Object-Oriented Programming

Lab session #3

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I. References

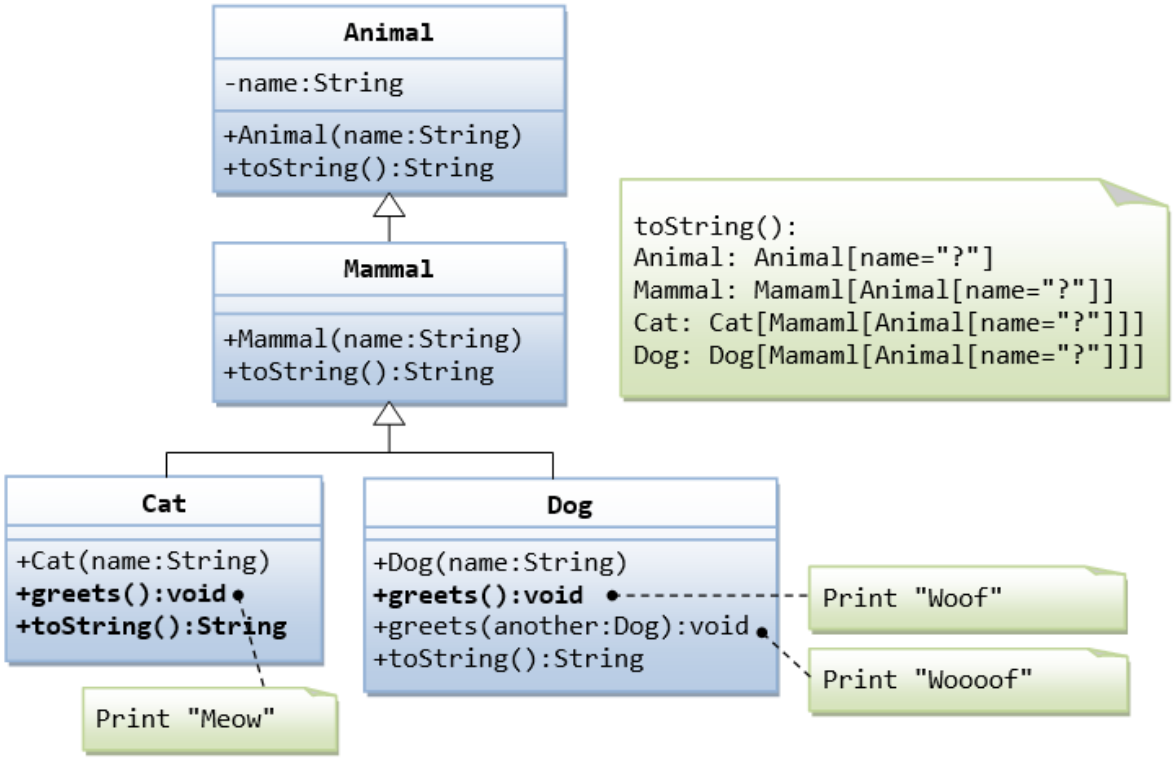
- Oracle Java Documentation: https://docs.oracle.com/javase/tutorial/java/IandI/index.html
- Inheritance in Java Tutorial: https://www.tutorialspoint.com/java/java_inheritance.htm
- Method overriding in Java Tutorial: https://www.tutorialspoint.com/java/java_overriding.htm
- Polymorphism in Java Tutorial: https://www.tutorialspoint.com/java/java_polymorphism.htm
- Abstraction in Java Tutorial: https://www.tutorialspoint.com/java/java_abstraction.htm
- Interface in Java Tutorial: https://www.tutorialspoint.com/java/java_interfaces.htm
- Set attribute default value: https://stackoverflow.com/questions/43509987/how-do-i-set-default-values-for-instance-variables

II. Exercises

You are required to implement the following design as well as a main() method in an another class to test your implementation:

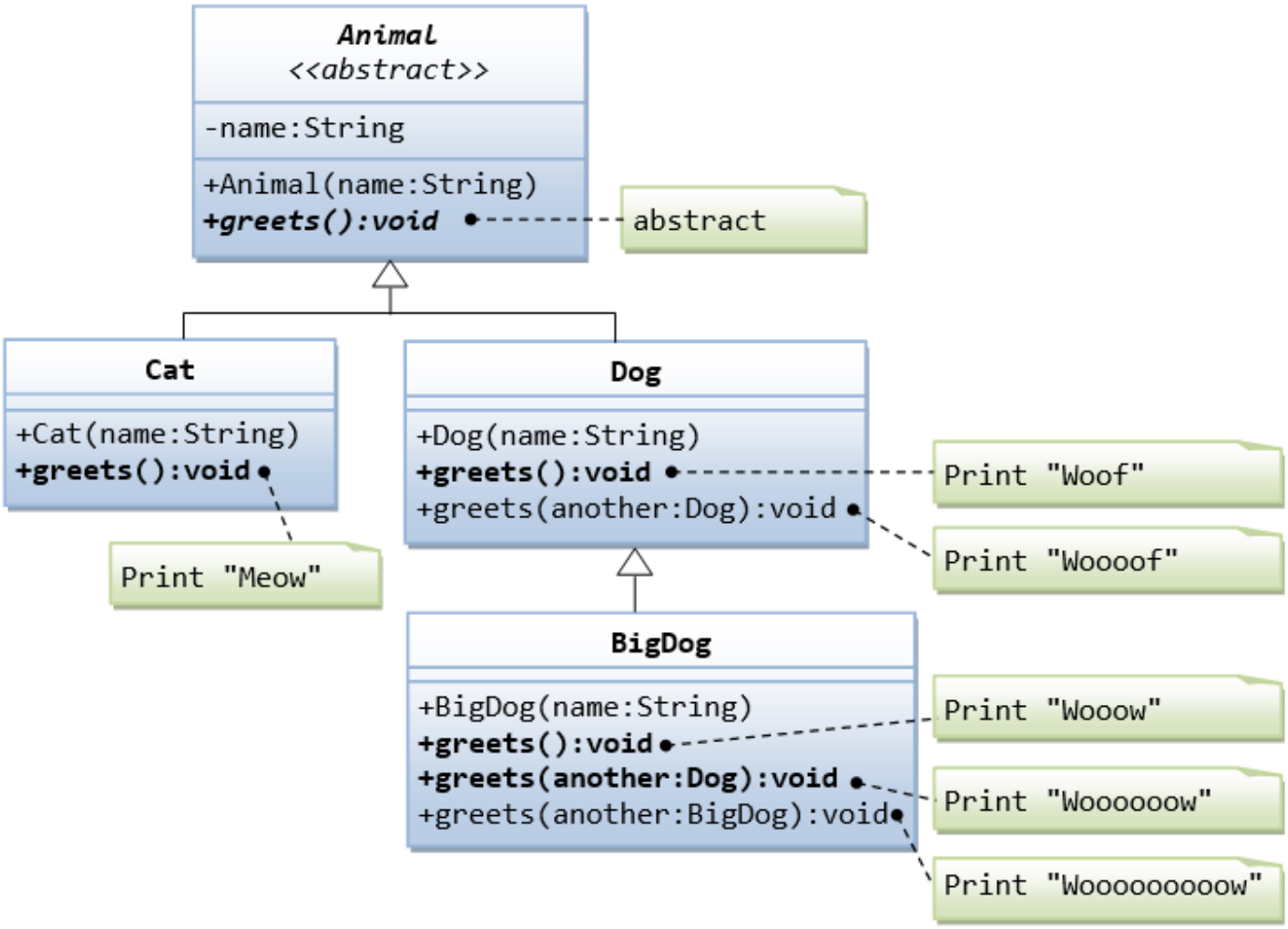
Question 1A: Superclass Animal and its subclasses (15 marks)

Write the codes for all the classes as shown in the class diagram:

