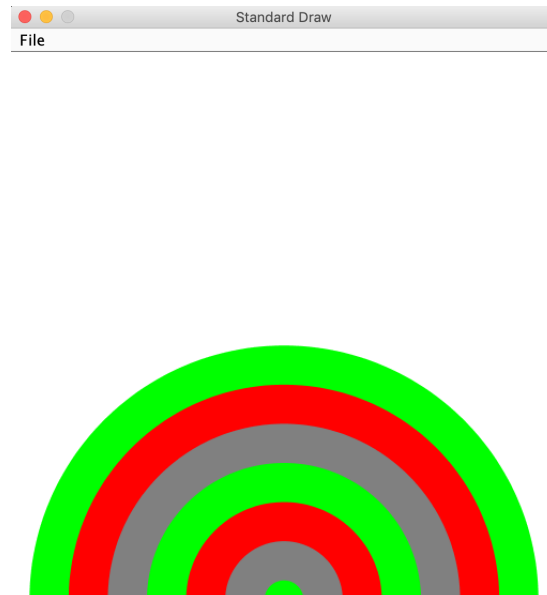
- In **Step3**, we can see that the color scheme is not beautiful and the **ShapeColor** is mainly used to check if the shape is in the boundary. We can define an interface named **ColorDraw**, in which declare an abstract method **customizedColor**.

1.2 User Defined Interface

- Define an `enum` class **ColorScheme**:

```java
public enum ColorScheme {
    SKY(new Color[]{new Color(0, 102, 204),
            new Color(0, 128, 255),
            new Color(51, 153, 255),
            new Color(102, 178, 255),
            new Color(153, 204, 255),
            new Color(204, 229, 255)}),
    RAINBOW(new Color[]{
            Color.RED,
            Color.ORANGE,
            Color.YELLOW,
            Color.GREEN,
            Color.CYAN,
            new Color(0, 128, 255),
            new Color(204, 153, 255)}),
    GRAY(new Color[]{
            Color.DARK_GRAY,
            Color.GRAY,
            Color.LIGHT_GRAY});

    Color[] colorList;

    private ColorScheme(Color[] color) {
        colorList = color;
    }
```

```java
    public Color[] getColorScheme() {
        return colorList;
    }

}
```
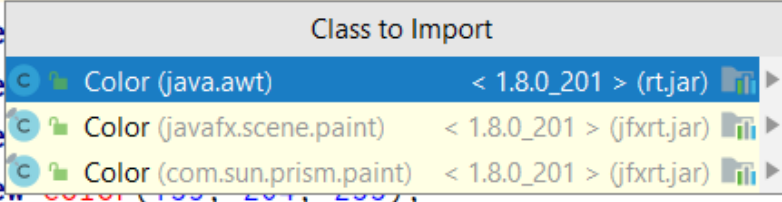
If you are using IDE, it may remind you to choose the package from which the Color class is imported. Here, please import from java.awt.

- <mark>Define an interface</mark>:

```java
public interface ColorDraw {
    public void customizedColor(ColorScheme colorScheme, int index);

}
```

- Implement the **ColorDraw** in **Circle**

```java
public class Circle extends Shape implements Comparable<Circle>, ColorDraw

@Override
public void customizedColor(ColorScheme colorScheme, int index) {
    Color[] colorList = colorScheme.getColorScheme();
    if (index < 0){
        index = 0;
    }
    if (index >= colorList.length){
        index = index % colorList.length;
    }
    StdDraw.setPenColor(colorList[index]);
    StdDraw.filledCircle(Shape.getX(), Shape.getY(), radius);
}
```

