

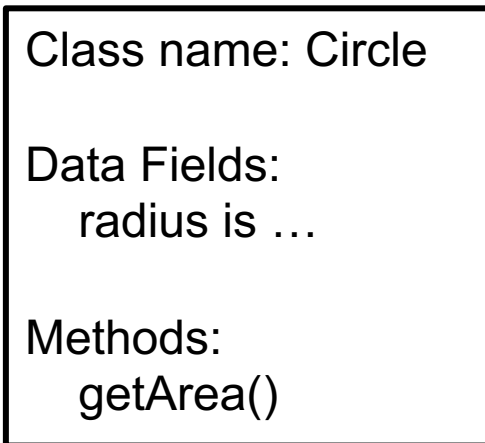
Lecture 7

Objects and Classes

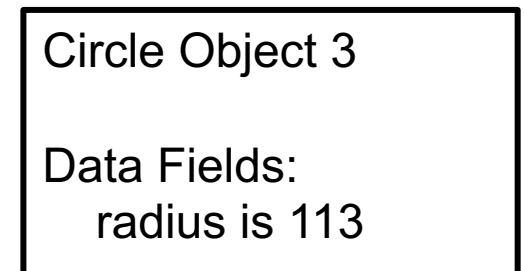
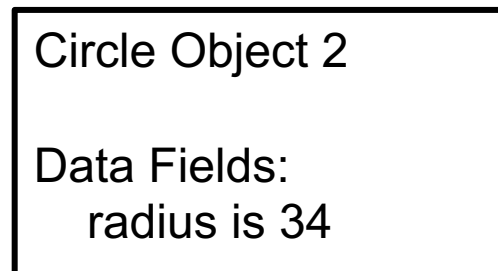
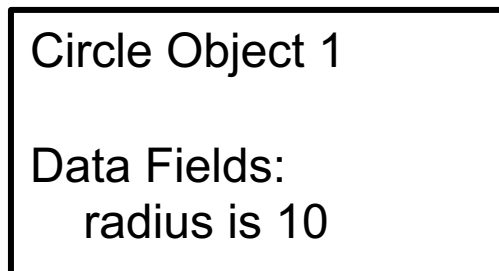
- **Object-oriented programming** (OOP) involves programming using objects.
- An **object** represents an entity in the real world that can be distinctly identified.
- Examples:
 - a student
 - a desk
 - a circle
 - a button
 - and even a loan.
- An object has a unique **identity**, **state**, and **behaviors**.
- The **state** of an object consists of a set of **data fields** (also known as *properties*) with their current values.
- The **behavior** of an object is defined by a set of **methods**.

- An object has both a state and behavior. The state defines the object, and the behavior defines what the object does.

A class template



Three object of the Circle class



- **Classes** are constructs that define objects of the same type.
- A Java class uses variables to define **data fields** and **methods** to define behaviors.
- Additionally, a class provides a special type of methods, known as **constructors**, which are invoked to construct objects from the class.

```
class Circle {
    /** The radius of this circle */
    double radius = 1.0;
```

Data field

```
    /** Construct a circle object */
    Circle() {
    }

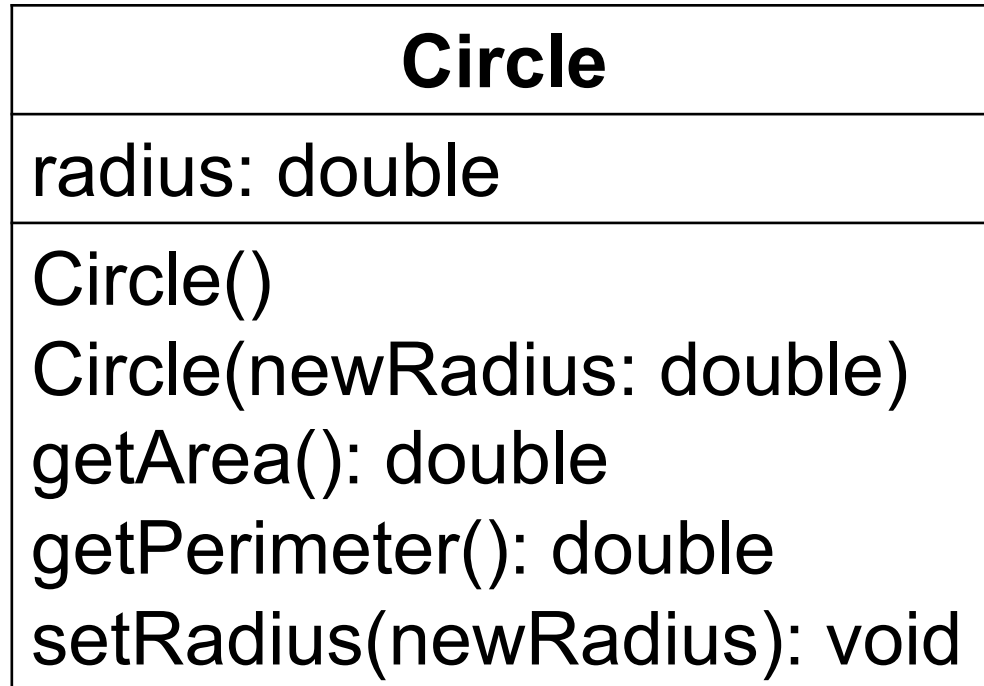
    /** Construct a circle object */
    Circle(double newRadius) {
        radius = newRadius;
    }
```

