Objects and Classes (Part 1)

Introduction to Programming and Computational Problem Solving - 2

CSE 8B

Lecture 9

Announcements

- Assignment 4 is due May 3, 11:59 PM
  - Upgrade beginning May 6, 12:01 AM
- Educational research study
  - May 5, weekly survey
- Midterm exam is May 8
- Assignments 2-4 upgrades due May 10

Object-oriented programming

- Object-oriented programming (OOP) involves programming using objects
- **This is the focus of CSE 8B**
  - The previous lectures
    - Introduction to Java
    - Review fundamentals of (procedural) programing
  - 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

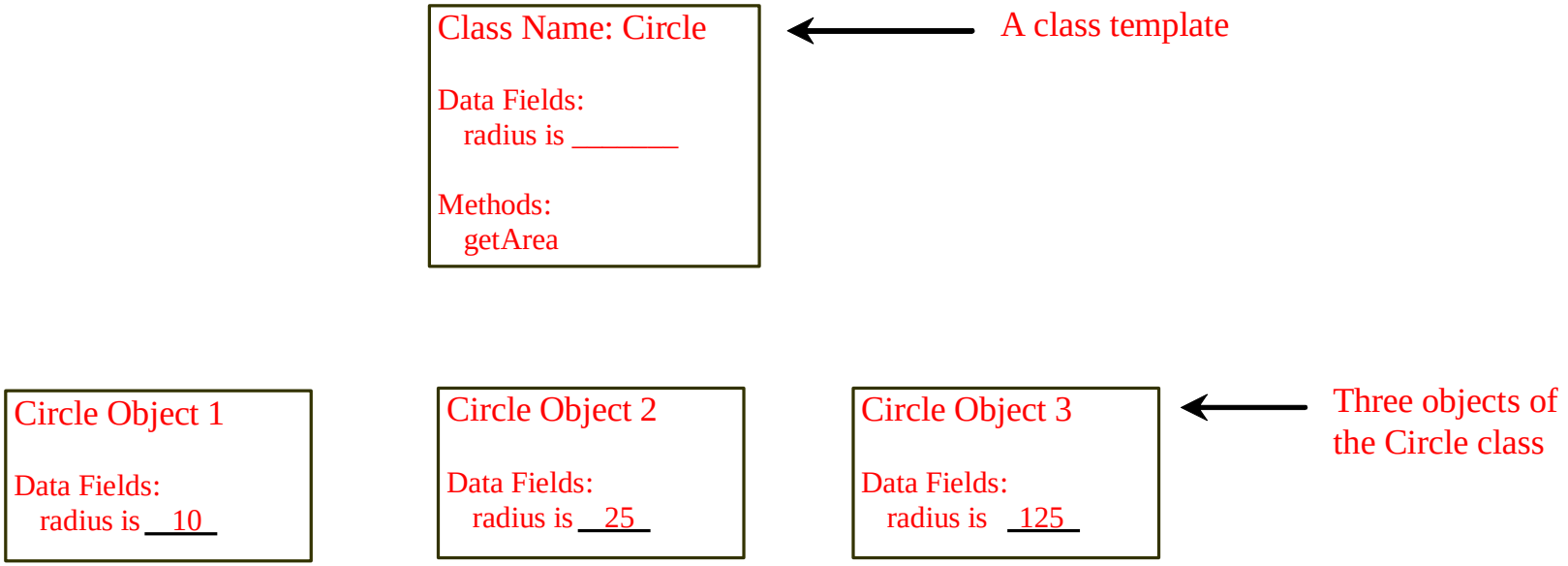
- An object represents an entity in the real world that can be distinctly identified
  - For example, a student, a desk, a circle, a button, and even a loan can all be viewed as objects
  - An object has a unique identity, state, and behaviors
- Classes are constructs that define objects of the same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

