ÖZYEĞİN UNIVERSITY

CS 102
Object Oriented Programming

Abstract Classes and Interfaces

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Shapes

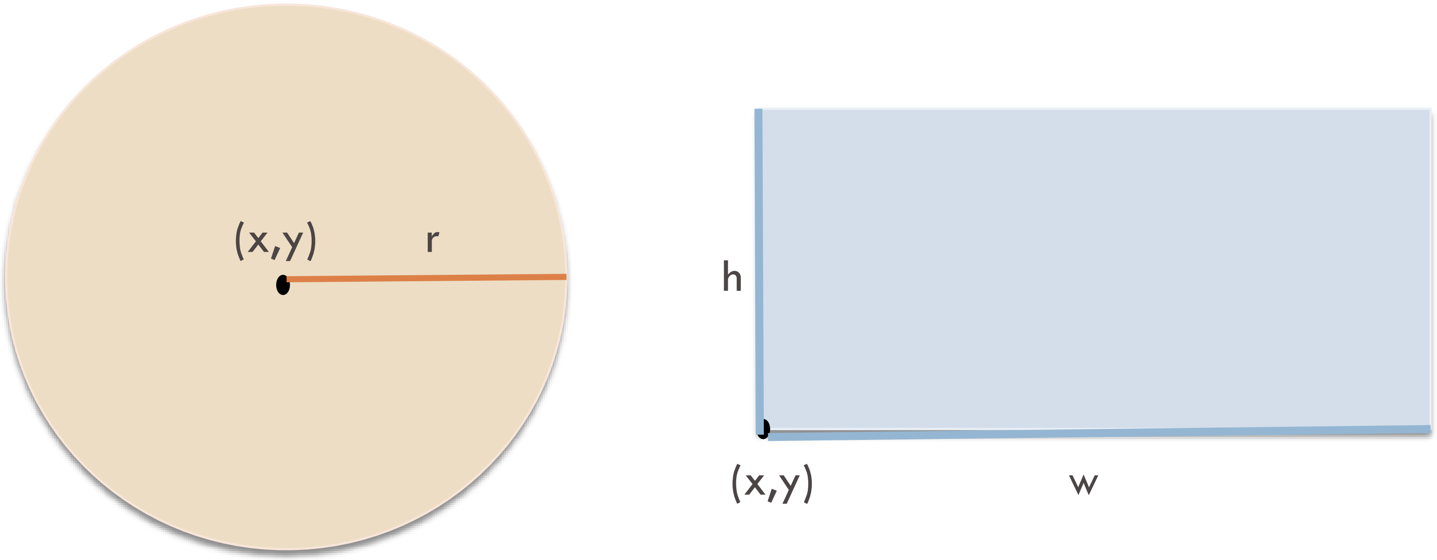
- Let’s implement classes for shapes
  - Rectangle
  - Circle
  - etc.

Shapes

- Let's implement classes for shapes
  - Rectangle
  - Circle
  - etc.
- What is common in all these shapes?
  - x and y coordinates that hints about the location of the shape.

Shapes

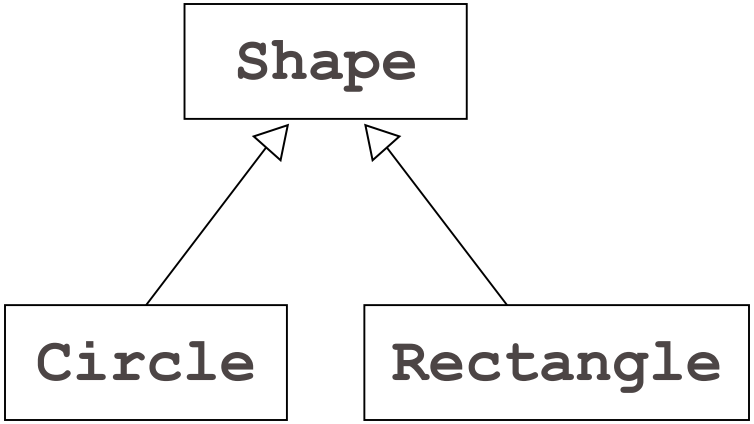
- (x,y) coordinate •



In circle we hold an additional radius, in rectangle we have height and width.

Inheritance

- We can have a shape class.
- Other shapes can inherit from the shape class.



- Sometimes a class should define a method that logically belongs in the class, but that class cannot specify how to implement the method.

- Sometimes a class should define a method that logically belongs in the class, but that class cannot specify how to implement the method.
- For instance:
  - Every shape has an area.
  - Logically, every shape should have a **getArea** method.
  - But …

- Every shape has an area.
- Logically, every shape should have a **getArea** method.
- But, the area of every shape is calculated differently.
  - Area of Circle = square(radius) * pi
  - Area of Rectangle = height * width

- Every shape has an area.
- Logically, every shape should have a **getArea** method.
- But, the area of every shape is calculated differently.
- There is not any implementation of **getArea** method in the **Shape** class that is correct for all subclasses of Shape.
- Therefore, we need to enforce the subclasses of Shape to implement the **getArea** method.

- At this point
  - Every shape has an area.
  - But there is not any way to implement the **getArea** method in the **Shape** class.
  - Therefore, maybe we should not let the instantiation of a **Shape** object, even when we have the **Shape** class. Can we?
    - *instantiate*: create a new instance

- At this point
  - Every shape has an area.
  - But there is not any way to implement the **getArea** method in the **Shape** class.
  - Therefore, maybe we should not let the instantiation of a **Shape** object, even when we have the **Shape** class. Can we?
  - Yes we can, with use of **abstract** classes.

Abstract Classes

- Classes that cannot be used to instantiate objects are **abstract classes.**

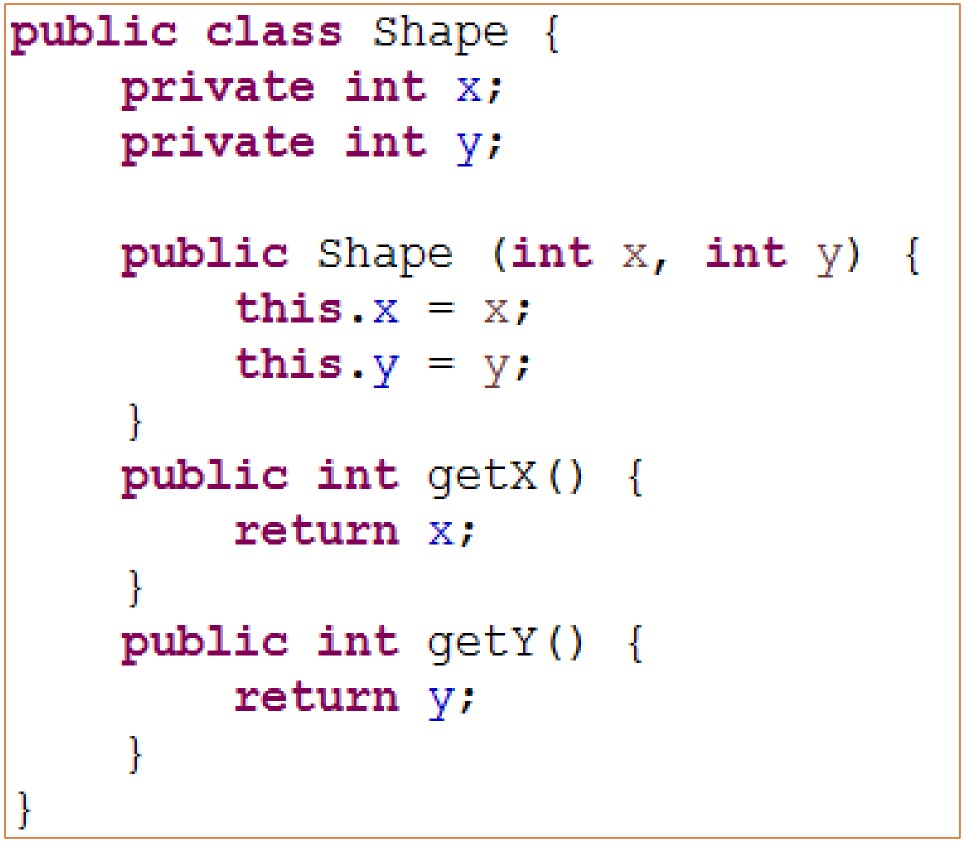
Abstract and Concrete Classes

- Classes that cannot be used to instantiate objects are **abstract classes.**
- Classes that can be used to instantiate objects are **concrete classes.**
- Concrete class is the default class.