Constructors

```
    /** Return the area of this circle */
    double getArea() {
        return radius * radius * 3.14159;
    }
```

Method

```
}
```



circle1: Circle

radius = 1.0

circle2: Circle

radius = 10.0

circle3: Circle

radius = 145.0

- Constructors are a special kind of methods that are invoked to construct objects.

```
Circle() {  
}
```

```
Circle(double newRadius) {  
    radius = newRadius;  
}
```

- A constructor with no parameters is referred to as a **no-arg** or **empty** constructor.
- Constructors must have the same name as the class itself.
- Constructors do not have a return type—not even void.
- Constructors are invoked using the new operator when an object is created.
- Constructors play the role of initializing objects.

- `new ClassName();`

- **Example:**

- `new Circle();`

- `new Circle(5.0);`

- A class may be defined **without** constructors.
- In this case, a no-arg constructor with an empty body is **implicitly defined** in the class.
- This constructor, called *a **default constructor***
- Is provided automatically *only if no constructors are explicitly defined in the class.*

- The data fields can be of reference types. For example, the following Student class contains a data field name of the String type.

```
public class Student {  
    String name; // name has default value null  
    int age; // age has default value 0  
    // isScienceMajor has default value false  
    boolean isScienceMajor;  
    char gender; // c has default value '\u0000'  
}
```

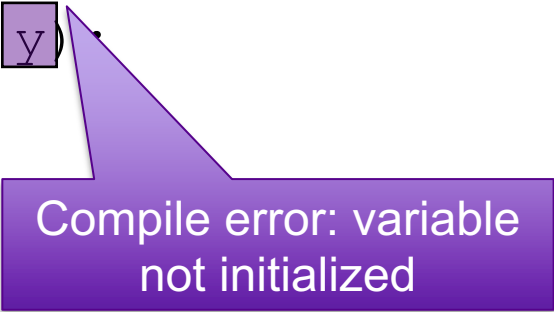
- If a data field of a reference type does not reference any object, the data field holds a special literal value, **null**.
- The default value of a data field is 0 for a numeric type, false for a boolean type, and '\u0000' for a char type.

```
public class Test {  
    public static void main(String[] args) {  
        Student student = new Student();  
        System.out.println("name? " + student.name);  
        System.out.println("age? " + student.age);  
        System.out.println("isScienceMajor? " +  
student.isScienceMajor);  
        System.out.println("gender? " + student.gender);  
    }  
}
```



- Java assigns **no default value** to a local variable inside a method.

```
public class Test {  
    public static void main(String[] args) {  
        int x; // x has no default value  
        String y; // y has no default value  
        System.out.println("x is " + x);  
        System.out.println("y is " + y);  
    }  
}
```



Compile error: variable
not initialized



- To reference an object, assign the object to a reference variable.
- To declare a reference variable, use the syntax:
 - `ClassName objectRefVar;`
 - **Example:**
 - `Circle myCircle;`



- `ClassName objectRefVar =
new ClassName();`

- Example:

- `Circle myCircle = new Circle();`

Assign object reference Create an object

- Referencing the object's data:
 - `objectRefVar.data`
 - `myCircle.radius`
- Invoking the object's method:
 - `objectRefVar.methodName (arguments)`
 - `myCircle.getArea()`



```
Circle myCircle = new Circle(5.0);
```

Declare myCircle

```
Circle yourCircle = new Circle();
```

```
yourCircle.radius = 100;
```

```
myCircle
```

no value

```
Circle myCircle = new Circle(5.0);
```

Create a circle

```
Circle yourCircle = new Circle();
```

```
yourCircle.radius = 100;
```

```
myCircle
```

no value

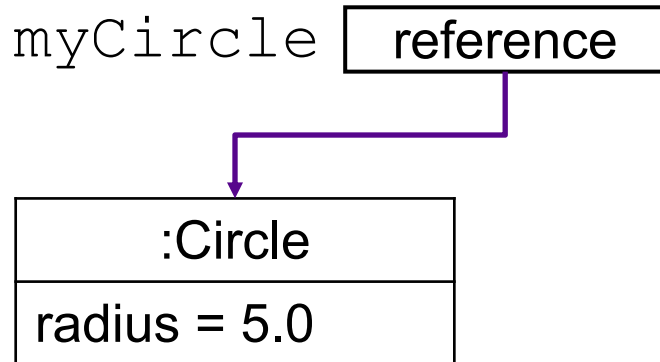
:Circle
radius = 5.0

```
Circle myCircle = new Circle(5.0);
```