  /** 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;
  }
}
```

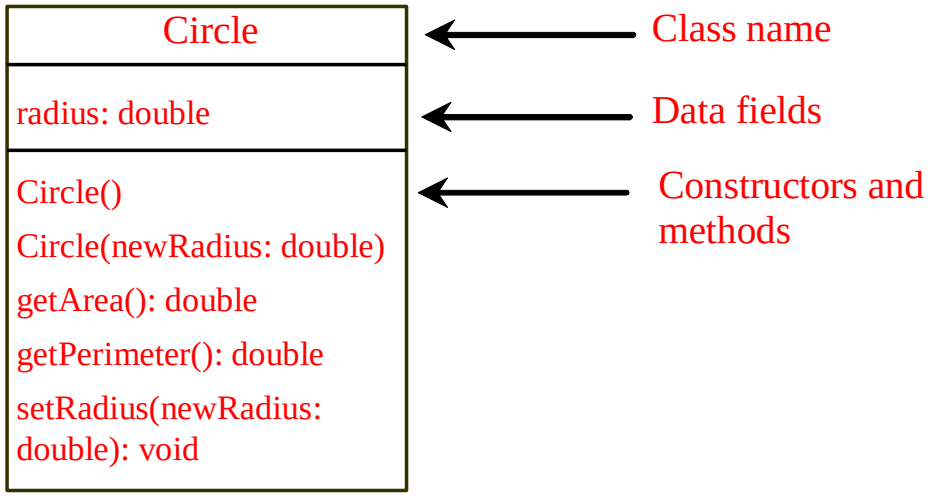
Data field

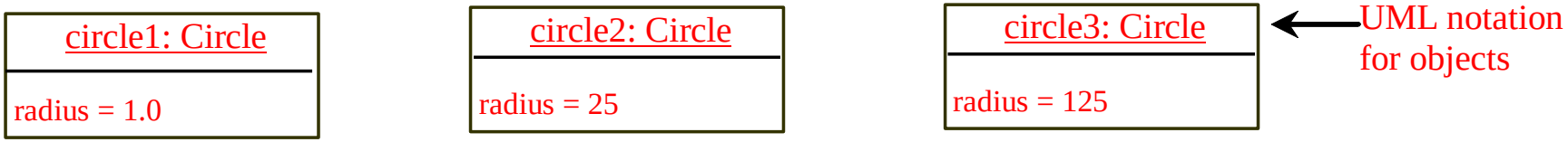
Constructors

Method

Unified Modeling Language (UML)

UML Class Diagram





Constructors

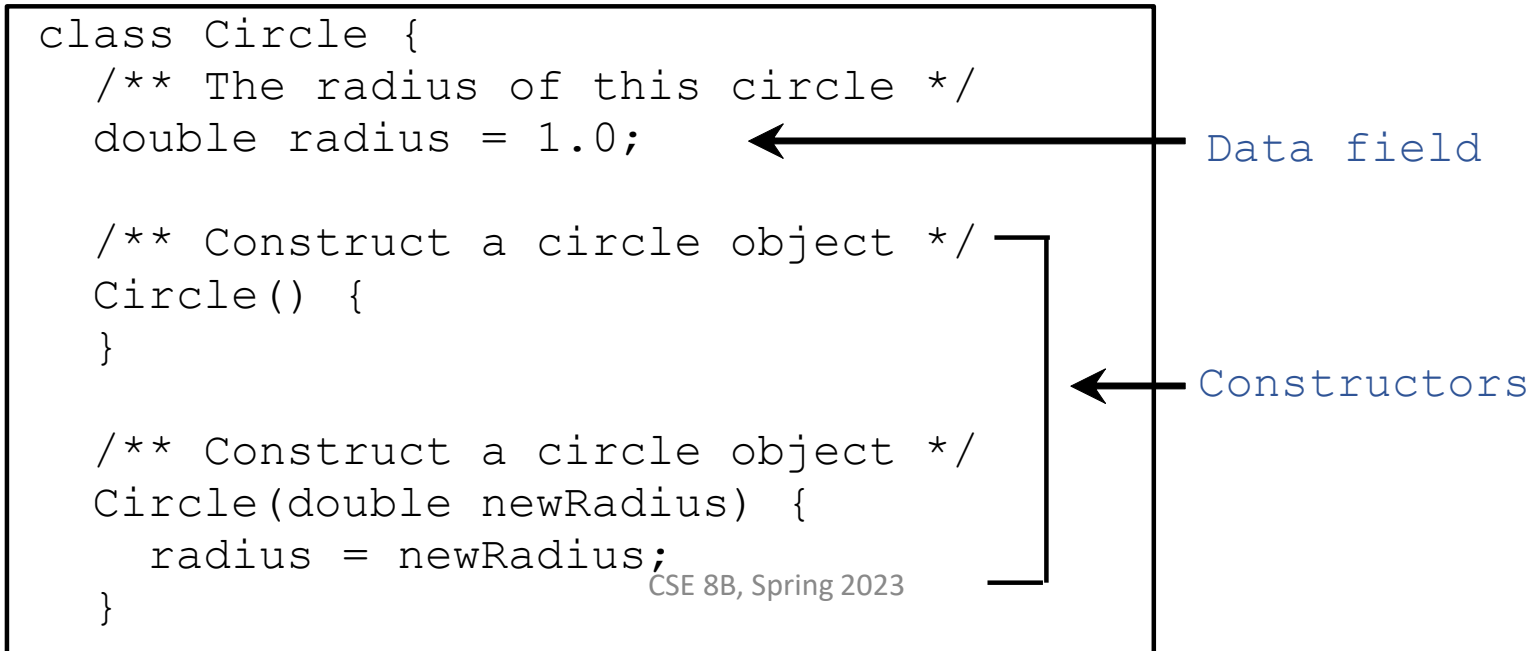
- Constructors must have the **same name** as the class itself
- A constructor with no parameters is referred to as a *no-arg constructor*
  - It is a best practice to provide (if possible) a no-arg constructor for every class (we'll cover why later in the quarter)
- Constructors **do not have a return 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);
```