- In **ShapeTest**, we change main method to the following code:

```java
List<Circle> circleList = new ArrayList<Circle>();
        Shape.setScreenSize(14);
        StdDraw.setScale(-Shape.getScreenSize(), Shape.getScreenSize());
```
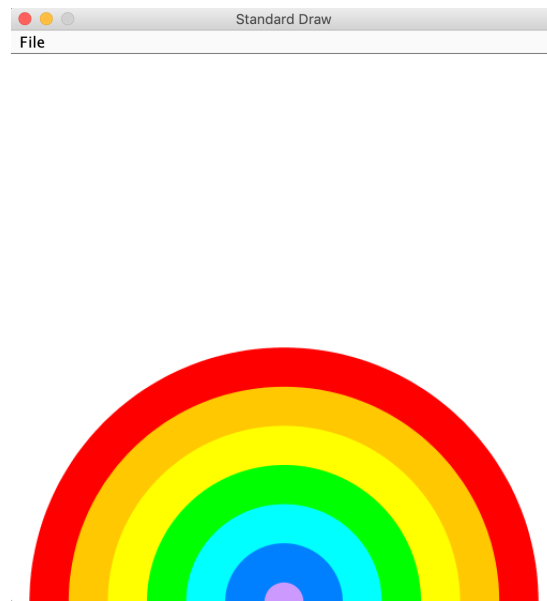
```
        for (int i = 1; i < Shape.getScreenSize(); i += 2) {
            circleList.add(new Circle(i, 0, -Shape.getScreenSize()));
        }


        Collections.sort(circleList);


        for (int i = 0; i < circleList.size(); i++) {
            circleList.get(i).customizedColor(ColorScheme.RAINBOW, i);
        }
```
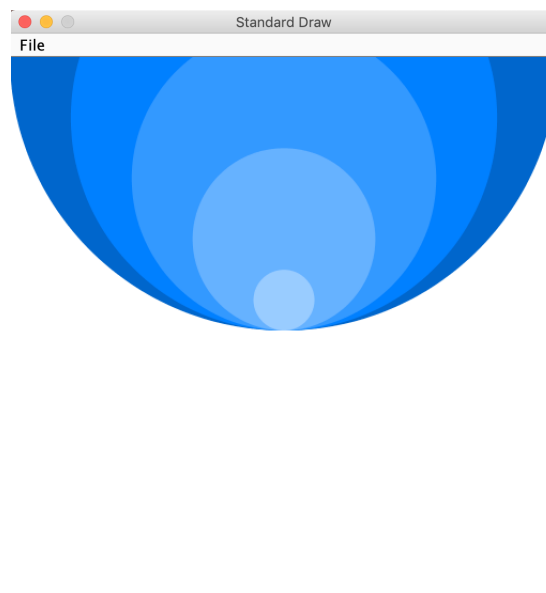
Run result:

2. Exercises

2.1 Exercise1

Modify the class **ShapeTest,** draw some circles like the following image:

Hint: ColorScheme.Sky

x	y	radius
0	1	1
0	3	3
0	5	5
0	7	7
0	9	9

screen size = 9

2.2 Exercise 2

Modify the class **Rectangle** given to you.

a.   Make **Rectangle** implements **Comparable**, override the method **compareTo** to order the rectangles from the largest to smallest according their area. If two rectangles have the same area, order the rectangles from smallest to largest according **x**.

b.   Make **Rectangle** implements **ColorDraw**, override the method **customizedColor** to draw the rectangle according to the specific **ColorScheme** and the index.
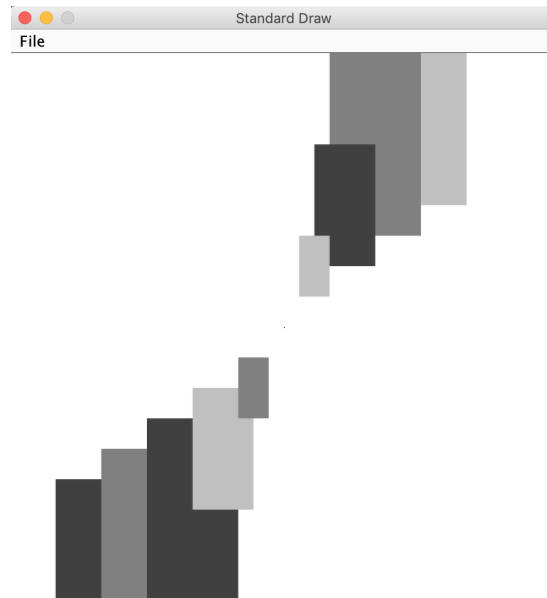
2.3 Exercise 3

Create a class **RectangleTest** for test.

```java
public class RectangleTest {
    public static void main(String[] args) {
        Shape.setScreenSize(9);
        StdDraw.setScale(-Shape.getScreenSize(), Shape.getScreenSize());

        List<Rectangle> rectanglList = new ArrayList<Rectangle>();
        for (int i = -5; i < 5; i ++) {
            rectanglList.add(new Rectangle(i,2*i,Math.abs(i), 2*Math.abs(i)));
        }
        Collections.sort(rectanglList);

        for (int i = 0; i < rectanglList.size(); i++) {
            rectanglList.get(i).customizedColor(ColorScheme.GRAY, i);
            System.out.println(rectanglList.get(i));
        }
    }
}
```

Here is a sample run:

2.4 Exercise 4

You can design yourself pattern that contains circles and rectangles, or other yourself defined shapes.