Assign object
reference to myCircle

```
Circle yourCircle = new Circle();
```

```
yourCircle.radius = 100;
```



```
Circle myCircle = new Circle(5.0);
```

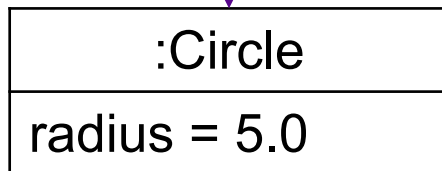
Declare `yourCircle`

```
Circle yourCircle = new Circle();
```

```
yourCircle.radius = 100;
```

`myCircle` **reference**

`yourCircle` **no value**



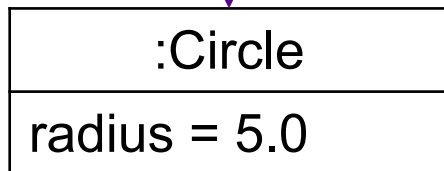
```
Circle myCircle = new Circle(5.0);
```

```
Circle yourCircle = new Circle();
```

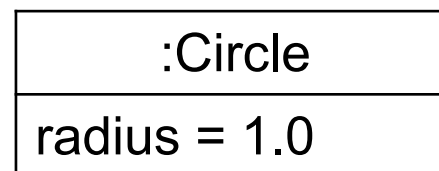
Create a
new Circle object

```
yourCircle.radius = 100;
```

myCircle **reference**



yourCircle **no value**

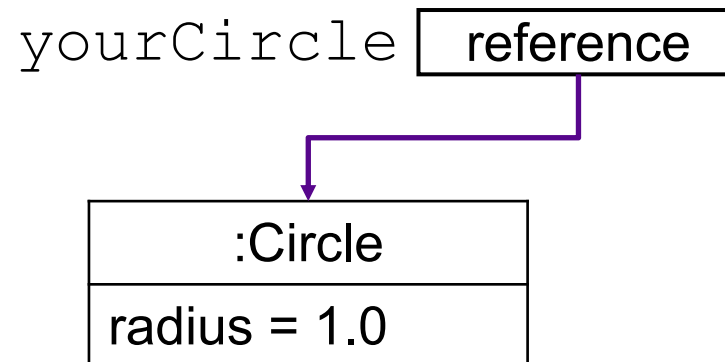
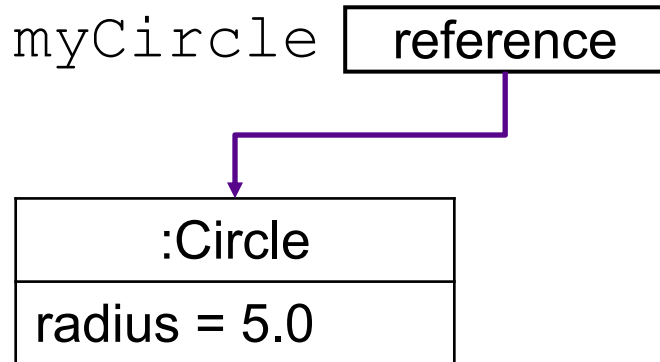


```
Circle myCircle = new Circle(5.0);
```

Assign object reference
to yourCircle

```
Circle yourCircle = new Circle();
```

```
yourCircle.radius = 100;
```

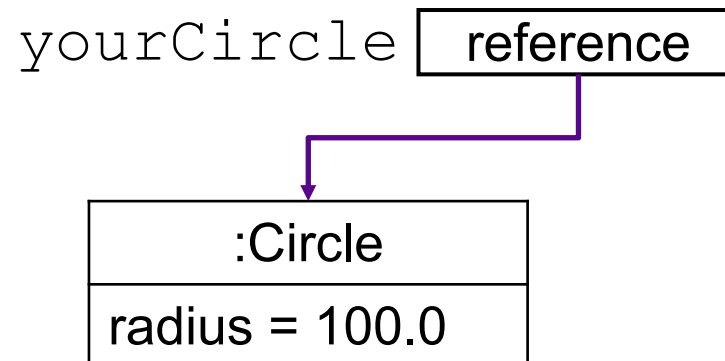
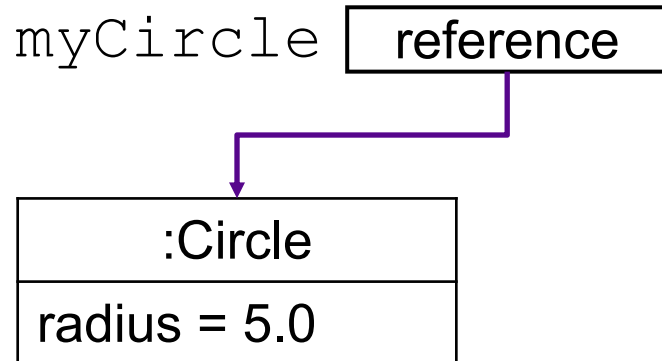


```
Circle myCircle = new Circle(5.0);
```

```
Circle yourCircle = new Circle();
```