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;
```

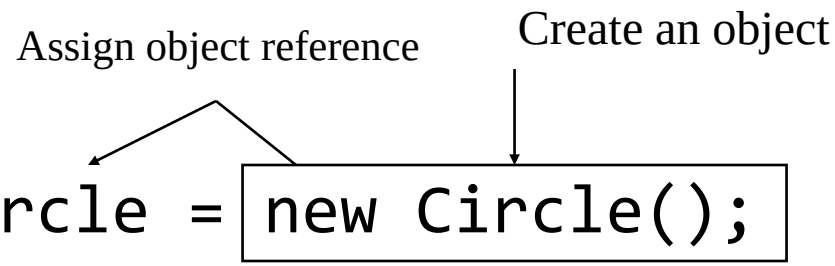
- For example

```
Circle myCircle;
```

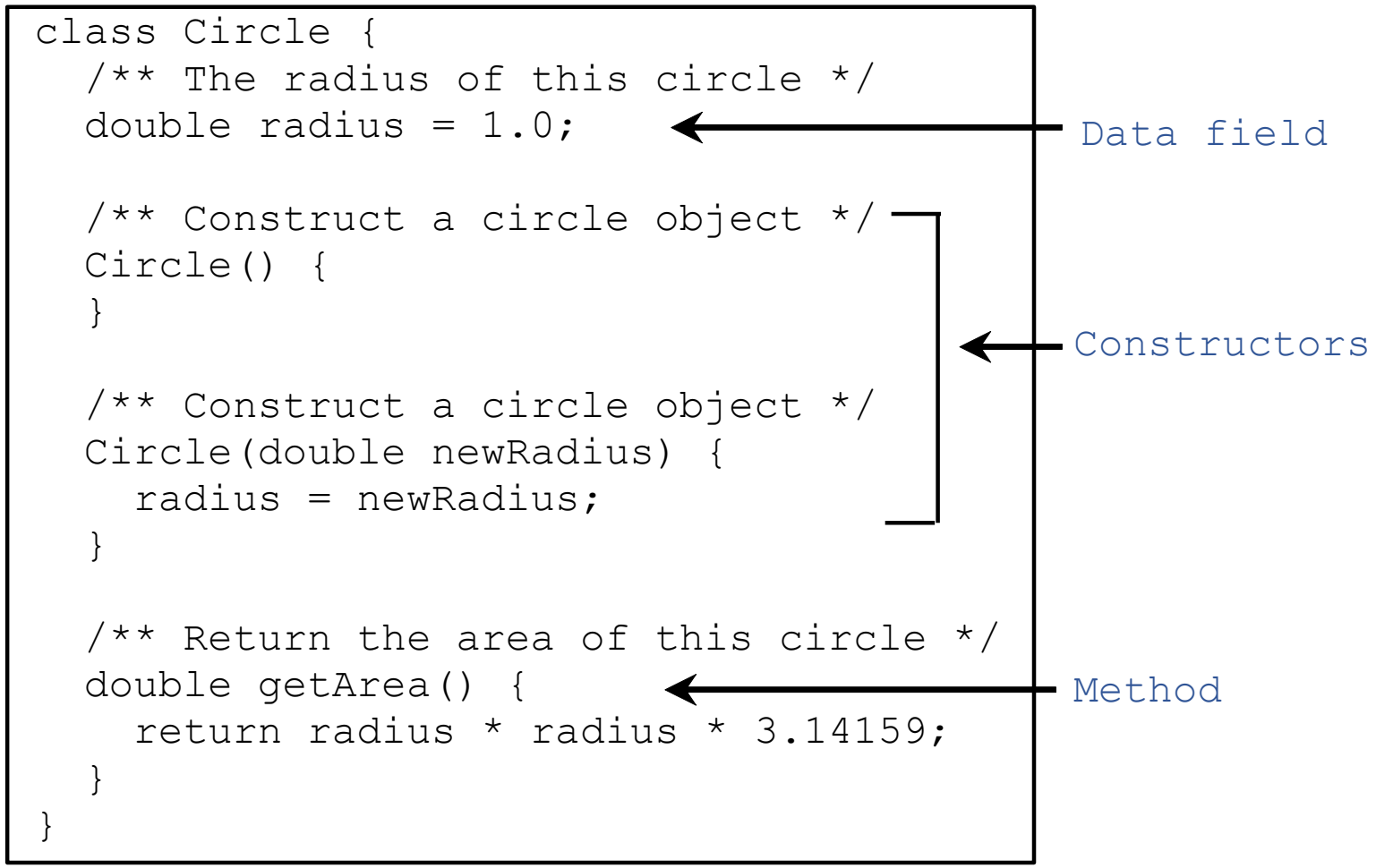
Declaring and creating in one step

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

For example



Classes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}
}
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()`

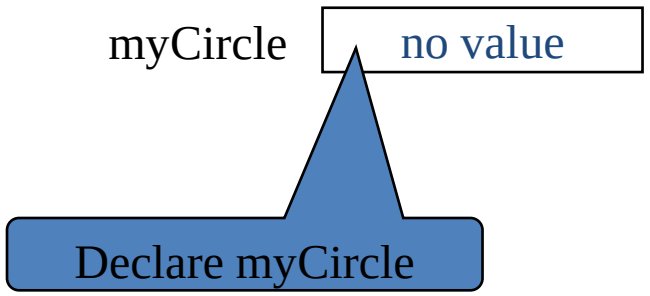
Member variables and methods **do not use the dot operator** to access other member variables and methods **within the same class** (but, when method formal parameters have the same name as a member, then member variables and methods must be accessed a special way; covered next lecture).

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;
```



