

## 2.1 Exercise: Abstract Superclass Shape and Its Concrete Subclasses

Rewrite the superclass **Shape** and its subclasses **Circle**, **Rectangle** and **Square**, as shown in the class diagram.



In this exercise, **Shape** shall be defined as an abstract class, which contains:

- Two protected instance variables `color<String>` and `filled<boolean>`. The protected variables can be accessed by its subclasses and classes in the same package. They are denoted with a `"#"` sign in the class diagram.
- Getter and setter for all the instance variables, and `toString()`.
- Two abstract methods `getArea()` and `getPerimeter()` (shown in italics in the class diagram).

The subclasses **Circle** and **Rectangle** shall override the abstract methods `getArea()` and `getPerimeter()` and provide the proper implementation. They also override the `toString()`.

Write a test class to test these statements involving polymorphism and explain the outputs. Some statements may trigger compilation errors. Explain the errors, if any.

```
Shape s1 = new Circle(5.5, "RED", false); // Upcast Circle to Shape
System.out.println(s1);                  // which version?
System.out.println(s1.getArea());         // which version?
System.out.println(s1.getPerimeter());    // which version?
System.out.println(s1.getColor());
System.out.println(s1.isFilled());
System.out.println(s1.getRadius());

Circle c1 = (Circle)s1;                  // Downcast back to Circle
System.out.println(c1);
System.out.println(c1.getArea());
System.out.println(c1.getPerimeter());
System.out.println(c1.getColor());
System.out.println(c1.isFilled());
System.out.println(c1.getRadius());

Shape s2 = new Shape();

Shape s3 = new Rectangle(1.0, 2.0, "RED", false); // Upcast
System.out.println(s3);
System.out.println(s3.getArea());
System.out.println(s3.getPerimeter());
System.out.println(s3.getColor());
System.out.println(s3.getLength());

Rectangle r1 = (Rectangle)s3; // downcast
System.out.println(r1);
System.out.println(r1.getArea());
System.out.println(r1.getColor());
System.out.println(r1.getLength());

Shape s4 = new Square(6.6); // Upcast
System.out.println(s4);
System.out.println(s4.getArea());
System.out.println(s4.getColor());
System.out.println(s4.getSide());

// Take note that we downcast Shape s4 to Rectangle,
// which is a superclass of Square, instead of Square
Rectangle r2 = (Rectangle)s4;
System.out.println(r2);
System.out.println(r2.getArea());
System.out.println(r2.getColor());
System.out.println(r2.getSide());
System.out.println(r2.getLength());

// Downcast Rectangle r2 to Square
Square sq1 = (Square)r2;
System.out.println(sq1);
System.out.println(sq1.getArea());
System.out.println(sq1.getColor());
System.out.println(sq1.getSide());
System.out.println(sq1.getLength());
```

What is the usage of the abstract method and abstract class