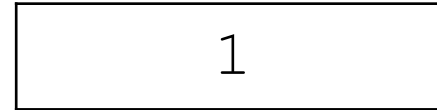
```
yourCircle.radius = 100;
```

Change radius in
yourCircle



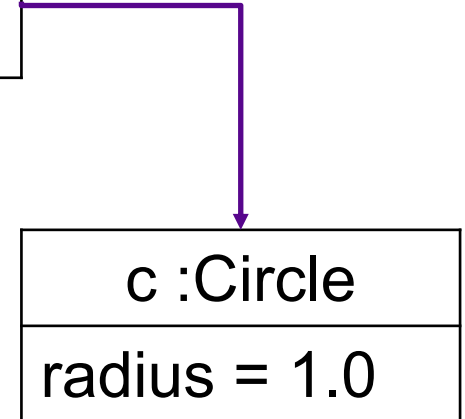
Primitive type

`int i = 1` `i`

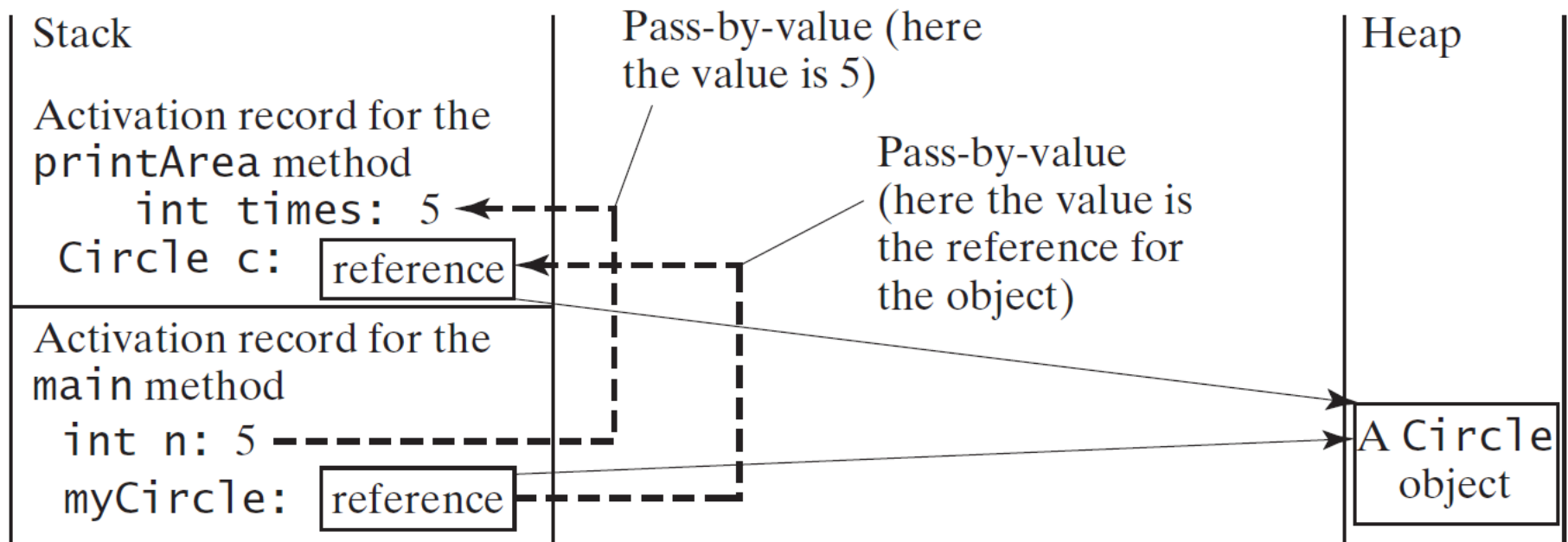


Object type

`Circle c` `c`



- Passing by value for primitive type value
 - the value is passed to the parameter
- Passing by value for reference type value
 - the value is the reference to the object