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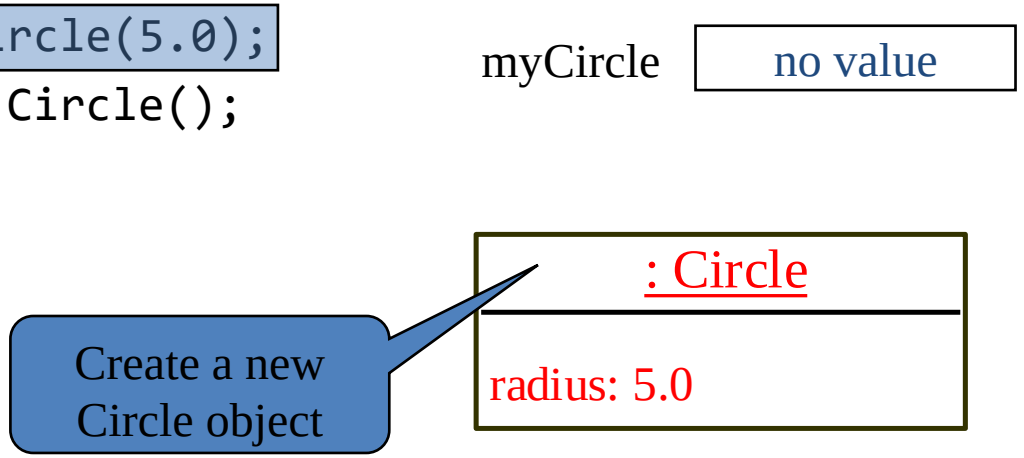

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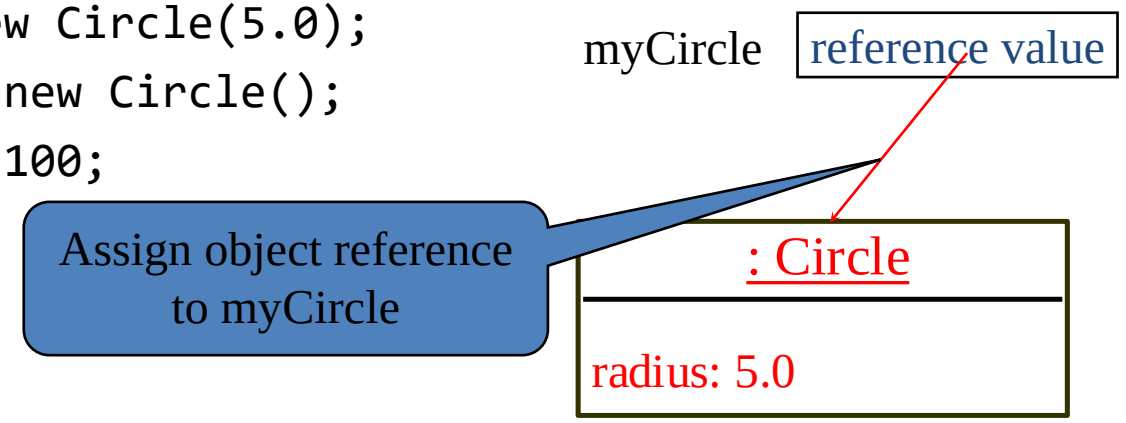

