

# Objects and Classes (Part 1)

Introduction to Programming and  
Computational Problem Solving:  
Accelerated Pace

CSE 11

Lecture 9

# Announcements

- Assignment 4 is due Oct 29, 11:59 PM
  - Upgrade beginning Nov 1, 12:01 AM
- Midterm assessment is Nov 3-8
- Assignments 2-4 upgrades due Nov 5, 11:59 PM
- Assignment 5 will be released Nov 5
  - Due Nov 13, 11:59 PM

# Object-oriented programming

- Object-oriented programming (OOP) involves programming using objects
- **This is the focus of the remainder of the quarter**
  - The previous lectures
    - Introduction to Java
    - Review fundamentals of (procedural) programming
  - Beginning with this lecture
    - Object-oriented programming and additional topics

# Procedural programming vs object-oriented programming

- Procedural programming
  - Data and operations on data are separate
  - Requires passing data to methods
- Object-oriented programming
  - Data and operations on data are in an object
  - Organizes programs like the real world
    - All objects are associated with both attributes and activities
  - Using objects improves software reusability and makes programs easier to both develop and maintain

# Objects and classes

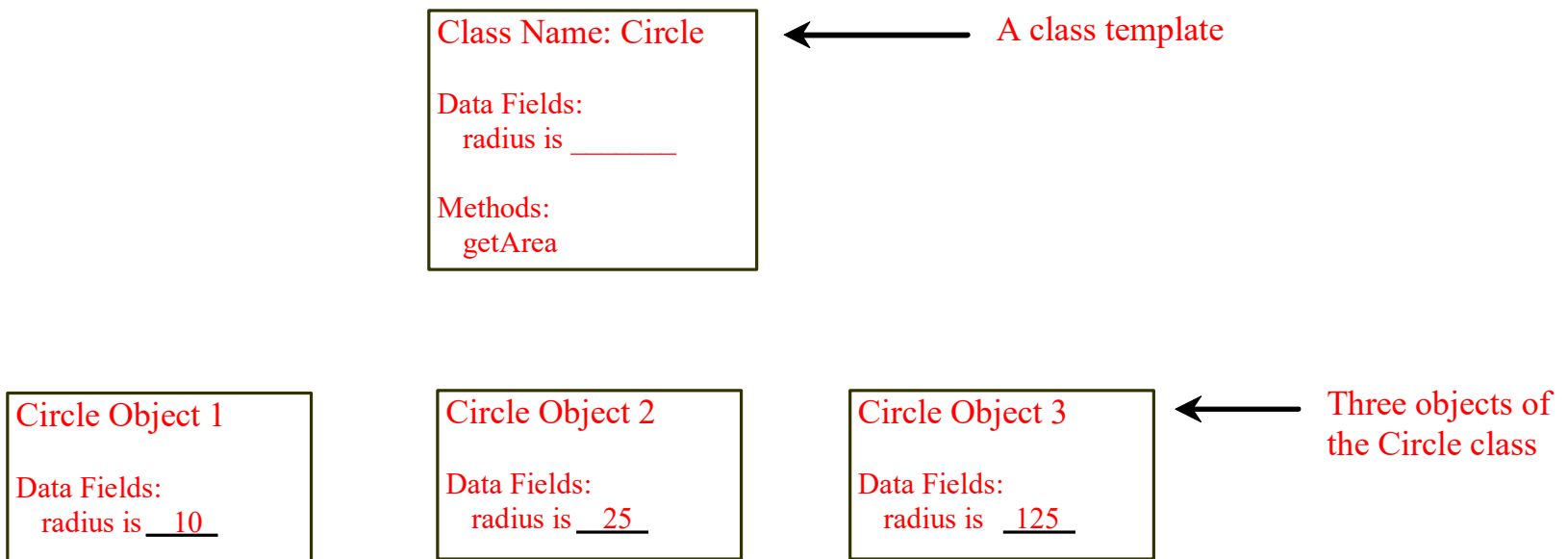
- An object represents an entity in the real world that can be distinctly identified
  - For example, a student, a desk, a circle, a button, and even a loan can all be viewed as objects
  - An object has a unique identity, state, and behaviors
- Classes are constructs that define objects of the same type

# Objects

- An object has a unique identity, state, and behaviors
  - An object is a **unique instance of a class**
  - 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**