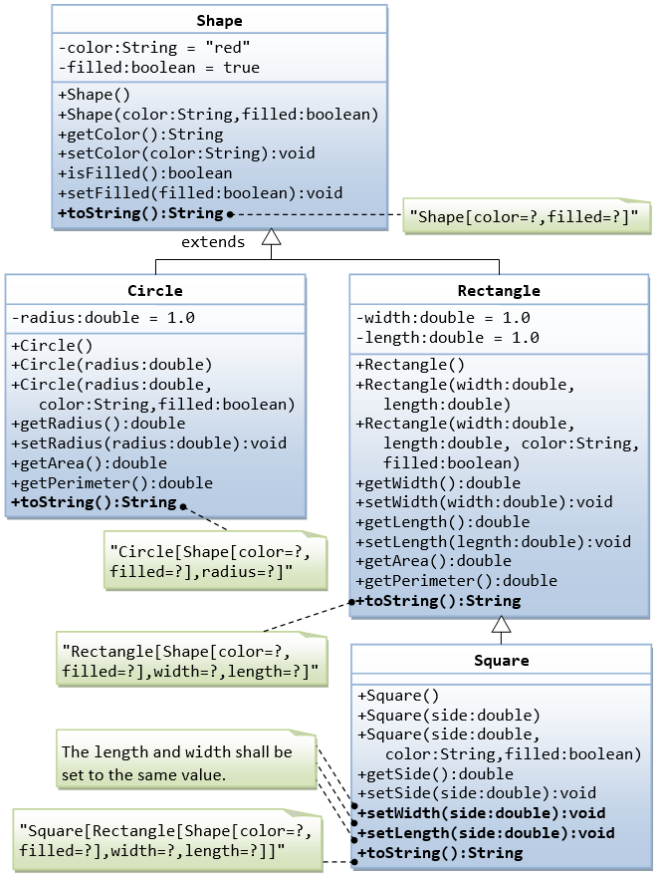


Question 1B: Abstract Superclass Animal and its Implementation Subclasses (15 marks)

Write the codes for all the classes shown in the class diagram. Mark all the overridden methods with annotation @Override.


Animal
<<abstract>>
-name:String
+Animal(name:String)
+greets():void
abstract
Cat
+Cat(name:String)
+greets():void
Print "Meow"
Dog
+Dog(name:String)
+greets():void
+greets(another:Dog):void
Print "Woof"
Print "Woooof"
BigDog
+BigDog(name:String)
+greets():void
+greets(another:Dog):void
+greets(another:BigDog):void
Print "Wooow"
Print "Wooooooow"
Print "Woooooooooow"

Question 2A: Superclass Shape and its subclasses Circle, Rectangle and Square (15 marks)



Write a **superclass** called **`Shape`** (as shown in the class diagram), 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`**.

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.

- 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:

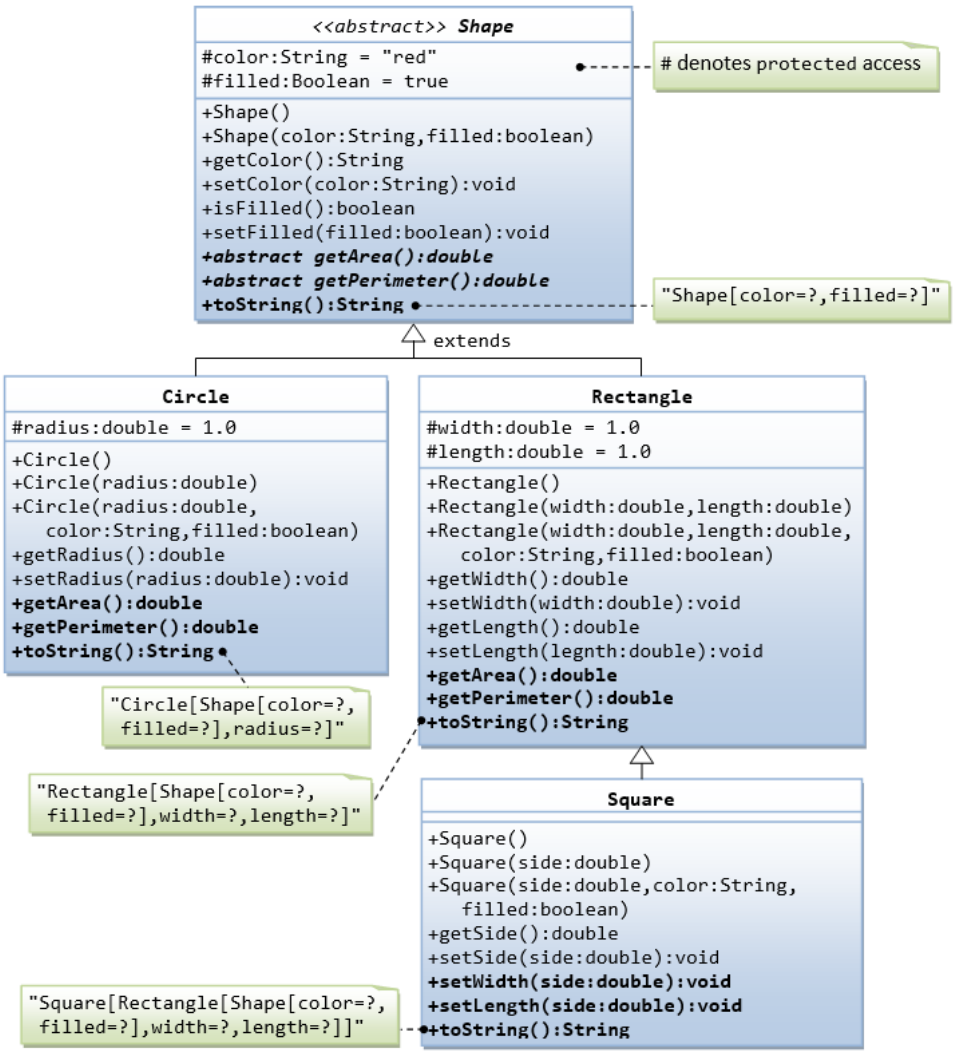
```
public Square(double side) {
   super(side, side);  // Call superclass Rectangle(double, double)
}
```