Abstract Classes

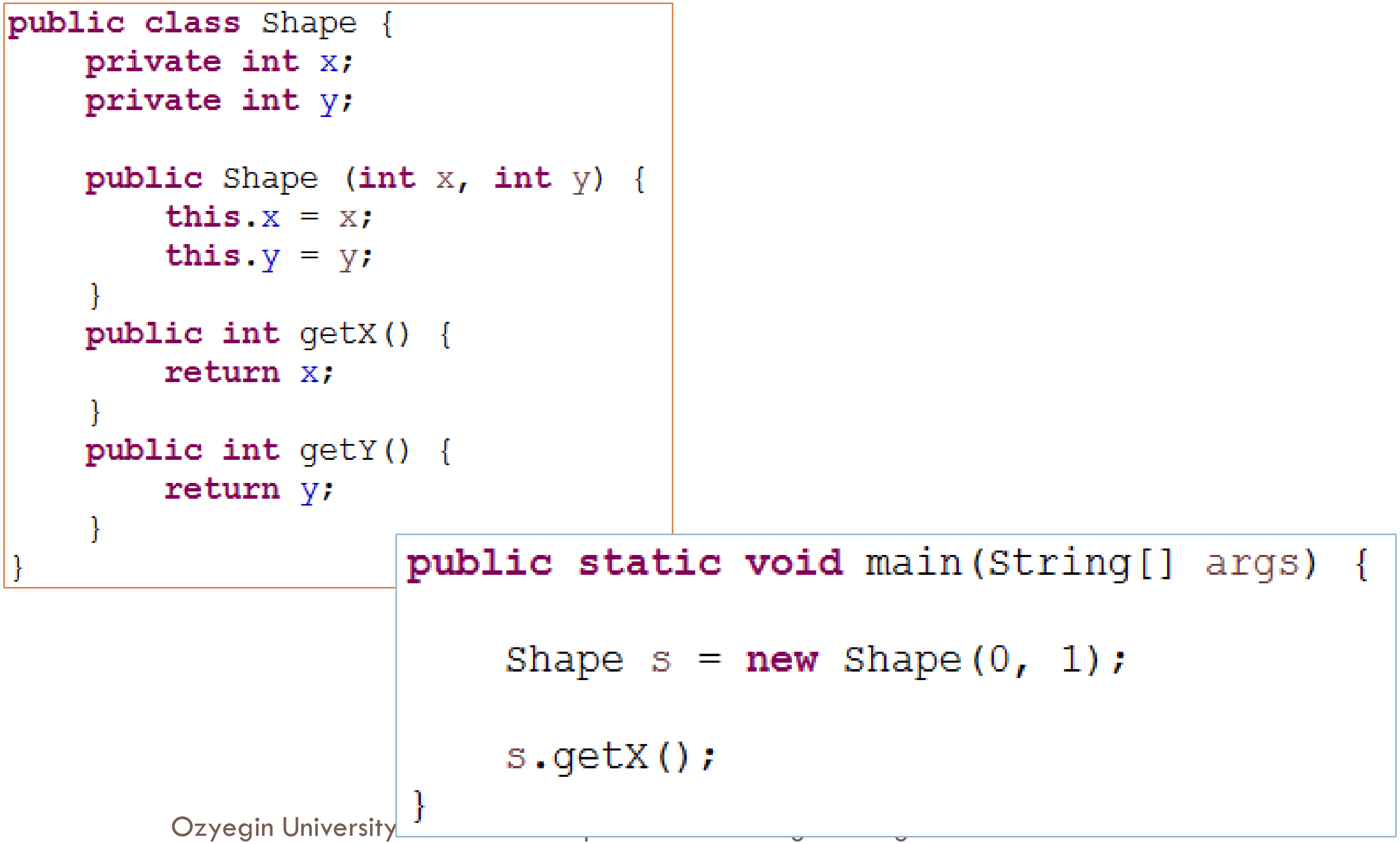
- Classes that cannot be used to instantiate objects are **abstract classes.**
- They are used as superclasses during inheritance and provide common attributes and behaviors to its subclasses.

Shape Class (Concrete)



```
public class Shape {
    private int x;
    private int y;

    public Shape (int x, int y) {
        this.x = x;
        this.y = y;
    }
    public int getX() {
        return x;
    }
    public int getY() {
        return y;
    }
}
```

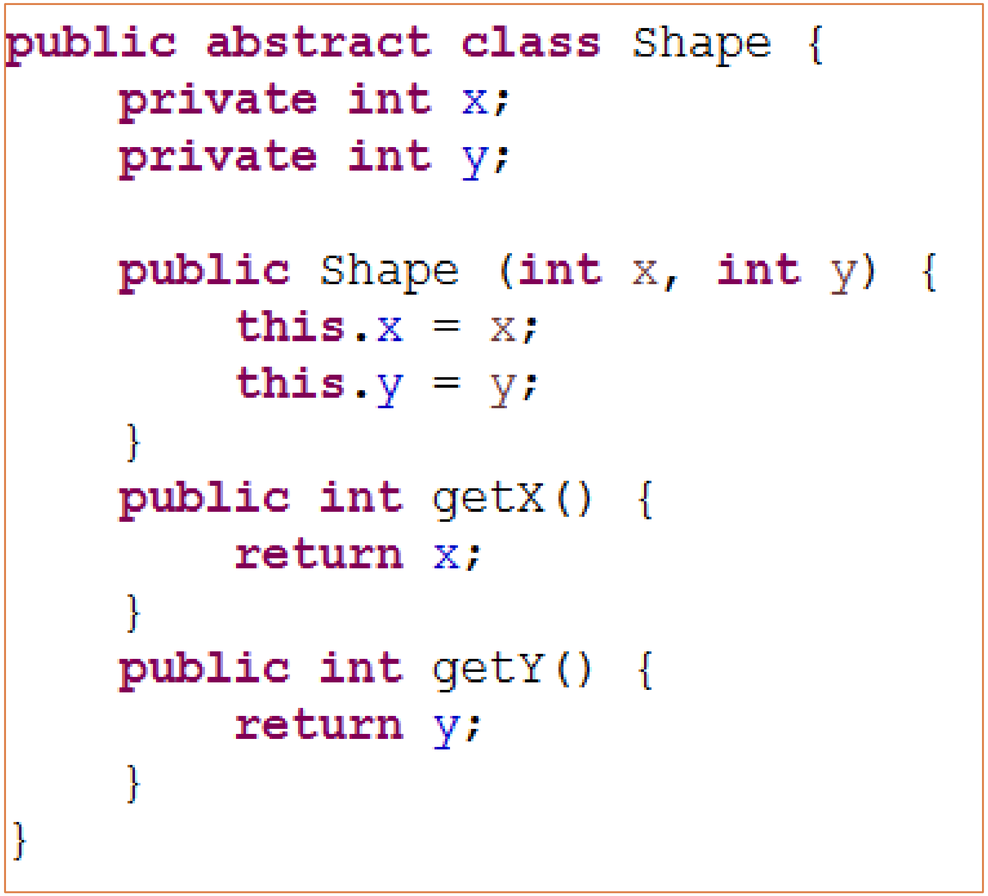
Shape Class (Concrete)



```
public class Shape {
    private int x;
    private int y;

    public Shape (int x, int y) {
        this.x = x;
        this.y = y;
    }
    public int getX() {
        return x;
    }
    public int getY() {
        return y;
    }
}
```

```
public static void main(String[] args) {

    Shape s = new Shape(0, 1);

    s.getX();
}
```

