OBJECT-ORIENTED PROGRAMMING
LAB 7: POLYMORPHISM, ABSTRACTION

I. Objective

After completing this first lab tutorial, you can:

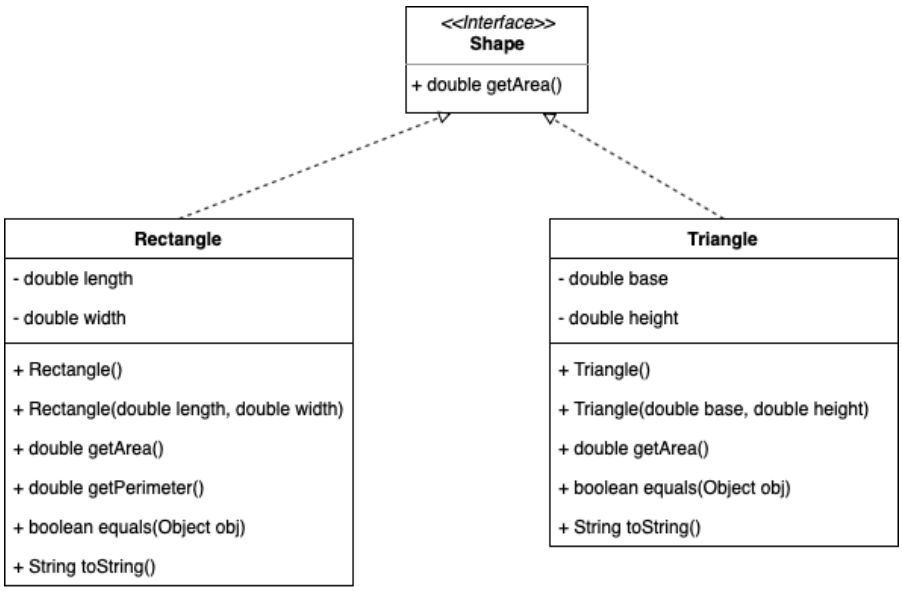
- Understand *polymorphism* and *abstraction* in OOP.

II. Polymorphism

Polymorphism is the behavior of functionality changes according to the actual type of data. We have two mechanisms are Overloading and Overriding to approach the polymorphism in Java. The most common use of polymorphism in OOP occurs when a parent class reference is used to refer to a child class object.

In this section, we will show you how the behavior of overridden methods in Java allows you to take advantage of polymorphism when designing your classes through the example of the *interface* in Java.

In the following example, we have two real objects, which are Rectangle and Triangle, and a general object Shape. In reality, we don't need to create a Shape object, since it does not have any behavior. The question is how can we prevent users from creating Shape objects.




```java
// Shape.java
public interface Shape {
    public double getArea();
}
```

```java
// Rectangle.java
public class Rectangle implements Shape {
    private double length;
    private double width;

    public Rectangle() {
        this.length = 0.0;
        this.width = 0.0;
    }

    public Rectangle(double length, double width) {
        this.length = length;
        this.width = width;
    }

    public double getLength() {
        return this.length;
    }

    public double getWidth() {
        return this.width;
    }

    public void setLength(double length) {
        this.length = length;
    }

    public void setWidth(double width) {
        this.width = width;
    }

    @Override
    public double getArea() {
        return this.length * this.width;
    }

    public double getPerimeter() {
        return (this.length + this.width) * 2.0;
    }

    @Override
    public String toString() {
        return "Rectangle{" + "length=" + this.length + ", width=" +
            this.width + '}';
    }
}
```