Primitive type assignment

`i = j`

Before

`i` 1

`j` 2

After

`i` 2

`j` 2

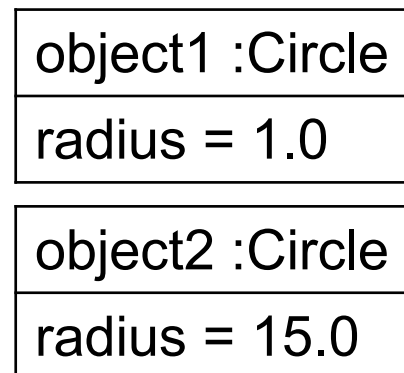
Object type assignment

`object1 = object2`

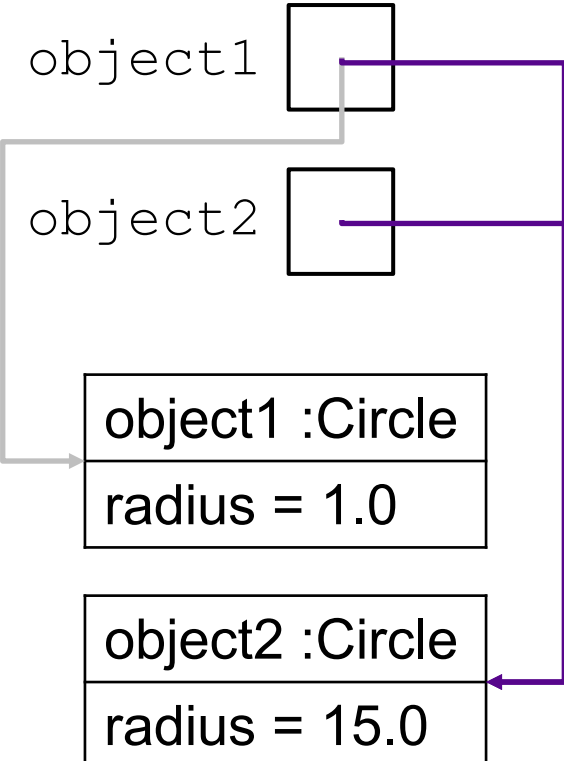
Before

`object1`

`object2`



After



- After the assignment statement
`object1 = object2`
- `object1` points to the same object referenced by `object2`.
- The object previously referenced by `object1` is no longer referenced.
- This object is known as **garbage**.
- Garbage is automatically collected by JVM.
- If you know that an object is no longer needed, you can explicitly assign **null** to a reference variable for the object.
- The JVM will automatically collect the space if the object is not referenced by any variable.

- Java provides a system-independent encapsulation of date and time in the `java.util.Date` class.
- You can use the `Date` class to create an instance for the current date and time and use its `toString` method to return the date and time as a string.

java.util.Date	
Date()	Constructs a Date for the current time
Date(elapseTime: long)	Constructs a Date for a given time
toString(): String	Returns a string representing the date
getTime(): long	Returns the number of ms since 1/1/1970 GMT
setTime(elapseTime: long): void	Sets the number of ms since 1/1/1970 GMT

- For example, the following code
 - `java.util.Date date = new java.util.Date();`
 - `System.out.println(date.toString());`
- displays a string like Sun Mar 09 13:50:19 EST 2018.

- You have used `Math.random()` to obtain a random double value between 0.0 and 1.0 (excluding 1.0).
- A more useful random number generator is provided in the `java.util.Random` class.

`java.util.Random`

`Random()`

`Random(seed: long)`

`nextInt(): int`

`nextInt(n: int): int`

`nextLong(): long`

`nextDouble(): double`

`nextFloat(): float`

`nextBoolean(): boolean`

Constructs a `Random` with the current time as seed

Constructs a `Random` with a specified seed

Returns a random int value

Returns a random int value between 0 and n (exclusive)

Returns a random long value

Returns a random double value

Returns a random float value

Returns a random boolean value

- If two Random objects have the same seed, they will generate identical sequences of numbers.

```
Random random1 = new Random(3);  
System.out.print("From random1: ");  
for (int i = 0; i < 10; i++)  
    System.out.print(random1.nextInt(1000) + " ");  
Random random2 = new Random(3);  
System.out.print("\nFrom random2: ");  
for (int i = 0; i < 10; i++)  
    System.out.print(random2.nextInt(1000) + " ");
```

From random1: 734 660 210 581 128 202 549 564 459 961

From random2: 734 660 210 581 128 202 549 564 459 961

- Recall that you use to invoke a method in the Math class
`Math.methodName (arguments)`
 - `Math.pow (3, 2.5)`
- Can you invoke `getArea()` using `SimpleCircle.getArea()`?
 - The answer is no.
- All the methods used before until now are static methods, which are defined using the **static** keyword.
- `getArea ()` is non-static. It must be invoked from an object using
`objectRefVar.methodName (arguments)`
 - `myCircle.getArea ()`