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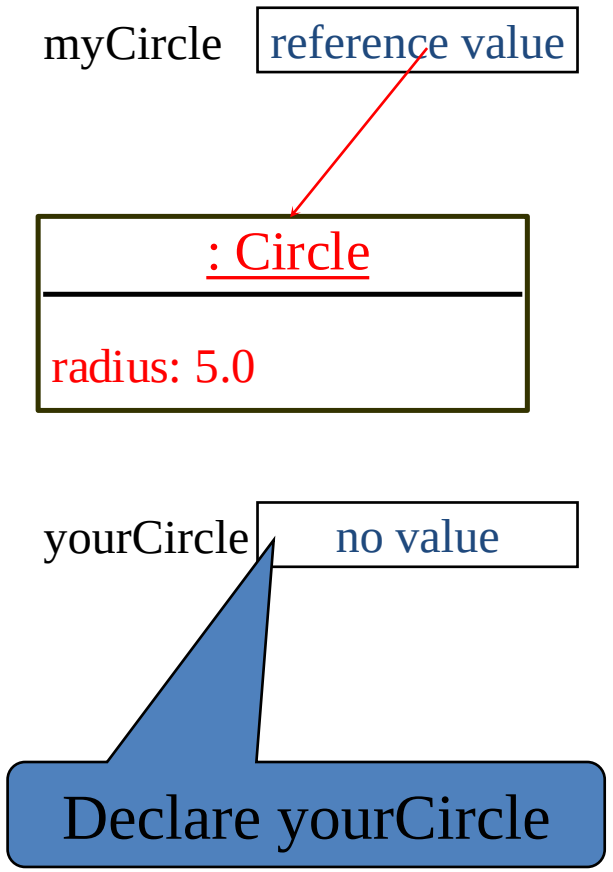

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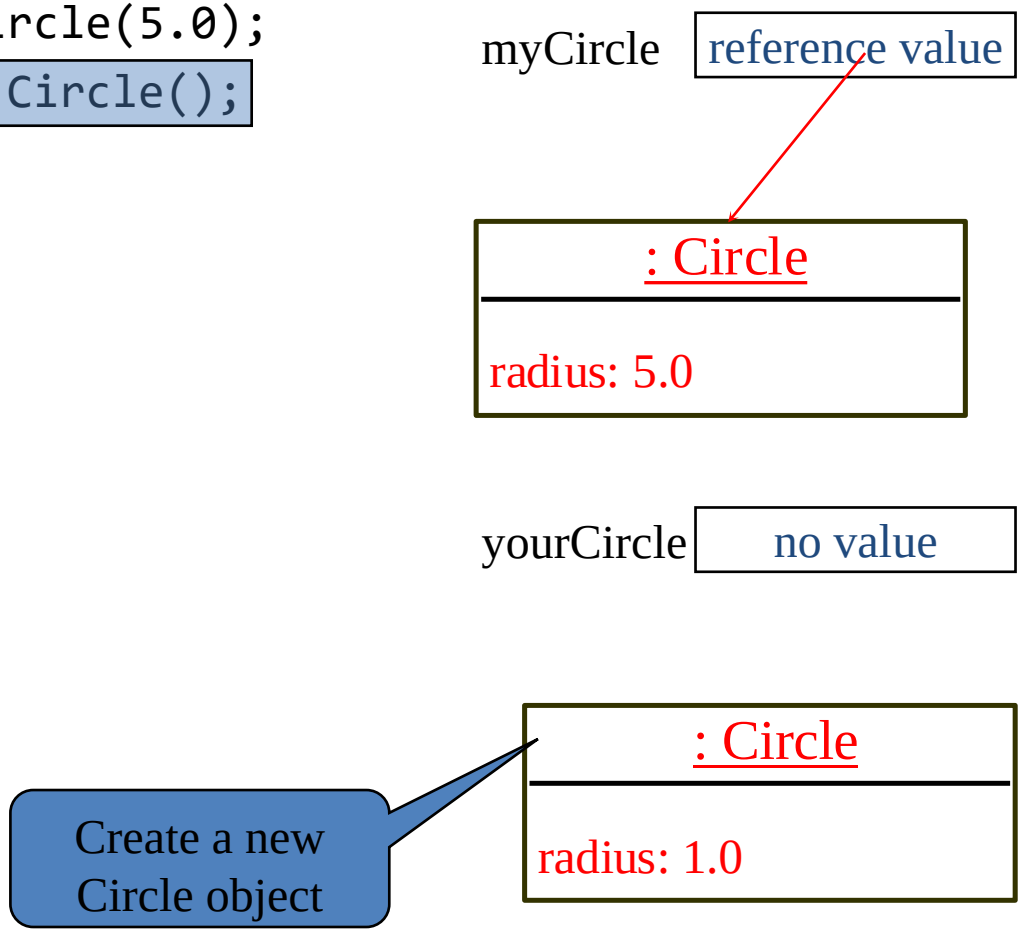