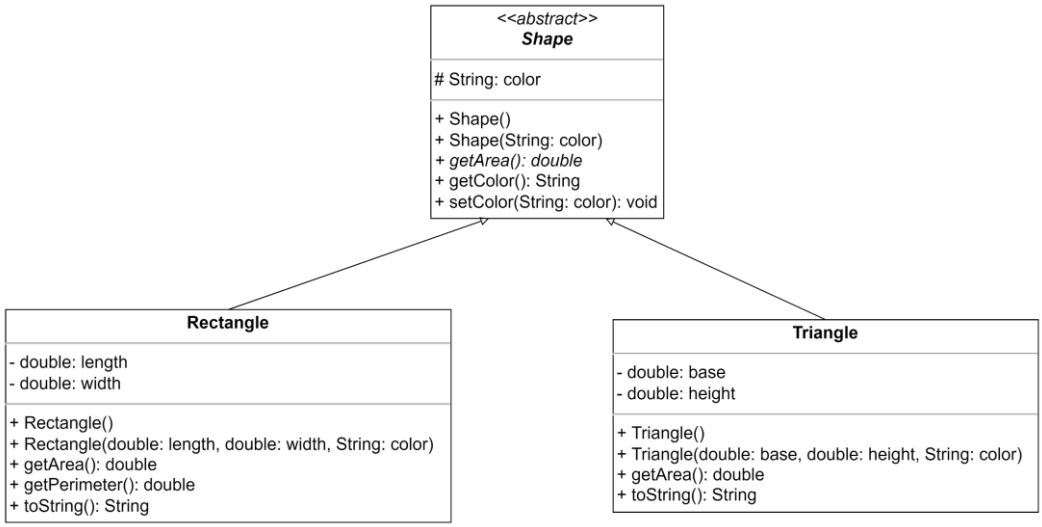
```java
// Test.java
public class Test {
    public static void main(String[] args) {
        Shape s = new Rectangle(4, 3);
        System.out.println(s.toString());
        System.out.println("Area = " + s.getArea()); // 12.0

        s = new Triangle(8, 7);
        System.out.println(s.toString());
        System.out.println("Area = " + s.getArea()); // 28.0
    }
}
```

III. Abstraction

Abstraction is the process of hiding the implementation details from the user, only the functionality will be provided to the user. For example, in the email system, to send an email, the user needs only to provide the recipient's email, and the email's content and click send. All implementation of the system is hidden. We have two approaches, the first one is taking advantage of the *interface* and the second is using *abstract* class.

Java provides a mechanism to allow a program to achieve abstraction using *abstract* keywords. The *abstract* keyword can be used for class and method definitions. For example, the following diagram will define an abstract class, *Shape*, which contains *color* attribute and *getArea*() behavior. That means every derived object from *Shape* will have *color* information and the *getArea*() method.

You should notice that if you define an abstract class, the method must be either abstract or implemented. An abstract class cannot be instantiated. This usually happens because it has one or more abstract methods. It must be implemented in concrete (i.e., non-abstract) subclasses.



```java
// Shape.java
public abstract class Shape {
    protected String color;

    public Shape() {
        this.color = "";
    }

    public Shape(String color) {
        this.color = color;
    }

    public abstract double getArea()

    public String getColor() {
        return this.color;
    }

    public void setColor(String color) {
        this.color = color;
    }
}
```

```java
// Rectangle.java
public class Rectangle extends Shape {
    private double length;
    private double width;

    public Rectangle() {
        super();
        this.length = 0;
        this.width = 0;
    }

    public Rectangle(double length, double width, String color) {
        super(color);
        this.length = length;
        this.width = width;
    }

    @Override
    public double getArea() {
        return this. length * this.width;
    }

    public double getPerimeter() {
        return (this.length + this.width) * 2.0;
    }

    public String toString() {
        return "Rectangle{" + "length=" + length +
                ", width=" + width +
                ", color=" + color + '}';
    }
}
```

```java
// Test.java
public class Test {
    public static void main(String[] args) {
        Shape s = new Rectangle(4, 3, "white");
        System.out.println(s.toString());
        System.out.println("Area = " + s.getArea());

        s = new Triangle(8, 7, "black");
        System.out.println(e.toString());
        System.out.println("Area = " + s.getArea());
    }
}
```