- 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.

Question 2B: Abstract Superclass Shape and Its Concrete Subclasses (15 marks)

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

`Shape` is an **`abstract`** class containing 2 **`abstract`** methods: **`getArea()`** and **`getPerimeter()`**, where its concrete subclasses must provide its implementation. All instance variables shall have **`protected`** access, i.e., accessible by its subclasses and classes in the same package. Mark all the overridden methods with annotation **`@Override`.**



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 (main class) to test these statements involving polymorphism and explain the outputs. Some statements may trigger compilation errors. Explain the errors, if any. Your main method should could look like this:

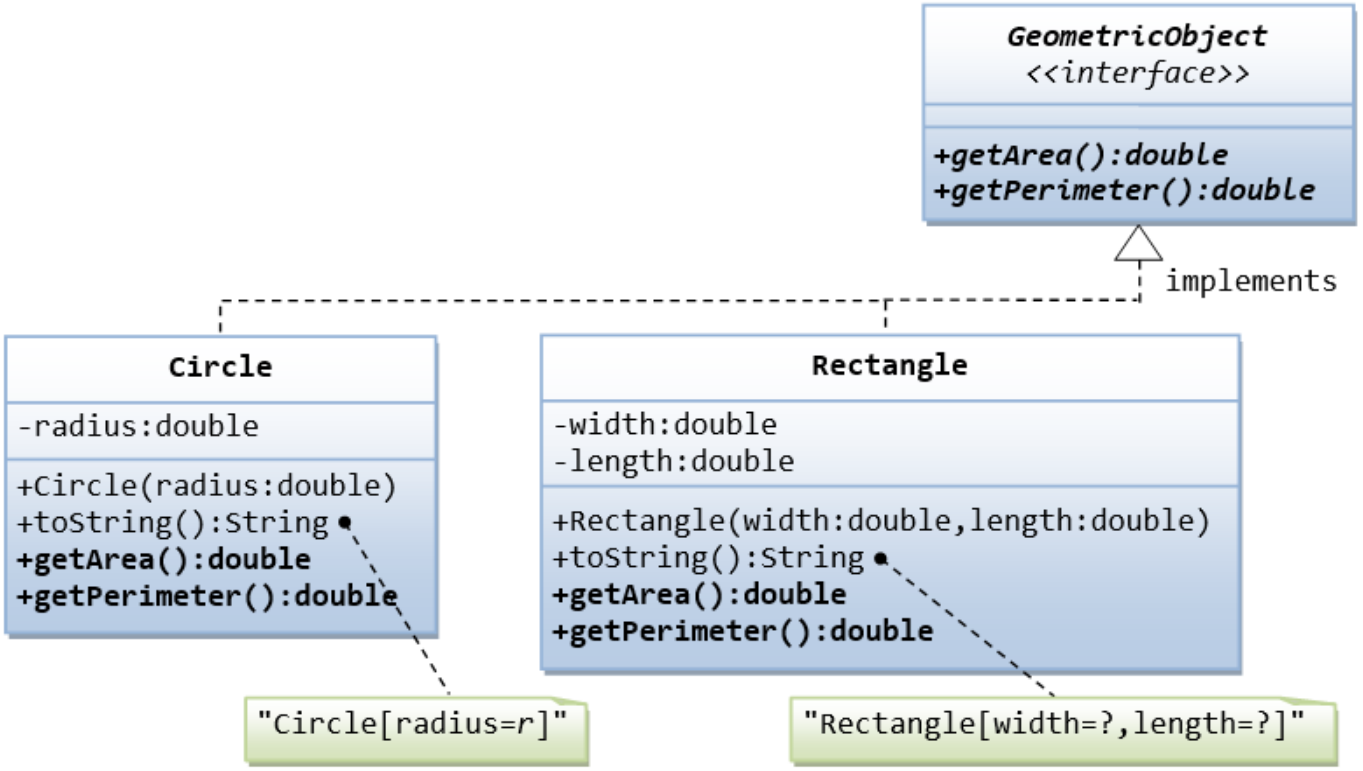
```
Shape s1 = new Circle(5.5, "red", false);  // Upcast Circle to Shape
System.out.println(s1);                    // which version?