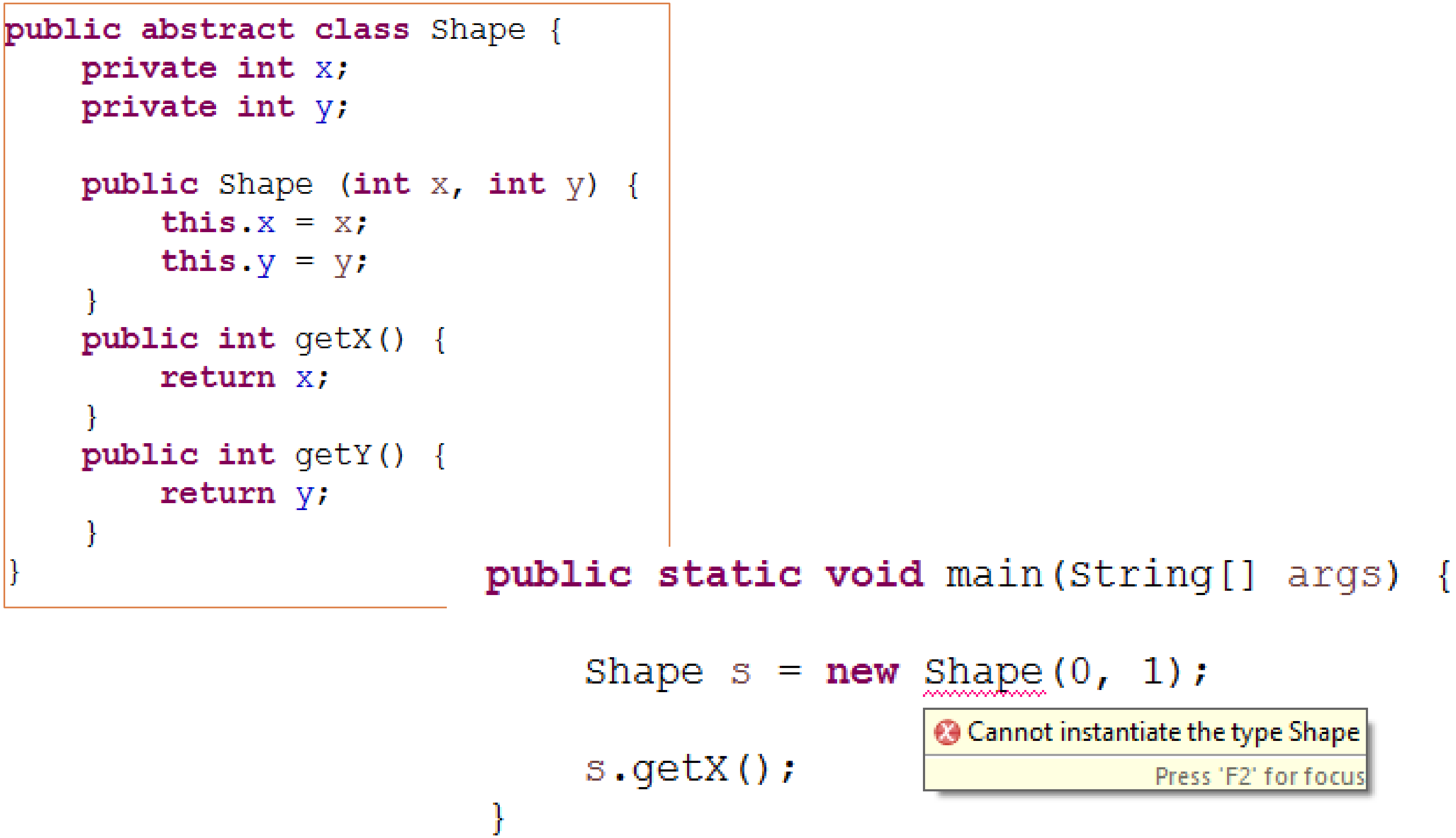
Shape Class (Abstract)



```
public abstract class Shape {
    private int x;
    private int y;

    public Shape (int x, int y) {
        this.x = x;
        this.y = y;
    }
    public int getX() {
        return x;
    }
    public int getY() {
        return y;
    }
}
```

- You make a class **abstract** by declaring it with keyword *abstract*.

Shape Class (Abstract)



```
public abstract class Shape {
    private int x;
    private int y;

    public Shape (int x, int y) {
        this.x = x;
        this.y = y;
    }
    public int getX() {
        return x;
    }
    public int getY() {
        return y;
    }
}
```

```
public static void main(String[] args) {

    Shape s = new Shape(0, 1);

    s.getX();
}
```

Cannot instantiate the type Shape

Abstract Classes

- Abstract classes are incomplete.
- Their subclasses can complete these incomplete parts and become concrete classes.
- If they don’t, subclasses will be also abstract.

Abstract Classes

- Abstract classes are incomplete.
- Their subclasses can complete these incomplete parts and become concrete classes.
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- What do we mean by incomplete?

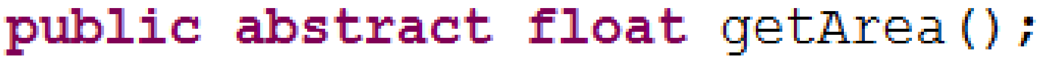
Abstract Classes

- Abstract classes are incomplete.
- Their subclasses can complete these incomplete parts and become concrete classes.
- If they don’t, subclasses will be also abstract.

- What do we mean by incomplete?
  - Remember the getArea function.

Abstract Functions

- A method that has been declared but not implemented is an abstract function.

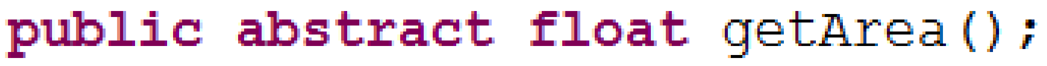


```
public abstract float getArea();
```

- The keyword **abstract** needs to be used.
- The body of the method is missing.
  - incomplete function

Abstract Functions

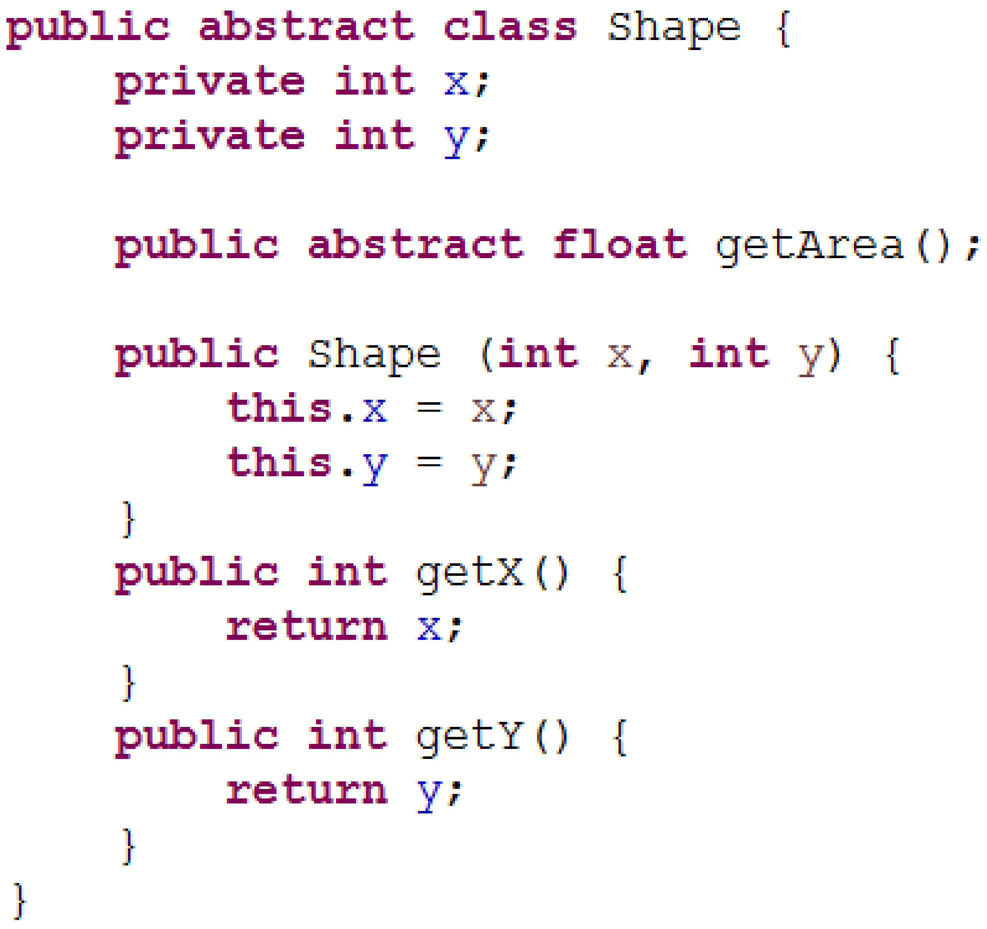
- A method that has been declared but not implemented is an abstract function.



```
public abstract float getArea();
```

- The keyword **abstract** needs to be used.
- The body of the method is missing.
  - incomplete function
- Constructors and static methods cannot be absract.

Shape Class (Abstract)



```java
public abstract class Shape {
    private int x;
    private int y;

    public abstract float getArea();

    public Shape (int x, int y) {
        this.x = x;
        this.y = y;
    }
    public int getX() {
        return x;
    }
    public int getY() {
        return y;
    }
}
```

Abstract Classes

- A class which contains at least one abstract function is an abstract class.
- A class can still be an abstract class even if it does not contain any abstract methods but contain the abstract keyword.