IV. instanceof operator and equals method

Sometimes, we need to compare two objects, but the object may have many attributes, Java doesn't know which criteria to evaluate two objects as equal or not. So you need to override the equals method from the Object class. Here are two examples:

a) You have two Rectangle objects and you said that two rectangles are equal when their area is the same. So we have class Rectangle and override the equals method:

```java
public class Rectangle {
    private double width;
    private double length;

    public Rectangle(double width, double length) {
        this.width = width;
        this.length = length;
    }

    public double getArea() {
        return this.length * this.width;
    }

    @Override
    public boolean equals(Object obj) {
        if(obj instanceof Rectangle) {
            Rectangle temp = (Rectangle) obj;
            if(this.getArea() == temp.getArea()) {
                return true;
            }
        }
        return false;
    }
}
```

You can test this Rectangle class as follows.

```
public class TestRectangle {
    public static void main(String[] args) {
        Rectangle rec = new Rectangle(6, 8);
        Rectangle rec1  = new Rectangle(6, 8);
        Rectangle rec2 = new Rectangle(7,9);

        System.out.println(rec.equals(rec1));
        System.out.println(rec.equals(rec2));
    }
}
```

b) You have two Fraction objects and these two fractions equal when they have the numerators and the denominators equal in reduced form. We can define the Fraction class:

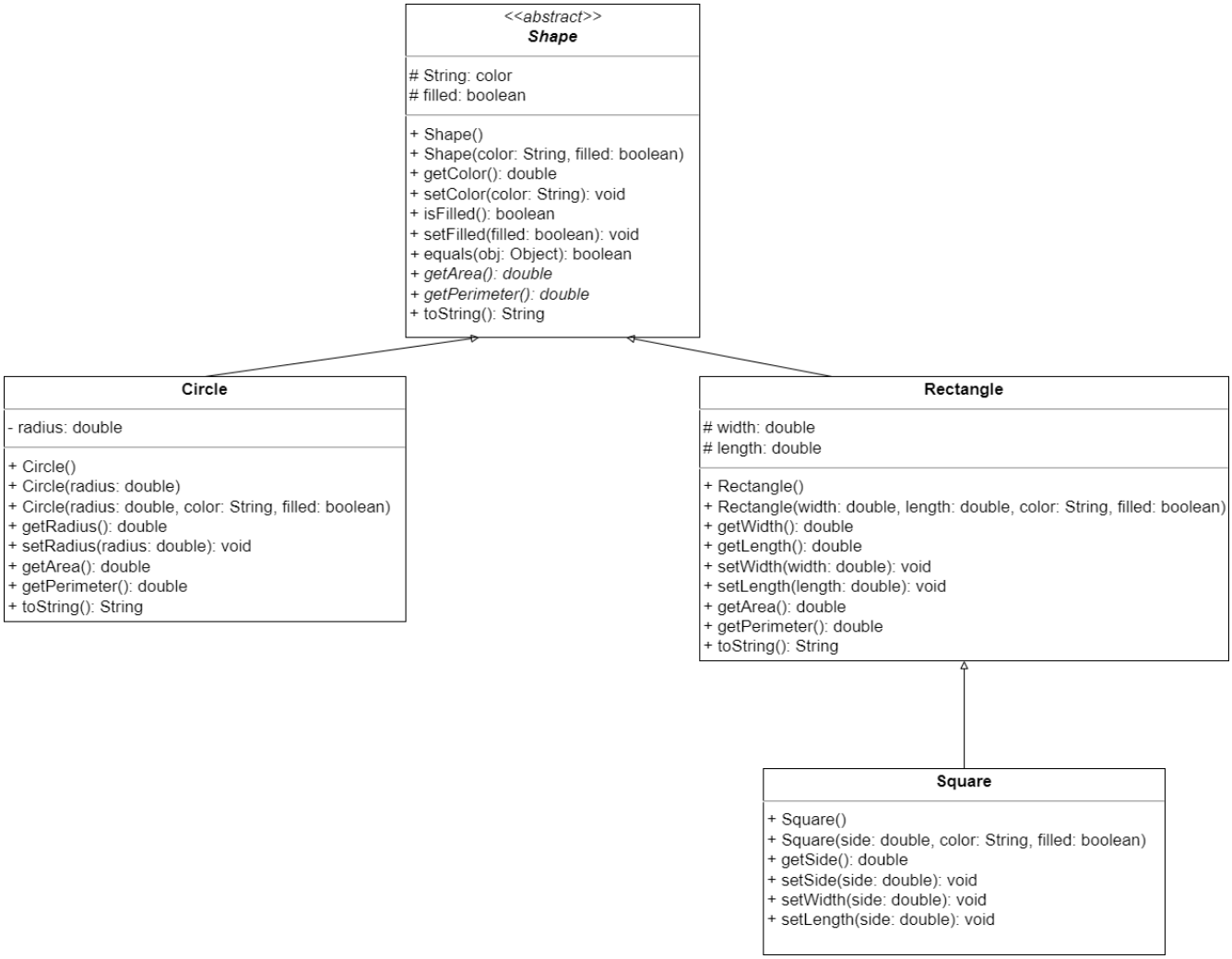
```
public class Fraction {
    private int numerator;
    private int denominator;

    public Fraction(int num, int den) {
        this.numerator = num;
        this.denominator = den;
    }
    public Fraction reducer() {
        int gcd = this.gcd(this.numerator, this.denominator);
        return new Fraction(this.numerator/gcd, this.denominator/gcd);
    }
    private int gcd(int num, int den) {
        while(num != den){
            if(num > den){
                num -= den;
            }else{
                den -= num;
            }
        }
        return num;
    }
    @Override
    public boolean equals(Object obj) {
        if(obj instanceof Fraction){
            Fraction temp = (Fraction) obj;
            temp = temp.reducer();
            Fraction temp1 = this.reducer();
            if(temp.numerator == temp1.numerator && temp.denominator == temp1.denominator){
                return true;
            }
        }
        return false;
    }
}
```