System.out.println(s1.getArea());          // which version?
System.out.println(s1.getPerimeter());     // which version?
System.out.println(s1.getColor());
System.out.println(s1.isFilled());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

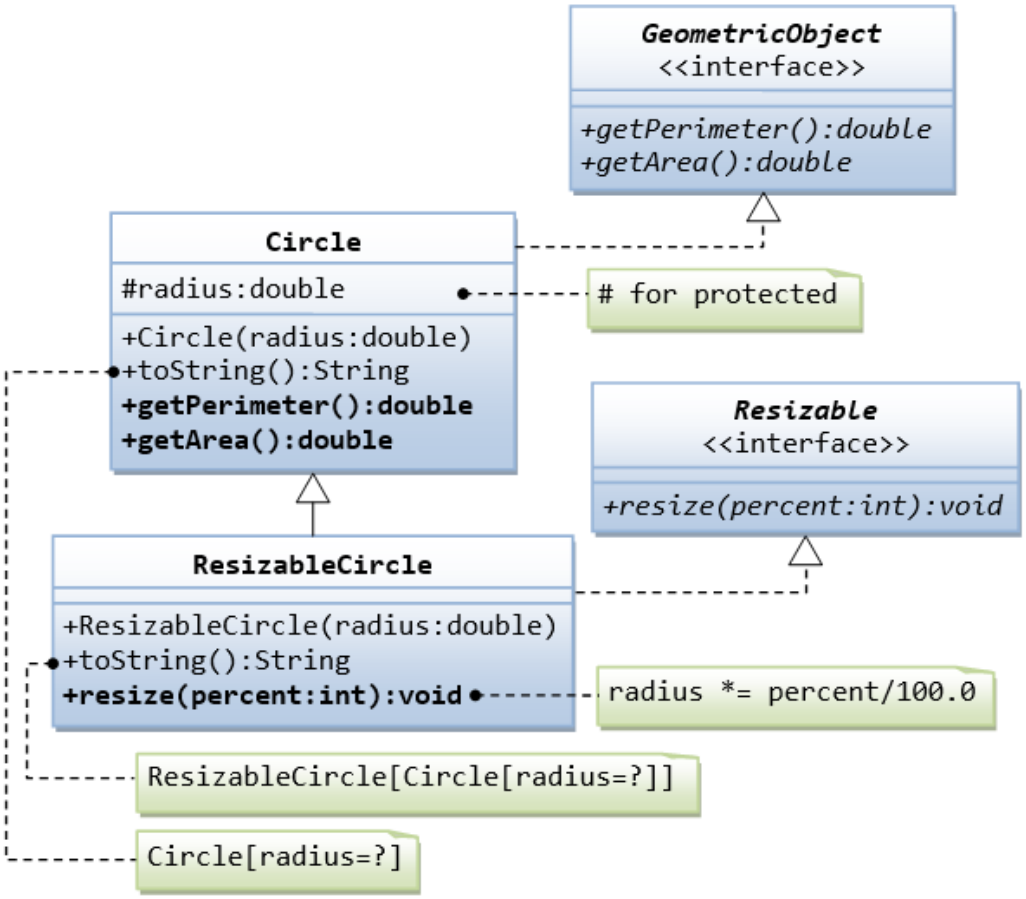
What is the usage of the **`abstract`** method and **`abstract`** class?

Question 3A: GeometricObject Interface and its Implementation Classes Circle and Rectangle (15 marks)

Write an **interface** called **`GeometricObject`**, which contains 2 **`abstract`** methods: **`getArea()`** and **`getPerimeter()`**, as shown in the class diagram. Also write an implementation class called **`Circle`**. Mark all the overridden methods with annotation **`@Override`**.



Question 3B: Interfaces Resizable and GeometricObject (15 marks)



Hints (step by step):

1. Write the **`interface`** called **`GeometricObject`**, which declares two **`abstract`** methods: **`getParameter()`** and **`getArea()`**, as specified in the class diagram.