Abstract Classes

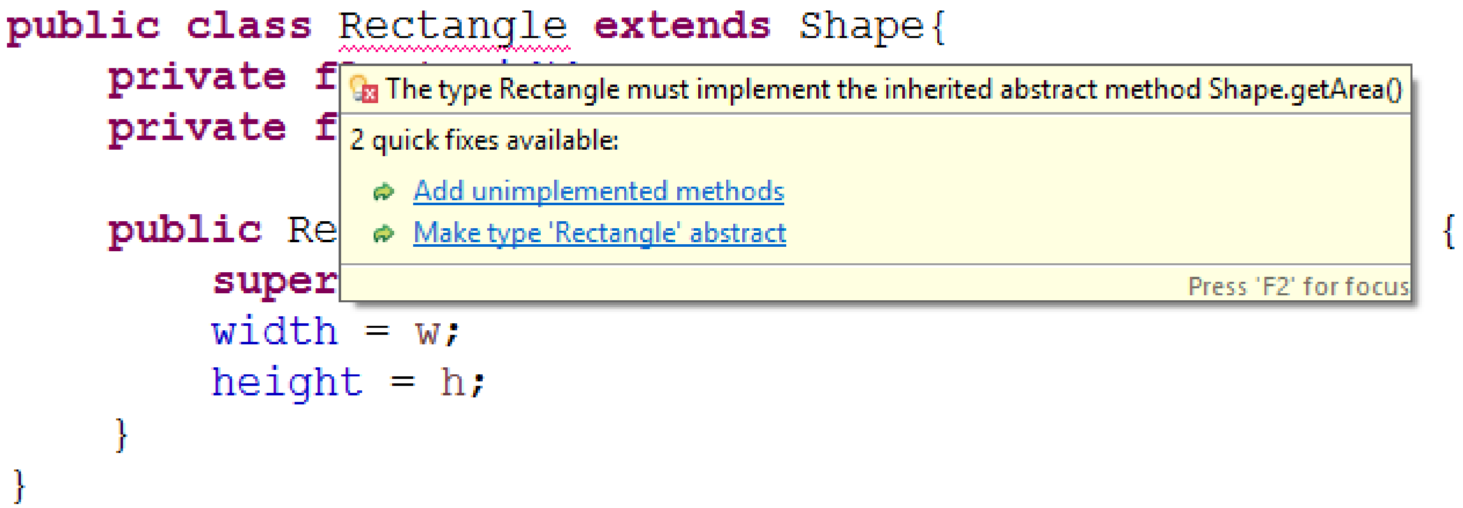
- A class which contains at least one abstract function is an abstract class.
- A class can still be an abstract class even if it does not contain any abstract methods but contain the abstract keyword.
- Concrete methods provide implementations of every method they declare.
- A concrete subclass needs to implement all the abstract methods inherited from the abstract superclass.

Abstract Classes

- When inheritting from an abstract class
  - If the subclass implements all the inherited abstract methods, it can be instantiated
  - If the subclass does *not* implement all the inherited abstract methods, it too must be abstract

Circle and Rectangle Classes

- Inheriting from abstract Shape class.



```
public class Rectangle extends Shape{
    private f
    private f

    public Re                                                   {
        super
        width = w;
        height = h;
    }
}
```

The type Rectangle must implement the inherited abstract method Shape.getArea()

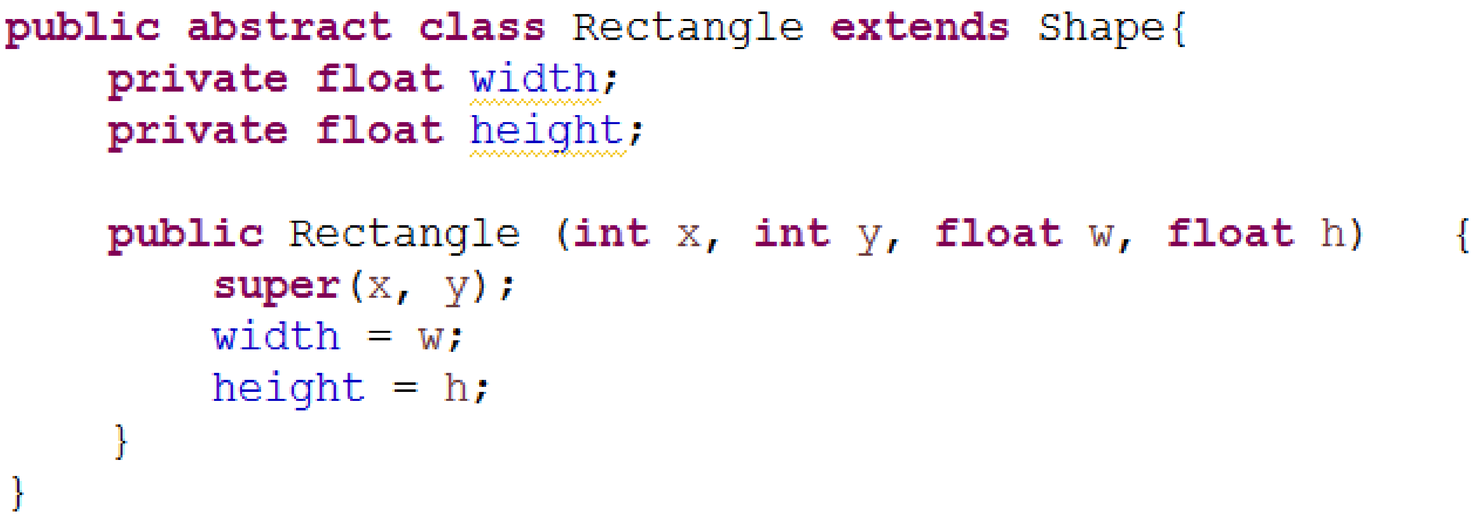
2 quick fixes available:

- Add unimplemented methods
- Make type 'Rectangle' abstract

Press 'F2' for focus

Circle and Rectangle Classes

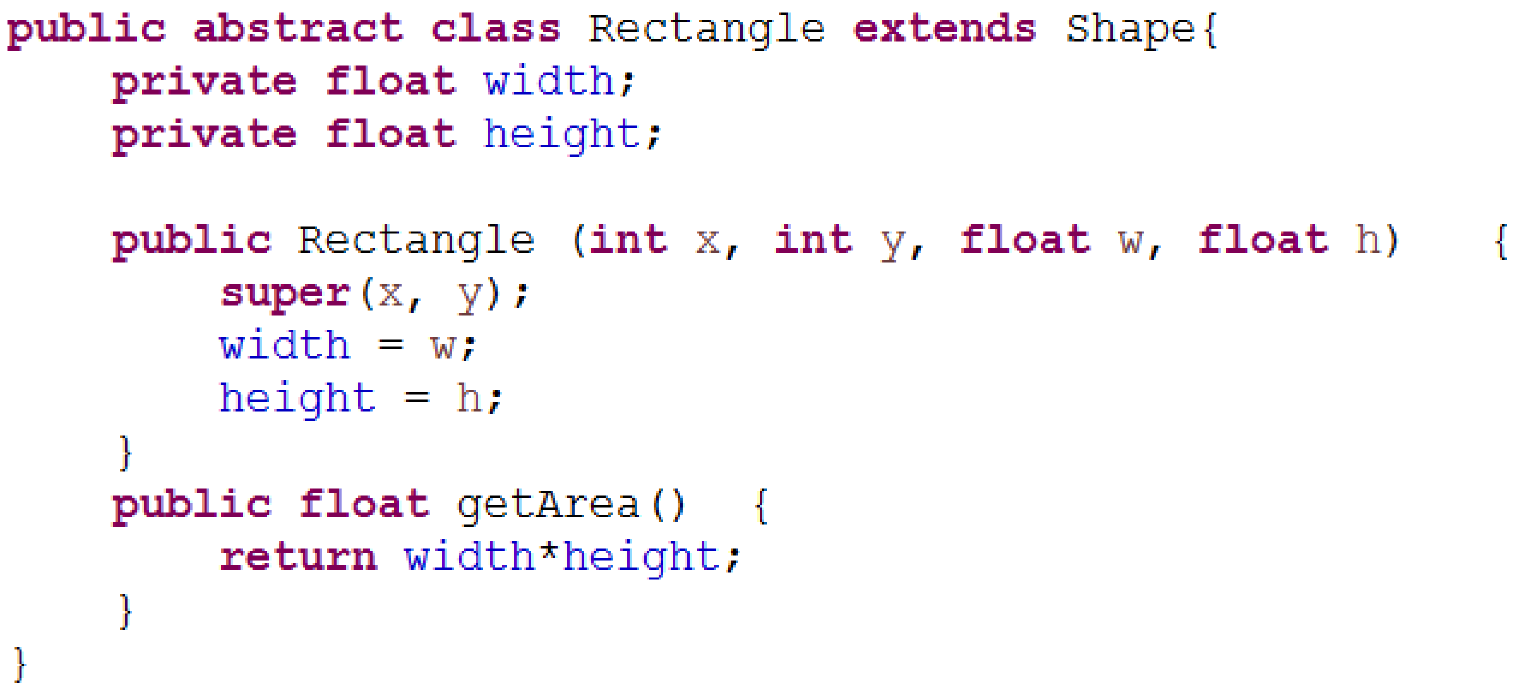
- Inheriting from abstract Shape class.
  - One solution is to make Rectangle class abstract as well



```java
public abstract class Rectangle extends Shape{
    private float width;
    private float height;

    public Rectangle (int x, int y, float w, float h)    {
        super(x, y);
        width = w;
        height = h;
    }
}
```