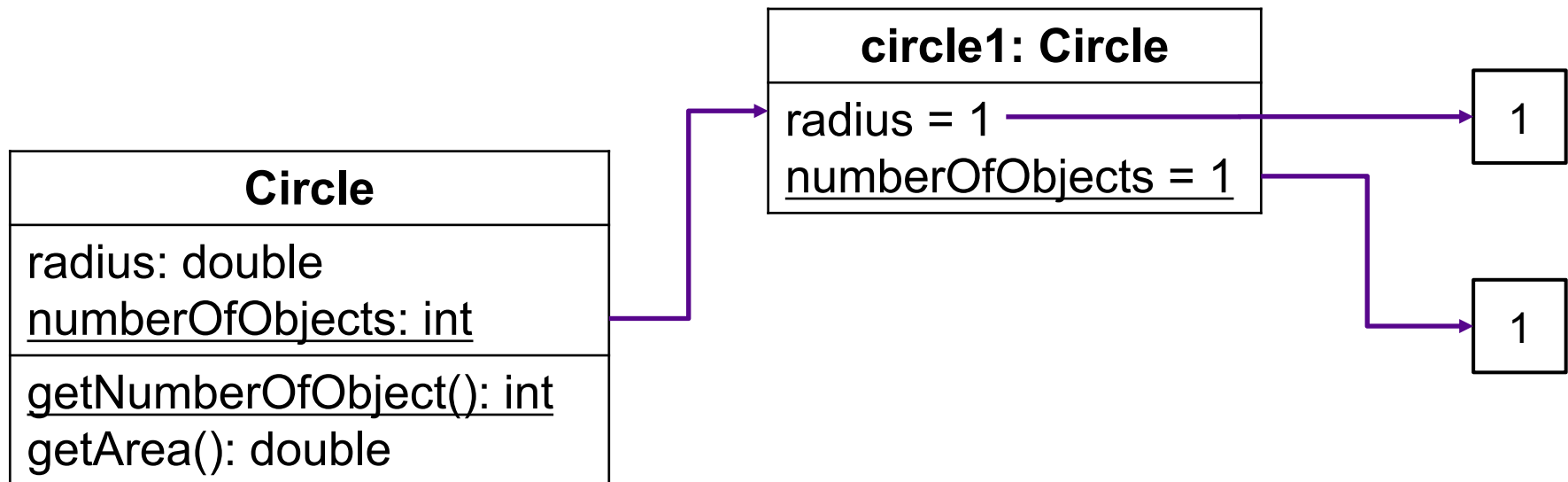
■ Instance

- Instance variables belong to a specific instance.
- Instance methods are invoked by an instance of the class.