You can test this Fraction class as follows.

```java
public class TestFraction {
    public static void main(String[] args) {
        Fraction f = new Fraction(3, 4);
        Fraction f1 = new Fraction(6, 8);
        Fraction f2 = new Fraction(3, 2);

        System.out.println(f.equals(f1));
        System.out.println(f.equals(f2));
    }
}
```

V. Exercises

1. Continue the above examples in Section III, and implement the Triangle class.
2. Given the Abstract superclass Shape and its concrete subclasses.



All Shapes will compare based on the area, if two Shapes have the same area, these Shapes will be equal.

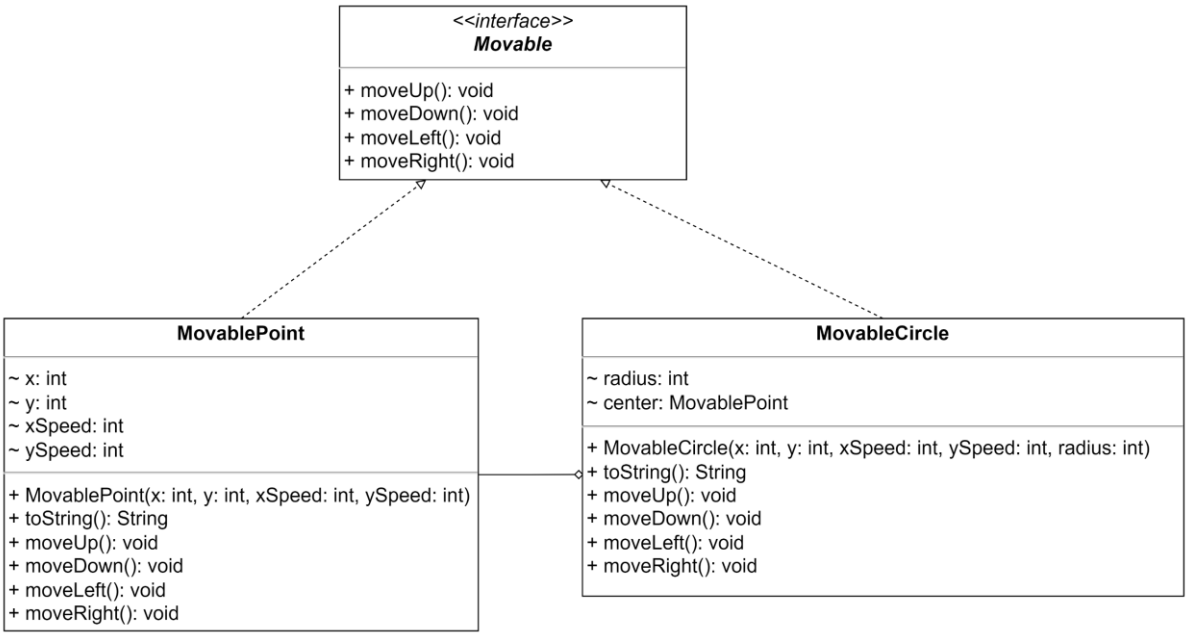
Write a class with a *main* method to test your work.