Circle and Rectangle Classes

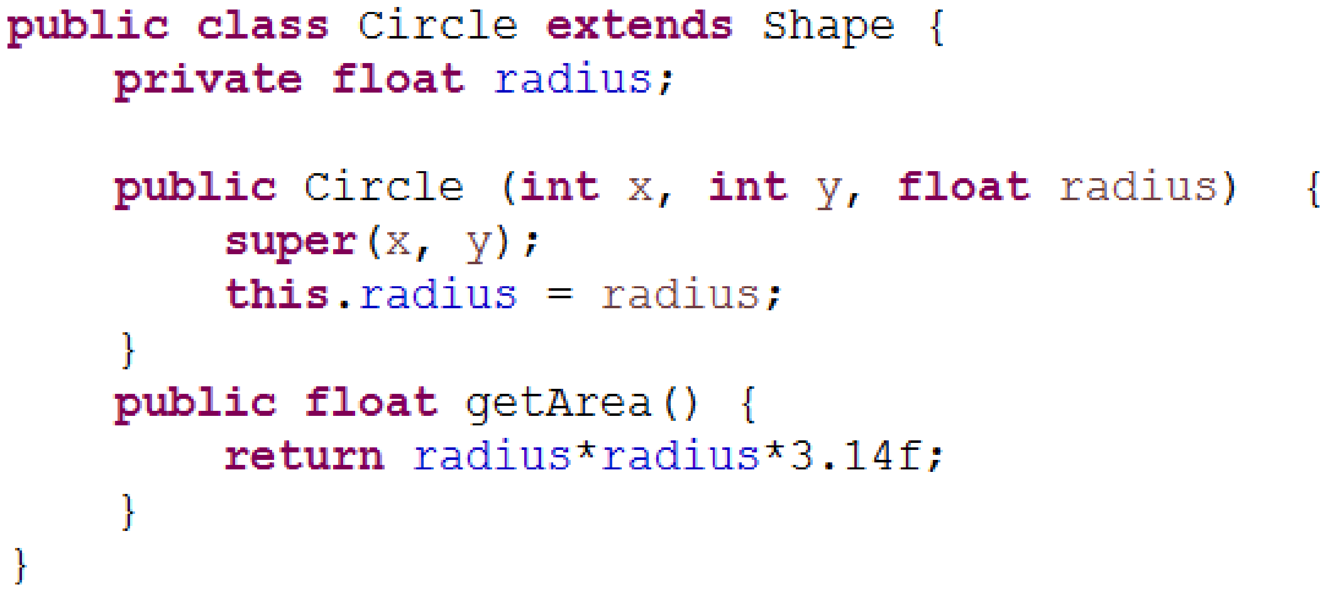
- Inheriting from abstract Shape class.
  - The other solution is to implement the getArea method.



```
public abstract class Rectangle extends Shape{
    private float width;
    private float height;

    public Rectangle (int x, int y, float w, float h)   {
        super(x, y);
        width = w;
        height = h;
    }
    public float getArea()  {
        return width*height;
    }
}
```

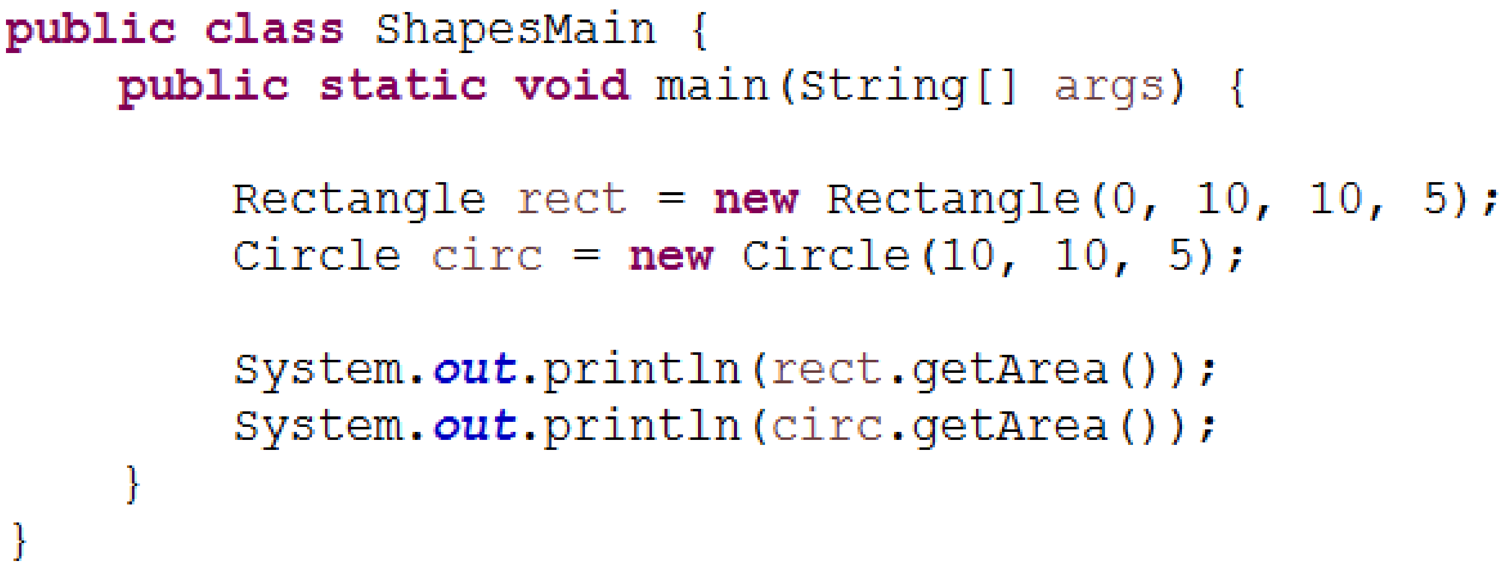
Circle and Rectangle Classes

- Inheriting from abstract Shape class.
  - Same for the circle class.

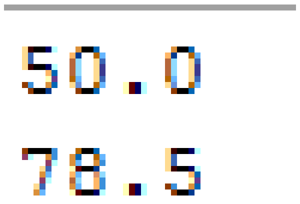


```
public class Circle extends Shape {
    private float radius;

    public Circle (int x, int y, float radius)  {
        super(x, y);
        this.radius = radius;
    }
    public float getArea() {
        return radius*radius*3.14f;
    }
}
```

Using Shapes



```
public class ShapesMain {
    public static void main(String[] args) {

        Rectangle rect = new Rectangle(0, 10, 10, 5);
        Circle circ = new Circle(10, 10, 5);

        System.out.println(rect.getArea());
        System.out.println(circ.getArea());
    }
}
```