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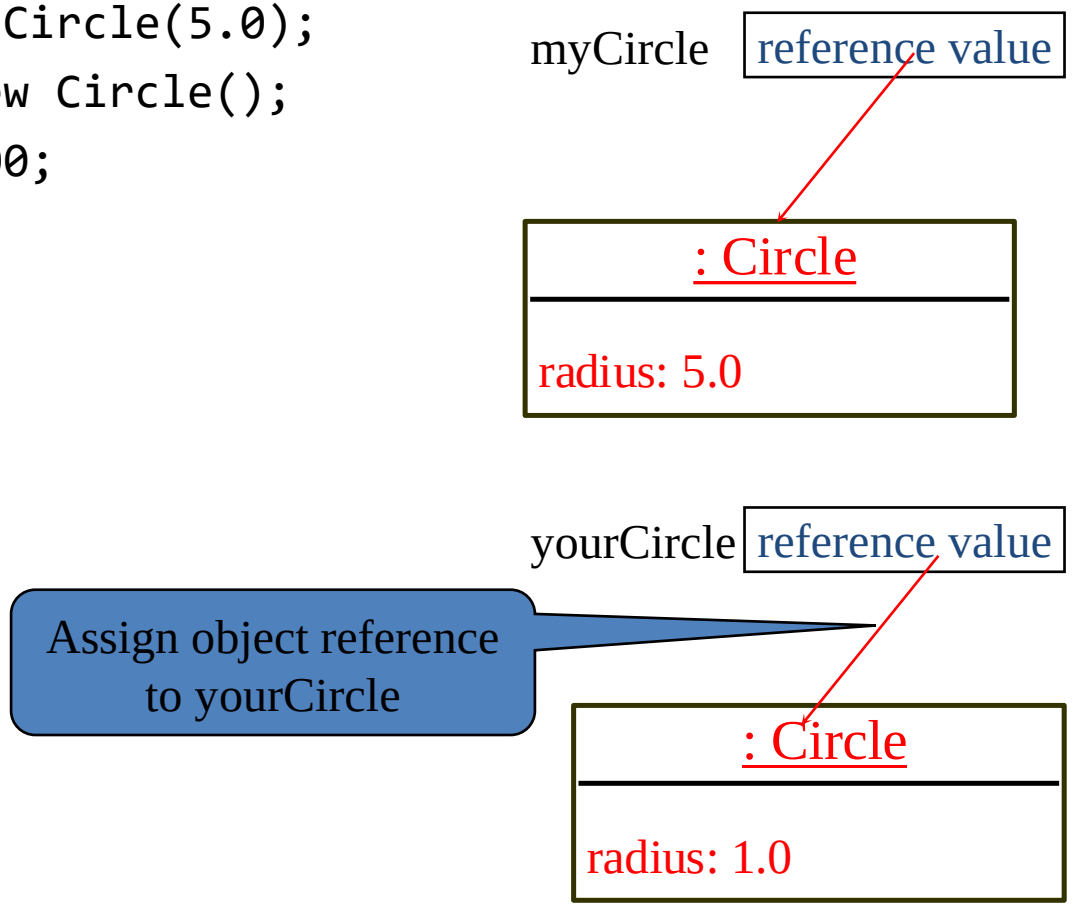