Assume that in the *main* method of the test class, you have a list containing any shapes. Your work is to find the shape that has the largest area in this list.

Example: Find the shape that has the largest area in the list below.

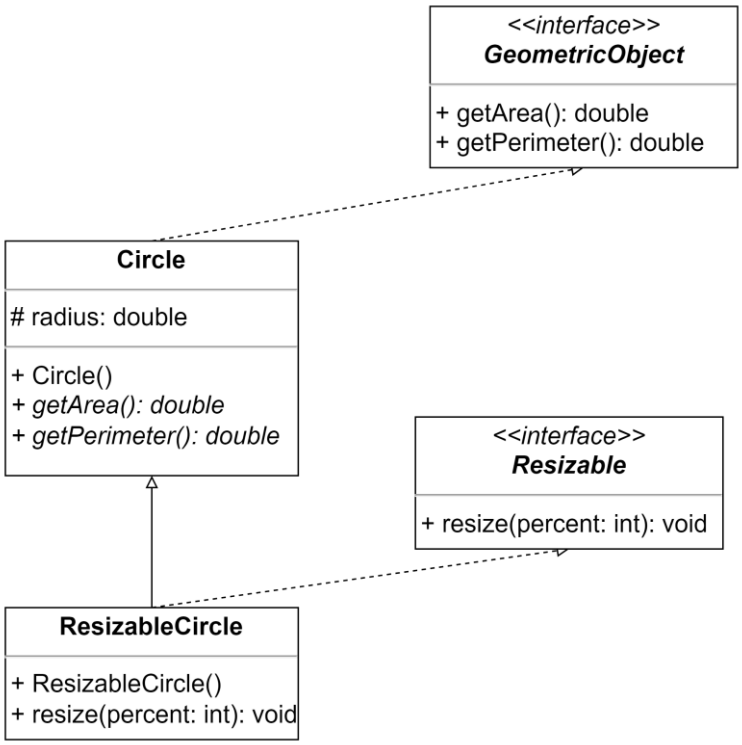
```
Shape[] shapes = new Shape[5];
shapes[0] = new Circle(4, "Red", true);
shapes[1] = new Rectangle(8, 4, "Blue", true);
shapes[2] = new Square(10, "Black", true);
shapes[3] = new Circle(9);
shapes[4] = new Rectangle(12, 8, "Blue", true);
```

3. Implement the below interface and classes to manage points in Descartes's coordinate system. Given that, the *move* methods will change the coordinate *x* or *y* based on the *xSpeed* or *ySpeed*.



Write a class with a *main* method to test your work.

4. Implement the below interface and classes. Know that the *resize()* method will change the *radius* based on the *percent* parameter.



Write a class with a *main* method to test your work.

--- THE END ---