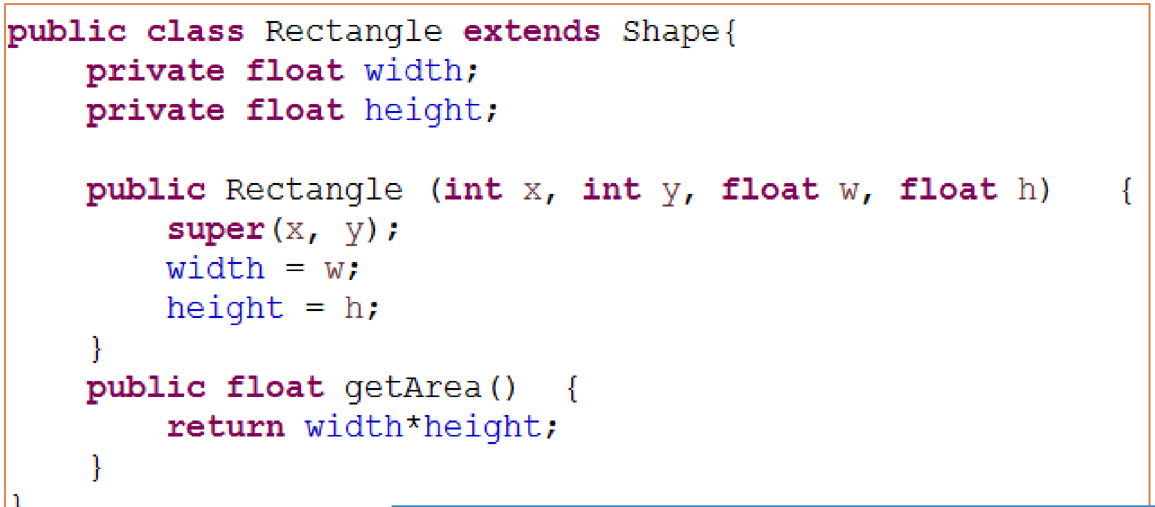
```
50.0
78.5
```

Quick Note

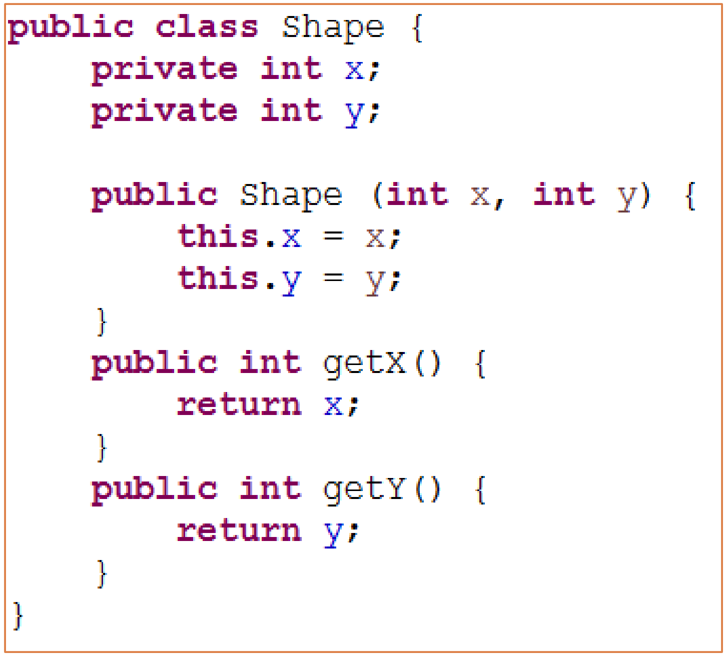
- Not all hierarchies contain abstract classes.
- Not all superclasses needs to be abstract.

Remember the last class

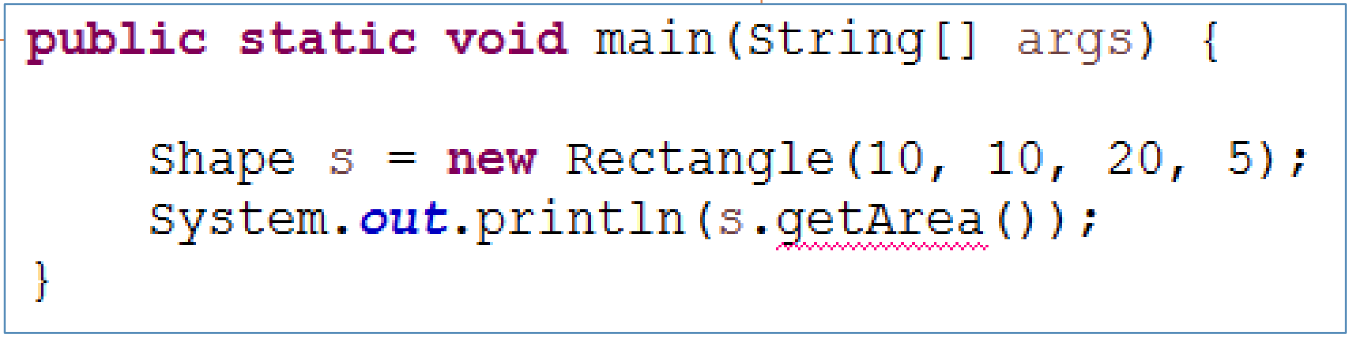
- We have the following classes:
  - Shape is not abstract



```
public class Rectangle extends Shape{
    private float width;
    private float height;

    public Rectangle (int x, int y, float w, float h)   {
        super(x, y);
        width = w;
        height = h;
    }
    public float getArea()  {
        return width*height;
    }
}
```



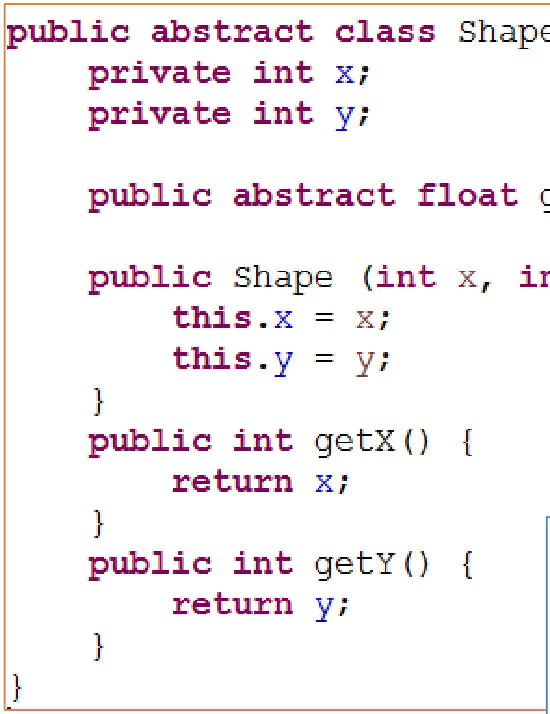
```
public class Shape {
    private int x;
    private int y;

    public Shape (int x, int y) {
        this.x = x;
        this.y = y;
    }
    public int getX() {
        return x;
    }
    public int getY() {
        return y;
    }
}
```



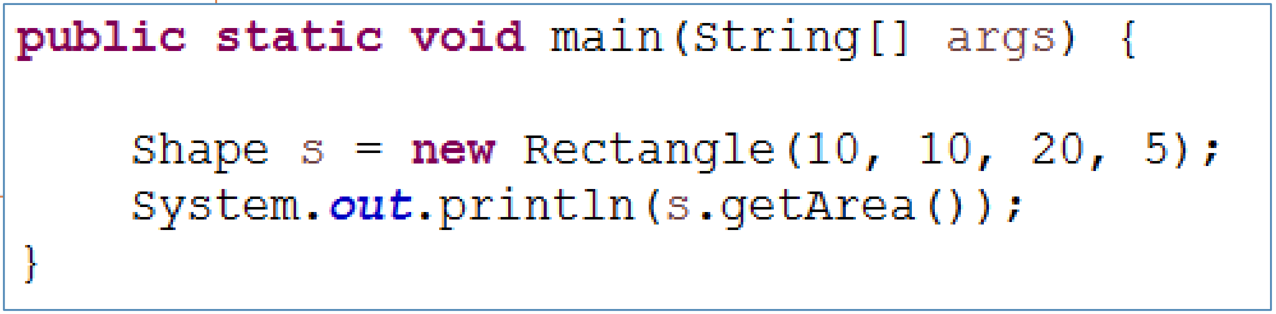
```
public static void main(String[] args) {

    Shape s = new Rectangle(10, 10, 20, 5);
    System.out.println(s.getArea());
}
```

Remember the last class

- When Shape is abstract, we don’t get that compiler error. Why?



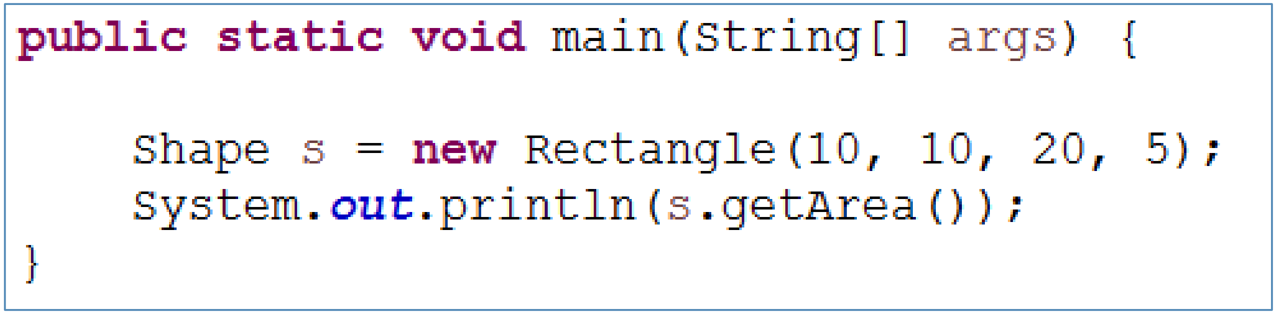
```java
public abstract class Shape {
    private int x;
    private int y;

    public abstract float getArea();

    public Shape (int x, int y) {
        this.x = x;
        this.y = y;
    }
    public int getX() {
        return x;
    }
    public int getY() {
        return y;
    }
}
```



```java
public static void main(String[] args) {

    Shape s = new Rectangle(10, 10, 20, 5);
    System.out.println(s.getArea());
}
```