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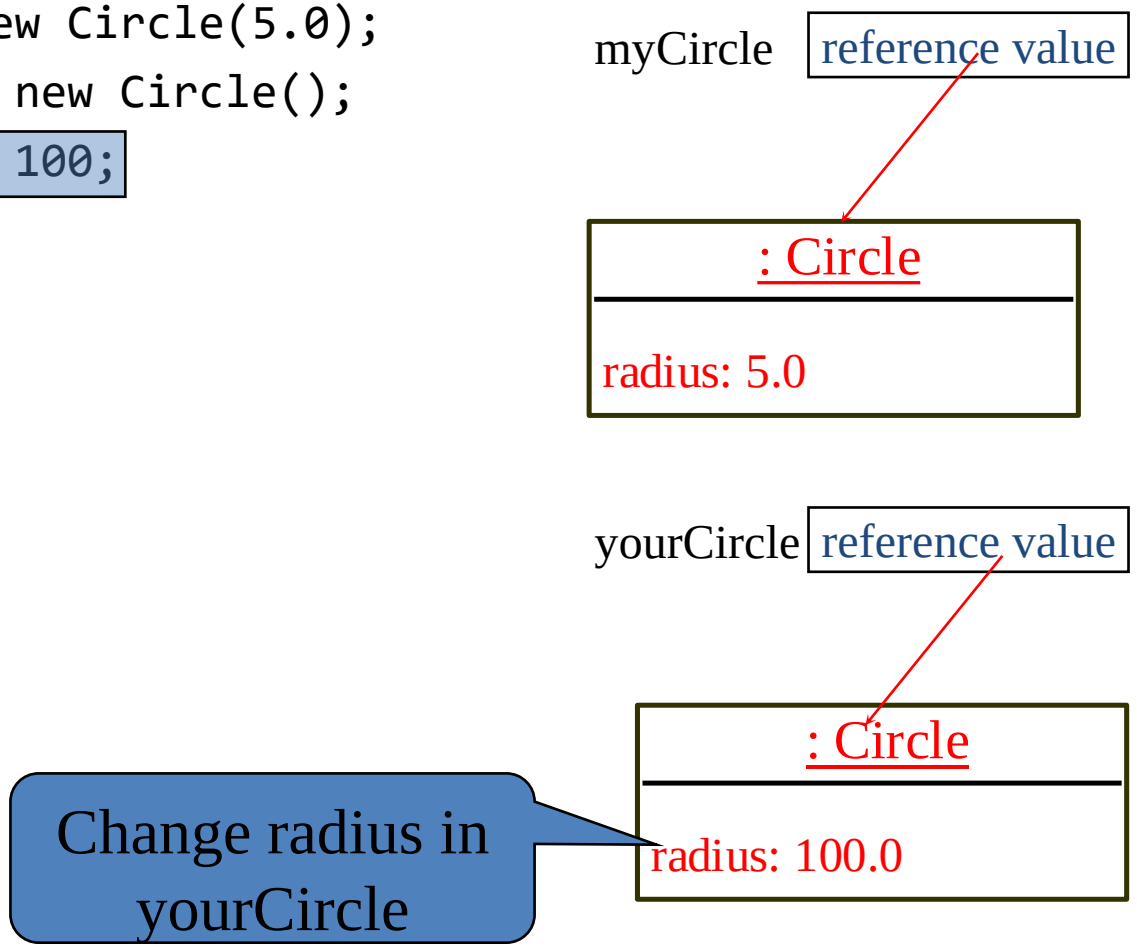


Reference data fields and `null`

- 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 isScienceMajor;
  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

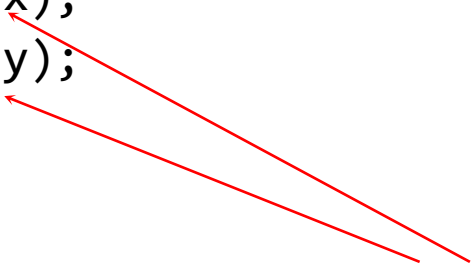
`'\u0000'` for a `char` type

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

Default values for local variables

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

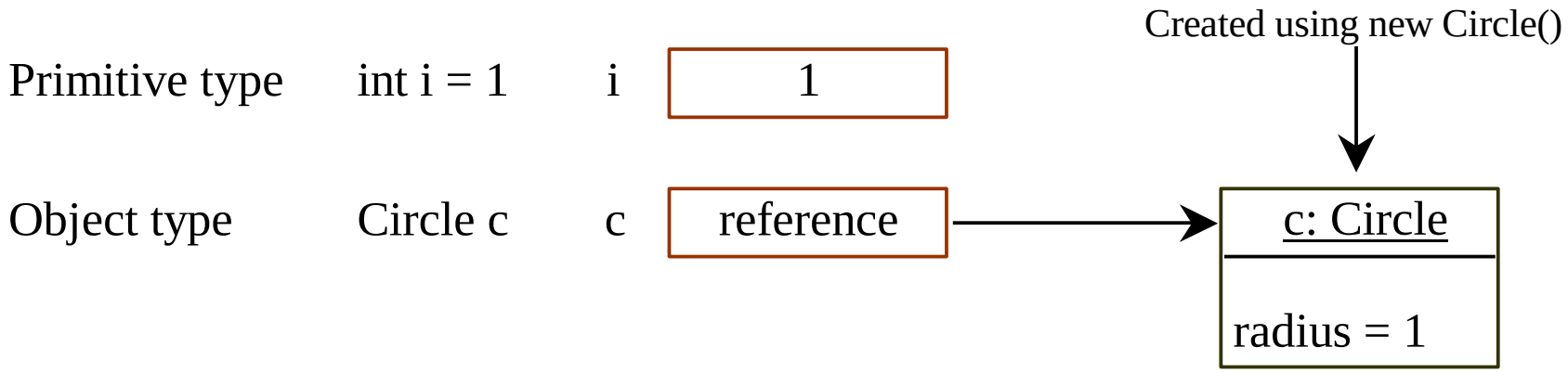
```
public class Test {
  public static void main(String[] args) {
    int x; // x has no default value
    String y; // y has no default value
    System.out.println("x is " + x);
    System.out.println("y is " + y);
  }
}
```