# Objects

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



# Classes

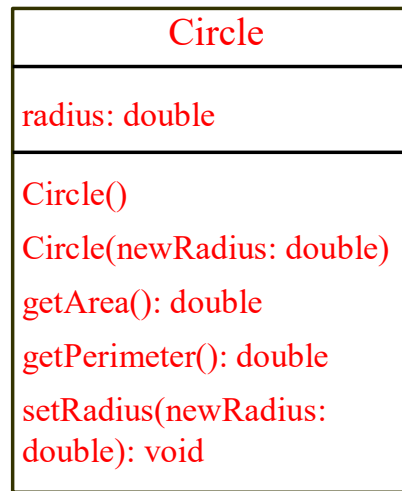
- A Java class uses **variables to define data fields** and **methods to define behaviors**
- Additionally, a class provides a special type of methods, known as **constructors**, which are invoked to construct objects from the class

# Classes

```
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() { ← Method  
        return radius * radius * 3.14159;  
    }  
}
```

# Unified Modeling Language (UML)

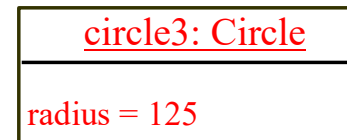
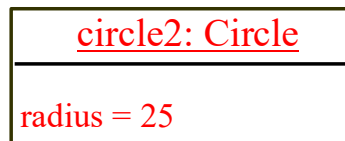
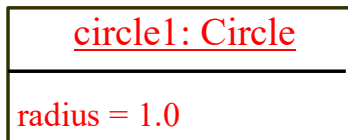
UML Class Diagram



← Class name

← Data fields

← Constructors and methods



← UML notation for objects

# Constructors

- Constructors must have the **same name** as the class itself
- A constructor with no parameters is referred to as a *no-arg constructor*
  - It is a best practice to provide (if possible) a no-arg constructor for every class (we'll cover why later in the quarter)
- 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

# Creating objects using constructors

`new ClassName();`

- For example

`new Circle();`

`new Circle(5.0);`

```
class Circle {  
    /** The radius of this circle */  
    double radius = 1.0;  
  
    /** Construct a circle object */  
    Circle() {  
    }  
  
    /** Construct a circle object */  
    Circle(double newRadius) {  
        radius = newRadius;  
    }  
}
```

← Data field

← Constructors

# Default constructor

- **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*
  - It is a best practice to provide (if possible) a no-arg constructor for every class (we'll cover why later in the quarter)

# Declaring object reference variables

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

# Declaring and creating in one step

```
ClassName objectRefVar = new ClassName();
```

For example

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

Assign object reference

Create an object

# Classes

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

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

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

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

← Data field

← Constructors

← Method

# Accessing an object's members

- Use the **object member access operator**
  - Also called the **dot operator** (`.`)
- Reference the object's data using `objectRefVar.variableName`
  - For example  
`myCircle.radius`
- Invoke the object's method using `objectRefVar.methodName(arguments)`
  - For example  
`myCircle.getArea()`

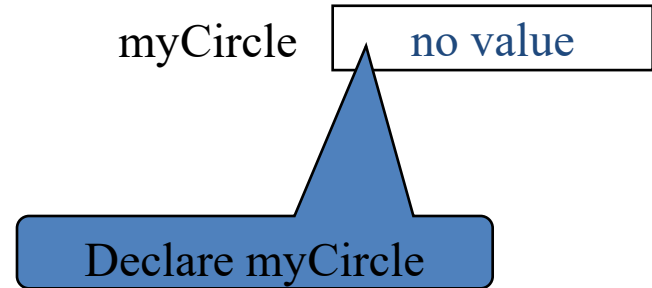
Member variables and methods **do not use the dot operator** to access other member variables and methods **within the same class** (but, when method formal parameters have the same name as a member, then member variables and methods must be accessed a special way; covered next lecture).

# Instance data fields and methods vs static data fields and methods

- **Instance** data fields and methods **can only be accessed using an object** (i.e., an instance of a class)
  - The syntax to access an **instance data field** is  
`objectReferenceVariable.variableName`
  - The syntax to invoke an **instance method** is  
`objectReferenceVariable.methodName(arguments)`
- **Static** data fields and methods (i.e., non-instance data fields and methods) can be accessed **without using an object** (i.e., they are not tied to a specific instance of a class)
  - The syntax to access a **static data field** is  
`ClassName.variableName`
  - The syntax to invoke a **static method** is  
`ClassName.methodName(arguments)`