Remember the last class

- When Shape is abstract, we don't get that compiler error. Why?
- getArea method has been declared in Shape class
- Any object that Shape can refer to needs to implement this getArea method in order to be instantiated.



```
public static void main(String[] args) {

    Shape s = new Rectangle(10, 10, 20, 5);
    System.out.println(s.getArea());
}
```

- There are things we cannot do with abstract classes.
- Lets see interfaces…

Interface

- Interfaces offer a capability requiring that unrelated classes implement a set of common methods

Interfaces

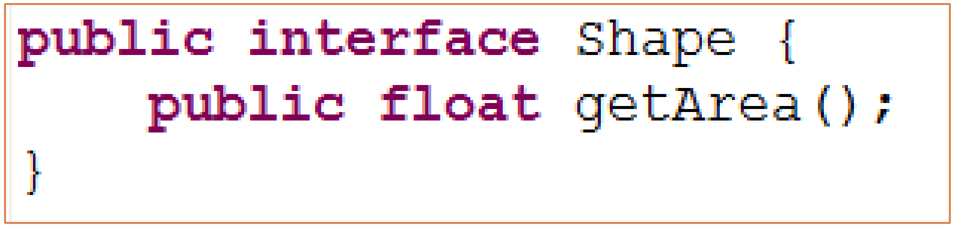
- An interface only declares the public behaviors of a class but does not implement them.

Inerfaces

- An **interface** only declares the public behaviors of a class but does not implement them.
- Based on this definition, in an interface
  - All methods are implicitly public
  - All methods are implicitly abstract
    - There are not any concrete methods
  - There are not any attributes
    - It does not contain any class instance
    - It can contain constants (**final** variables)

Example interface

- Use the keyword interface



```
public interface Shape {
    public float getArea();
}
```

Interface

- Can we instantiate an interface?

Interface

- Can we instantiate an interface?
  - No.

- Actually an interface is a very abstract class
  - None of its methods are implemented
  - All methods are abstract

When do you need an interface?

- You would write an interface when you want classes of various types to all have a certain set of capabilities (behaviors).
  - You can write methods that work for more than one kind of class.
- Very common in GUI implementations.

```
interface KeyListener {
        public void keyPressed(KeyEvent e);
        public void keyReleased(KeyEvent e);
        public void keyTyped(KeyEvent e);
}
```

Interface

- A class can **extend** a class.
- A class can **implement** an interface.

```
public interface Shape {
    public float getArea();
}
```

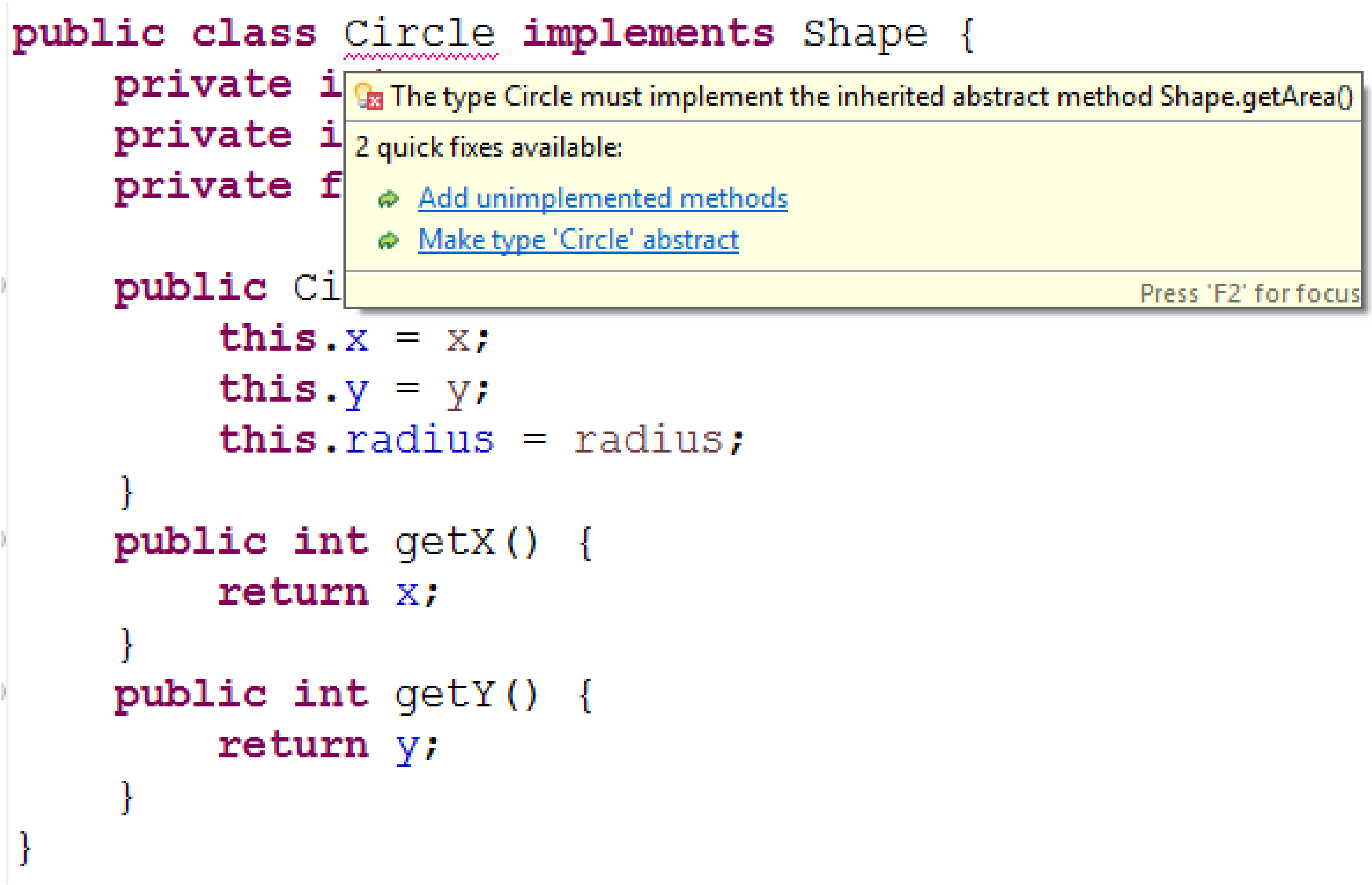
```
public class Circle implements Shape {
    private int x;
    private int y;
    private float radius;

    public Circle (int x, int y, float radius)  {
        this.x = x;
        this.y = y;
        this.radius = radius;
    }
    public float getArea() {
        return radius*radius*3.14f;
    }
    public int getX() {
        return x;
    }
    public int getY() {
        return y;
    }
}
```

Interface

- A class can only extend one class.
- A class can implement multiple interfaces.
  - This lets the class fill multiple "roles"
  - In writing Applets, it is common to have one class implement several different listeners
  - Example:

```
class MyApplet extends Applet
        implements ActionListener, KeyListener {
            ...
}
```