Compile error: variable not initialized

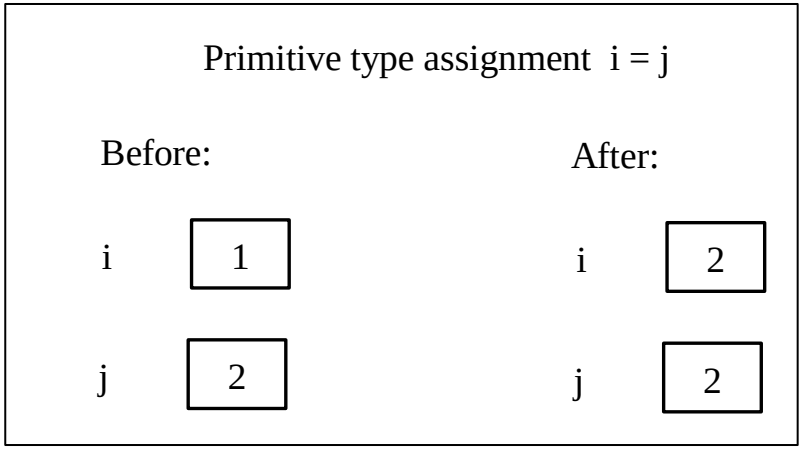
Differences between variables of primitive data types and object types

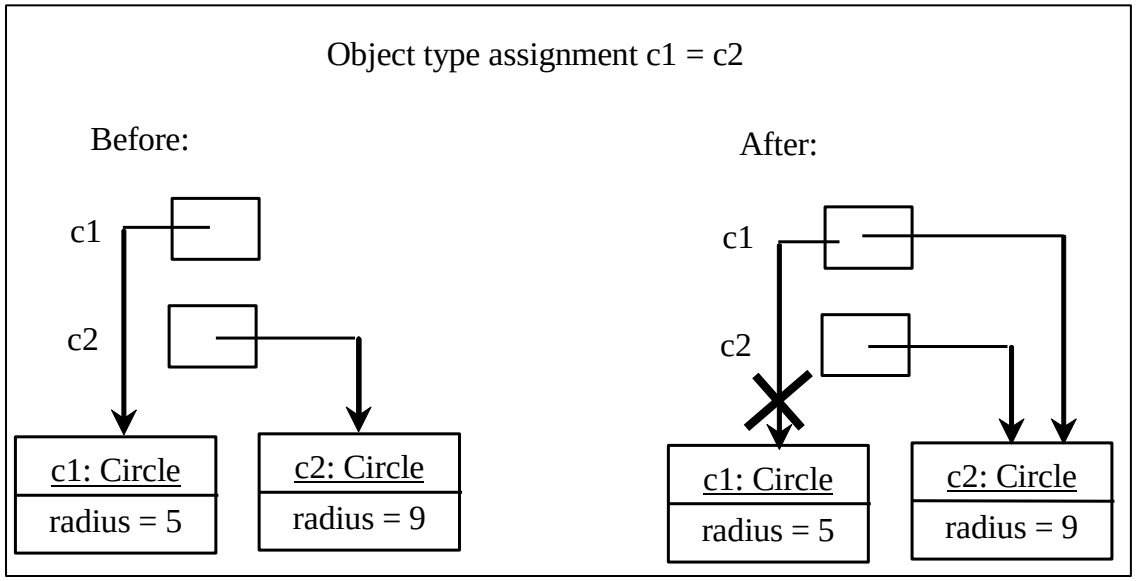
- A variable of a **primitive type** holds a value of the primitive type
- A variable of a **reference type** holds a reference to where an object is stored in memory



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