# Trace code

```
Circle myCircle = new Circle(5.0);  
Circle yourCircle = new Circle();  
yourCircle.radius = 100;
```



# Trace code

```
Circle myCircle = new Circle(5.0);  
Circle yourCircle = new Circle();  
yourCircle.radius = 100;
```

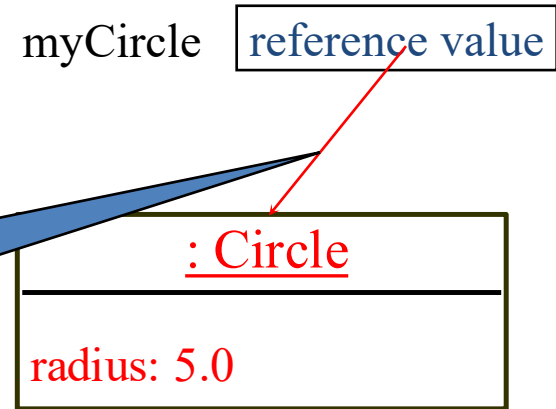
myCircle no value

Create a new  
Circle object

<u>: Circle</u>
radius: 5.0

# Trace code

```
Circle myCircle = new Circle(5.0);  
Circle yourCircle = new Circle();  
yourCircle.radius = 100;
```



Assign object reference  
to myCircle

# Trace code

```
Circle myCircle = new Circle(5.0);  
Circle yourCircle = new Circle();  
yourCircle.radius = 100;
```

myCircle reference value

: Circle  

---

radius: 5.0

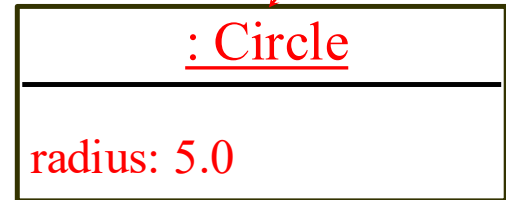
yourCircle no value

**Declare yourCircle**

# Trace code

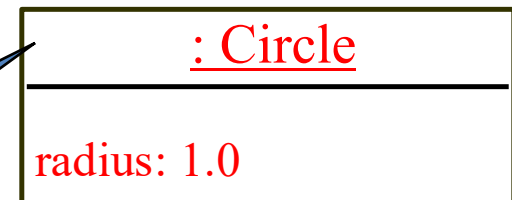
```
Circle myCircle = new Circle(5.0);  
Circle yourCircle = new Circle();  
yourCircle.radius = 100;
```

myCircle reference value



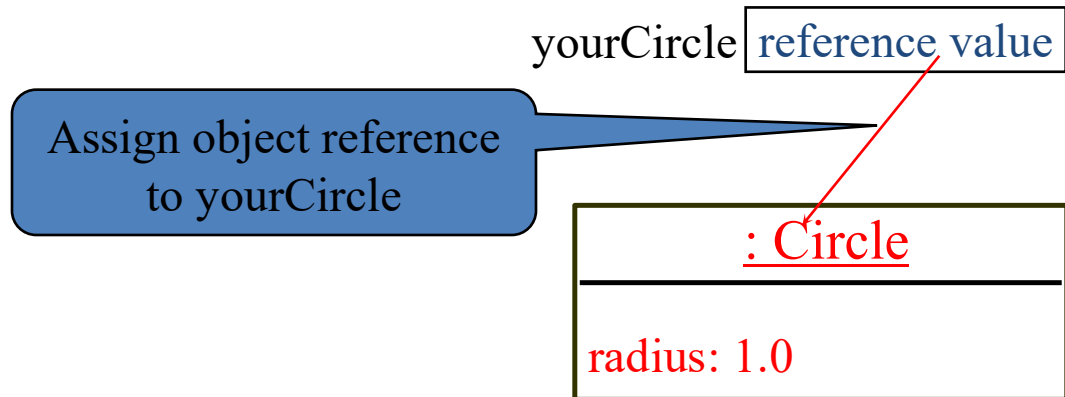
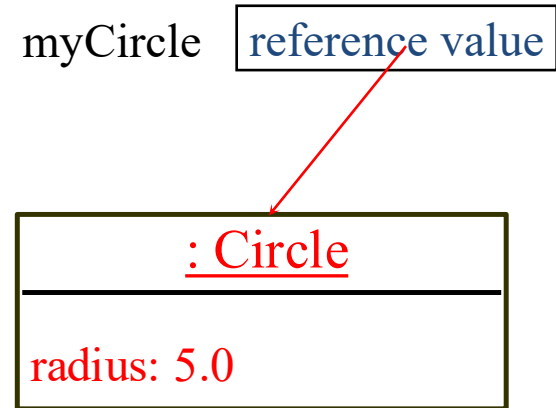
yourCircle no value