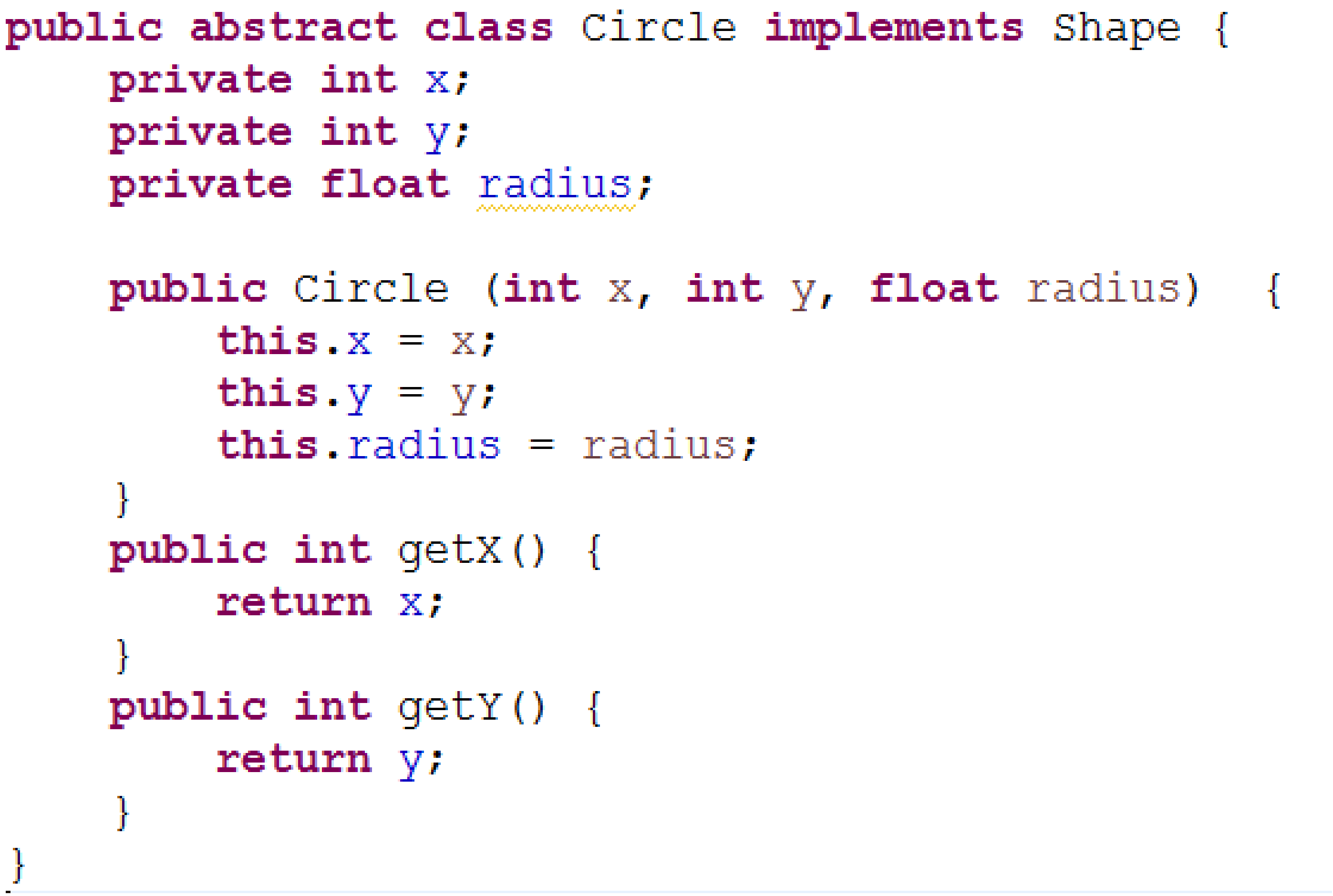
- When a class implements an interface, the class needs to implement all the declared methods of the interface.
- If all the declared methods are not implemented, then the class becomes an abstract class.
  - At this point, we need to use the keyword abstract



```
public class Circle implements Shape {
    private i
    private i
    private f

    public Ci
        this.x = x;
        this.y = y;
        this.radius = radius;
    }
    public int getX() {
        return x;
    }
    public int getY() {
        return y;
    }
}
```

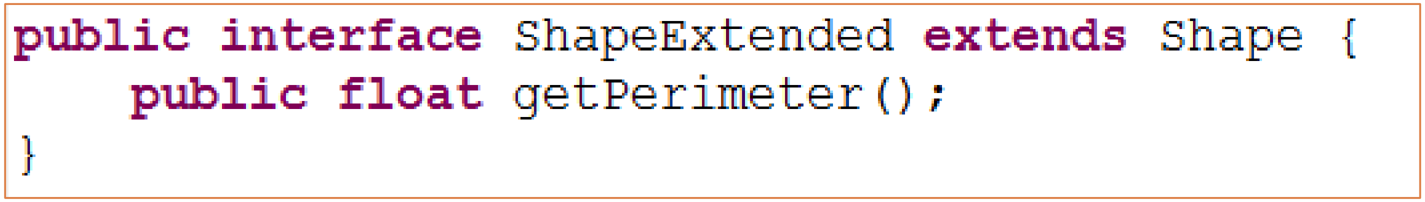
The type Circle must implement the inherited abstract method Shape.getArea()

2 quick fixes available:



```
public abstract class Circle implements Shape {
    private int x;
    private int y;
    private float radius;

    public Circle (int x, int y, float radius)  {
        this.x = x;
        this.y = y;
        this.radius = radius;
    }
    public int getX() {
        return x;
    }
    public int getY() {
        return y;
    }
}
```

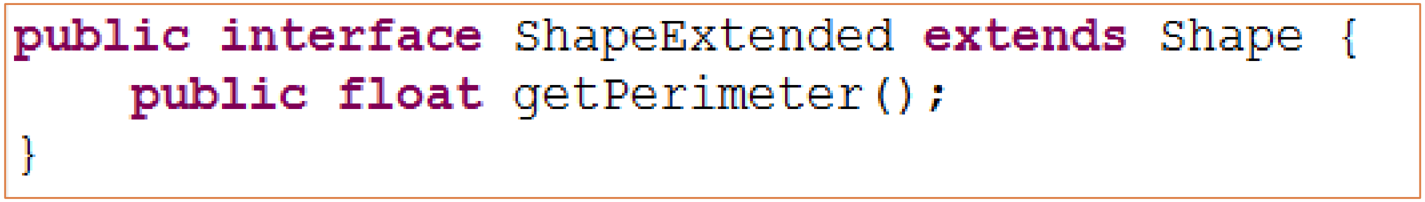
- You can even *extend* an interface (to add methods):



```
public interface ShapeExtended extends Shape {
    public float getPerimeter();
}
```

Interface

- You can even *extend* an interface (to add methods):



```
public interface ShapeExtended extends Shape {
    public float getPerimeter();
}
```

```
interface KeyListener {
        public void keyPressed(KeyEvent e);
        public void keyReleased(KeyEvent e);
        public void keyTyped(KeyEvent e);
}
interface FunkyKeyListener extends KeyListener {
       public void funkykeyEvent(KeyEvent e);
 }
```

Interface

- When you implement an interface, you need to implement *all* the declared functions.
- There can be a *lot* of methods

```
interface KeyListener {
    public void keyPressed(KeyEvent e);
    public void keyReleased(KeyEvent e);
    public void keyTyped(KeyEvent e);
}
```

- What if you only care about a couple of these methods, not all?

Adapter Class

- An adapter class implements an interface and provides empty method bodies

```
class  KeyAdapter implements KeyListener {
    public void keyPressed(KeyEvent e) { };
    public void keyReleased(KeyEvent e) { };
    public void keyTyped(KeyEvent e) { };
}
```

- You can override only the methods you care about
- This isn’t elegant, but it does work
- Java provides a number of adapter classes

Example

- With interface you can write methods that work with more than one class

```
interface RuleSet {
         boolean isLegal(Move m, Board b);
        void makeMove(Move m);
}
```

  - Every class that implements RuleSet must have these methods

Example – cont.

```
class CheckersRules implements RuleSet {
    public boolean isLegal(Move m, Board b) { … }
    public void makeMove(Move m) { … }
}


class ChessRules implements RuleSet {

    public boolean isLegal(Move m, Board b) { … }
    public void makeMove(Move m) { … }
 }
```

Example – cont.

- □ Is this a legal statement?

```
RuleSet rulesOfThisGame = new ChessRules();
```

Example – cont.

- Is this a legal statement?

```
RuleSet rulesOfThisGame = new ChessRules();
```

This assignment is legal because a rulesOfThisGame object *is* a RuleSet object.

Example – cont.

- □ Is this a legal statement?

```
if (rulesOfThisGame.isLegal(m, b)) {
        rulesOfThisGame.makeMove(m);
}
```

Example – cont.

- Is this a legal statement?

```
if (rulesOfThisGame.isLegal(m, b)) {
      rulesOfThisGame.makeMove(m);
}
```

This statement is legal because, *whatever* kind of RuleSet object rulesOfThisGame is, it *must* have isLegal and makeMove methods

instanceof operator

- *instanceof* is a keyword that tells you whether a variable "is a" member of a class or interface

```
class Dog extends Animal implements Pet {…}
Animal fido = new Dog();
```

Are these true or false?

```
fido instanceof Dog
fido instanceof Animal
fido instanceof Pet
```

Vocabulary - 1

- abstract method
  - a method which is declared but not defined (it has no method body)
- abstract class
  - a class which either (1) contains abstract methods, or (2) has been declared abstract
- Instantiate
  - to create an instance (object) of a class

Vocabulary - 2

- Interface
  - Similar to a class, but contains only abstract methods (and possibly constants)
- Adapter class
  - A class that implements an interface but has only empty method bodies

Vocabulary - 3

- Final methods
  - methods that cannot be overridden
  - all private or static methods are implicitly final
- Static (early) binding
  - Binding occurs during compile time
  - Uses reference type during binding
- Dynamic (late) binding
  - Binding occurs during runtime
  - Uses object type during binding

Any Questions ?