```
public interface GeometricObject {
   public double getPerimeter();
   ......
}
```

2. Write the implementation class **`Circle`**, with a protected variable **`radius`**, which implements the interface **`GeometricObject`**.

```
public class Circle implements GeometricObject {
   // Private variable
   ......

   // Constructor
   ......

   // Implement methods defined in the interface GeometricObject
   @Override
   public double getPerimeter() { ...... }

   ......
}
```

3. Write a test program called **`TestCircle`** to test the methods defined in **`Circle`**.
4. The class **`ResizableCircle`** is defined as a subclass of the class **`Circle`**, which also implements an interface called **`Resizable`**, as shown in class diagram. The interface **`Resizable`** declares an **`abstract`** method **`resize()`**, which modifies the dimension (such as **`radius`**) by the given percentage. Write the interface **`Resizable`** and the class **`ResizableCircle`**.

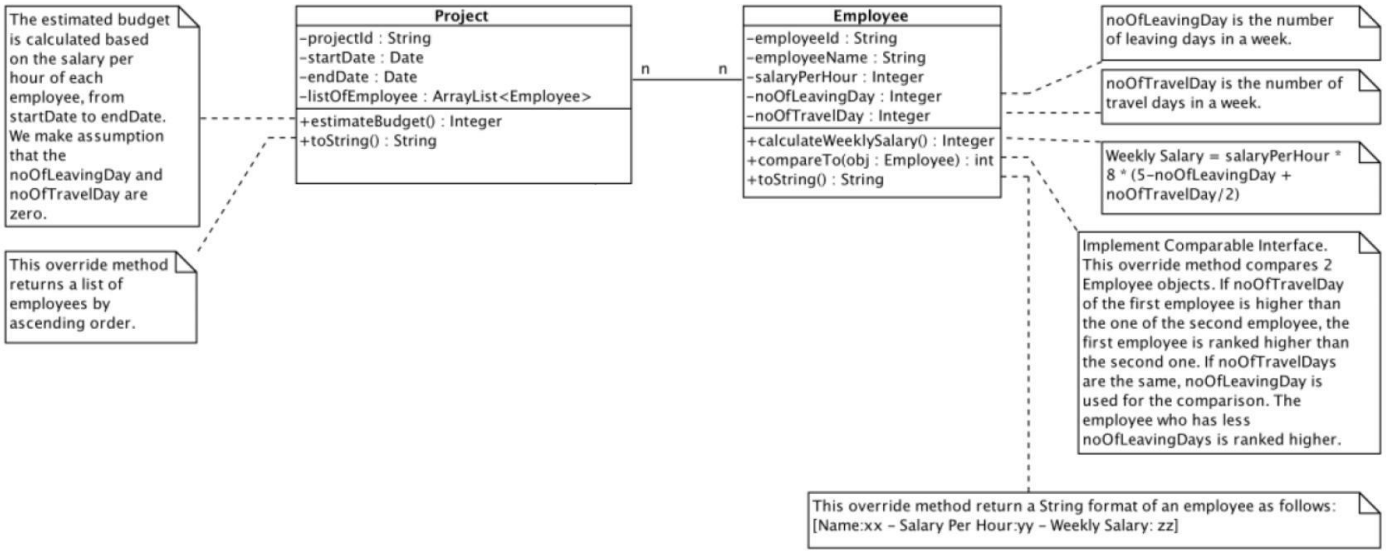
```
public interface Resizable {
   public double resize(...);
}
```

```
public class ResizableCircle extends Circle implements Resizeable {

   // Constructor
   public ResizableCircle(double radius) {
      super(...);
   }

   // Implement methods defined in the interface Resizable
   @Override
   public double resize(int percent) { ...... }
}
```

5. Write a test program called **`TestResizableCircle (with main method)`** to test the methods defined in **`ResizableCircle`**.

Question 4 (Bonus): Projects and Employees (30 marks)

You are required to implement the following design as well as an AppTest class to test your implementation. You must add appropriate constructors, getter and setter for each class. You can add private methods into the classes to support your work.



Hints:
To use Date datatype, remember to *import java.util.Date;*

References:
- Comparable Interface tutorial: https://www.javatpoint.com/Comparable-interface-in-collection-framework
- The reason why we want to implement comparable interface so that we can sort ArrayList of Employee to print it out in order in method toString() of Project like so: https://beginnersbook.com/2013/12/java-arraylist-of-object-sort-example-comparable-and-comparator/