Create a new  
Circle object



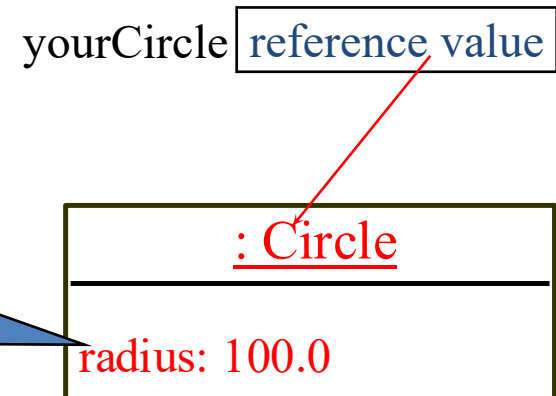
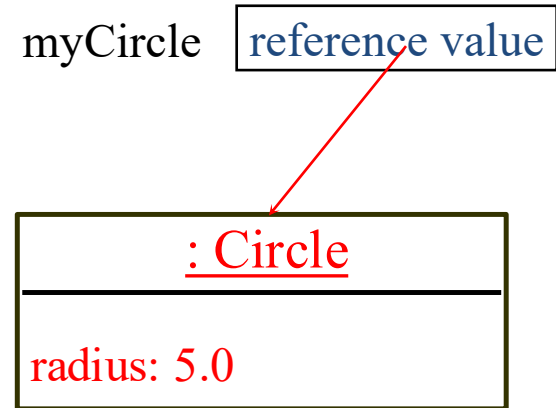
# Trace code

```
Circle myCircle = new Circle(5.0);  
Circle yourCircle = new Circle();  
yourCircle.radius = 100;
```