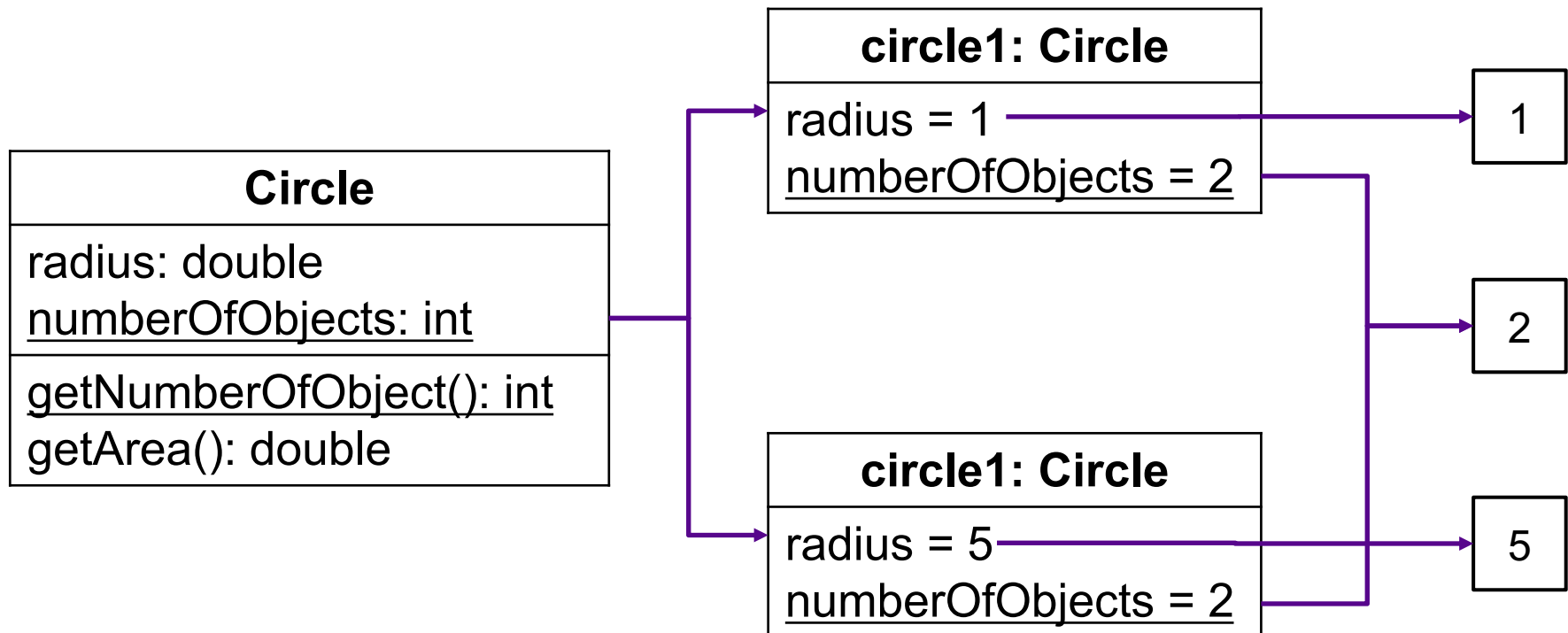
■ Static

- Static variables are shared by all the instances of the class.
- Static methods are not tied to a specific object.
- Static constants are final variables shared by all the instances of the class.
- To declare static variables, constants, and methods, use the static modifier.

- UML Notation: underline static variable of methods



- UML Notation: underline static variable of methods





- By default, the class, variable, or method can be accessed by any class in the same package.
- **public**
The class, data, or method is visible to any class in any package.
- **private**
The data or methods can be accessed only by the declaring class.
- The **get** and **set** methods are used to read and modify private properties.



- The private modifier restricts access to within a class, the default modifier restricts access to within a package, and the public modifier enables unrestricted access.

```
package p1;

public class C1 {
    public int x;
    int y;
    private int z;

    public void m1() {
    }
    void m2() {
    }
    private void m3() {
    }
}
```

```
package p1;

public class C2 {
    void aMethod() {
        C1 o = new C1();
        //can access o.x
        //can access o.y
        //cannot access o.z

        //can invoke o.m1()
        //can invoke o.m2()
        //cannot invoke o.m3()
    }
}
```



- The private modifier restricts access to within a class, the default modifier restricts access to within a package, and the public modifier enables unrestricted access.

```
package p1;

public class C1 {
    public int x;
    int y;
    private int z;

    public void m1() {
    }
    void m2() {
    }
    private void m3() {
    }
}
```

```
package p2;

public class C3 {
    void aMethod() {
        C1 o = new C1();
        //can access o.x
        //cannot access o.y
        //cannot access o.z

        //can invoke o.m1()
        //cannot invoke o.m2()
        //cannot invoke o.m3()
    }
}
```

- The default modifier on a class restricts access to within a package, and the public modifier enables unrestricted access.

```
package p1;  
  
class C1 {  
    ...  
}
```

```
package p1;  
  
public class C2 {  
    //can access C1  
}
```

```
package p2;  
  
public class C2 {  
    //cannot access C1  
    //can access C2  
}
```



- An object can access in its own private members

```
public class C {  
    private boolean x;  
  
    public static void main(String[] args) {  
        C c = new C();  
        System.out.println(c.x);  
        System.out.println(c.convert());  
    }  
  
    private int convert() {  
        return x ? 1 : -1;  
    }  
}
```




- Any other object cannot access private members

```
public class Test {  
    public static void main(String[] args) {  
        C c = new C();  
        System.out.println(c.x);  
        System.out.println(c.convert());  
    }  
}
```



- To protect data.
- To make code easy to maintain.

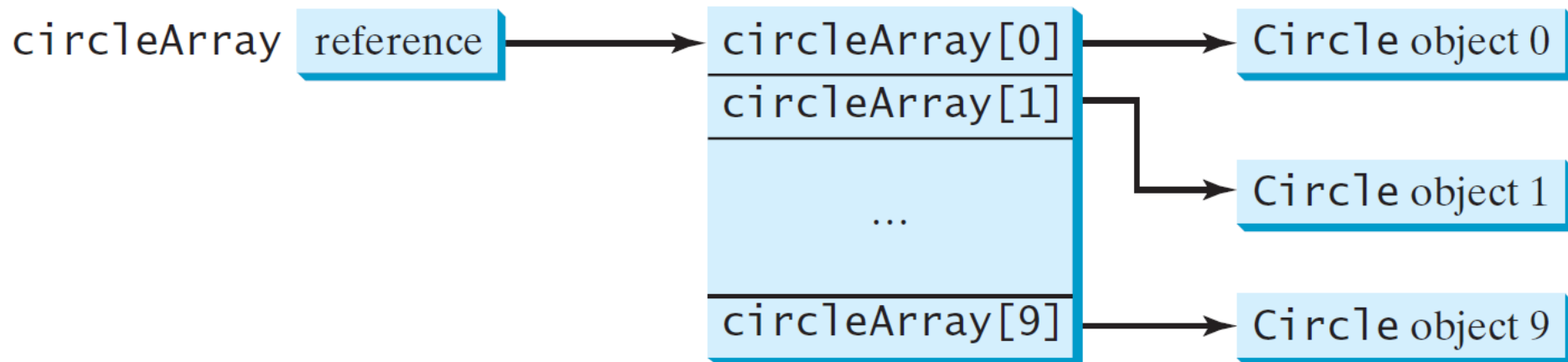
■ UML Notation:

- + sign indicates **public** modifier
- - sign indicates **private** modifier

Circle	
- radius: double	The radius of the circle (default: 1)
- <u>numberOfObjects</u> : int	The number of created objects
+ Circle()	Constructs a default circle
+ Circle(radius: double)	Constructs a circle with a specified radius
+ getRadius(): double	Returns the radius of this circle
+ setRadius(radius: double): void	Sets a new radius for this circle
+ getArea(): double	Returns the area of this circle
+ <u>getNumberOfObjects</u> (): int	Returns the number of circle objects created

- `Circle[] circleArray = new Circle[10];`
- An array of objects is actually an array of reference variables.
- So invoking `circleArray[1].getArea()` involves two levels of referencing.
- `circleArray` references to the entire array.
- `circleArray[1]` references to a `Circle` object.

- Circle[] circleArray = new Circle[10];



- If the contents of an object cannot be changed once the object is created, the object is called an **immutable object** and its class is called an **immutable class**.
- If you delete the set method in the Circle, the class would be immutable because radius is private and cannot be changed without a set method.
- A class with all private data fields and without mutators is not **necessarily immutable**.

```
public class Student {  
    private int id;  
    private BirthDate birthDate;  
  
    public Student(int ssn,  
        int year, int month, int day) {  
        id = ssn;  
        birthDate = new BirthDate(year, month, day);  
    }  
  
    public int getId() {  
        return id;  
    }  
  
    public BirthDate getBirthDate() {  
        return birthDate;  
    }  
}
```

```
public class BirthDate {  
    private int year;  
    private int month;  
    private int day;  
  
    public BirthDate(int newYear,  
        int newMonth, int newDay) {  
        year = newYear;  
        month = newMonth;  
        day = newDay;  
    }  
  
    public void setYear(int newYear) {  
        year = newYear;  
    }  
}
```




```
public class Test {  
    public static void main(String[] args) {  
        Student student =  
            new Student(111223333, 1970, 5, 3);  
        BirthDate date = student.getBirthDate();  
        date.setYear(2010);  
        // Now the student birth year is changed!  
    }  
}
```

- For a class to be immutable, it must mark all data fields private and provide no mutator methods and no accessor methods that would return a reference to a mutable data field object.

- The scope of instance and static variables **is the entire class**.
- They can be declared anywhere inside a class.

- The scope of a local variable starts from its declaration and continues to the end of the block that contains the variable.
- A local variable must be initialized explicitly before it can be used.

- The `this` keyword is the name of a reference that refers to an object itself.
- One common use of the `this` keyword is reference a class's hidden data fields.
- Another common use of the `this` keyword to enable a constructor to invoke another constructor of the same class.

```
public class F {  
    private int i = 5;  
    private static double k = 0;  
  
    void setI(int i) {  
        this.i = i;  
    }  
  
    static void setK(double k) {  
        F.k = k;  
    }  
}
```

Suppose that `f1` and `f2` are two objects of `F`.

```
F f1 = new F();
```

```
F f2 = new F();
```

Invoking `f1.setI(10)` is to execute **`this.i = 10`**, where ***this*** refers `f1`

Invoking `f2.setI(45)` is to execute **`this.i = 45`**, where ***this*** refers `f2`



```
public class Circle {  
    private double radius;
```

```
    public Circle(double radius) {  
        this.radius = radius;  
    }
```

this must be explicitly used
to reference the data field
radius of the object being
constructed

```
    public Circle() {  
        this(1.0);  
    }
```

this is used to invoke
another constructor

```
    public double getArea() {  
        return this.radius * this.radius * Math.PI;  
    }  
}
```

Every instance variable belongs to an instance
represented by this, which is normally omitted