# Trace code

```
Circle myCircle = new Circle(5.0);  
Circle yourCircle = new Circle();  
yourCircle.radius = 100;
```



Change radius in  
yourCircle

# Reference data fields and null

- 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;  
    int age;  
    boolean scienceMajor;  
    char gender;  
}
```

name is an object reference variable  
because String is a class

- If a data field of a reference type does not reference any object, then the data field holds the special Java literal value null

# Default value for a data field

- The default value of a **data field** is

`null` for a reference type

`0` for a numeric type

`false` for a boolean type

`'\u0000'` for a char type

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

# Default values for local variables

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

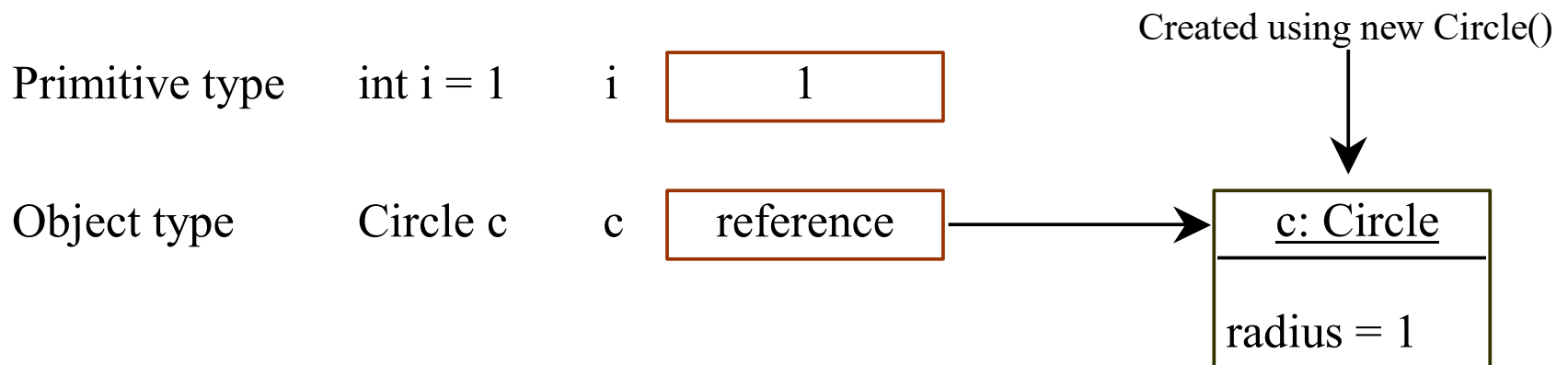
```
public class Test {  
    public static void main(String[] args) {  
        int x; // x has no default value  
        String y; // y has no default value  
        System.out.println("x is " + x);  
        System.out.println("y is " + y);  
    }  
}
```

Compile error: variable not initialized



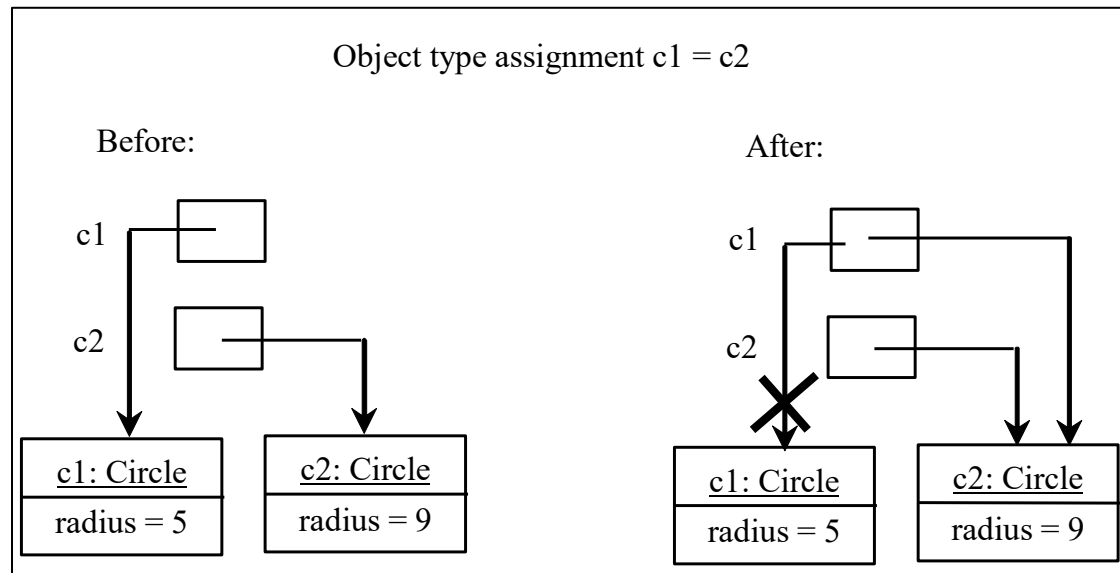
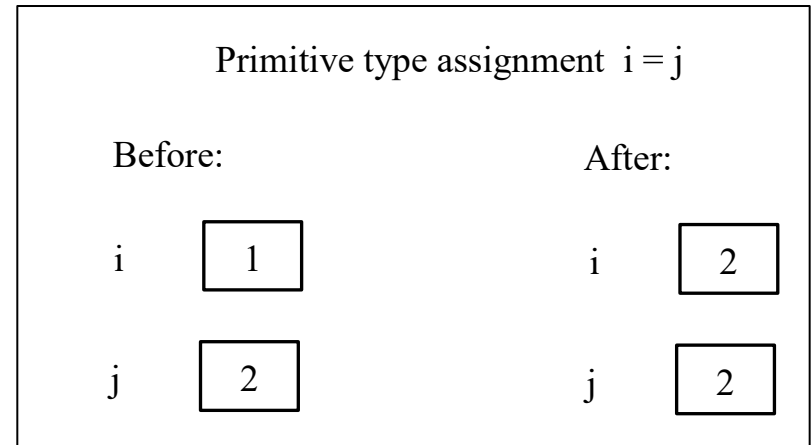
# Differences between variables of primitive data types and object types

- A variable of a **primitive type** holds a value of the primitive type
- A variable of a **reference type** holds a reference to where an object is stored in memory



# Differences between variables of primitive data types and object types

- Variable assignment



# Garbage and its collection

- If an object is no longer referenced, then it is considered **garbage**
- Garbage occupies memory space
- Garbage collection
  - The Java Virtual Machine (JVM) will automatically detects garbage and reclaims the space it occupies
- If you know an object is no longer needed, then you can explicitly assign `null` to the object reference variable

# Using classes from the Java library

- The Java API contains a rich set of classes for developing Java programs
- Some commonly used ones
  - The `String` class
  - The `java.util.Date` class
    - <https://docs.oracle.com/javase/8/docs/api/java/util/Date.html>
    - <https://docs.oracle.com/en/java/javase/11/docs/api/java.base/java/util/Date.html>
  - The `Math` class
  - The `java.util.Random` class
    - More capable than `Math.random` method
    - <https://docs.oracle.com/javase/8/docs/api/java/util/Random.html>
    - <https://docs.oracle.com/en/java/javase/11/docs/api/java.base/java/util/Random.html>

# Next Lecture

- Objects and classes