BIRZEIT UNIVERSITY

Objects & Classes

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OO Programming Concepts

❖ **O**bject-**O**riented **P**rogramming (OOP) involves programming using objects.

❖ An ***object*** represents an entity in the 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**.

- 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**.

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Objects and Classes

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

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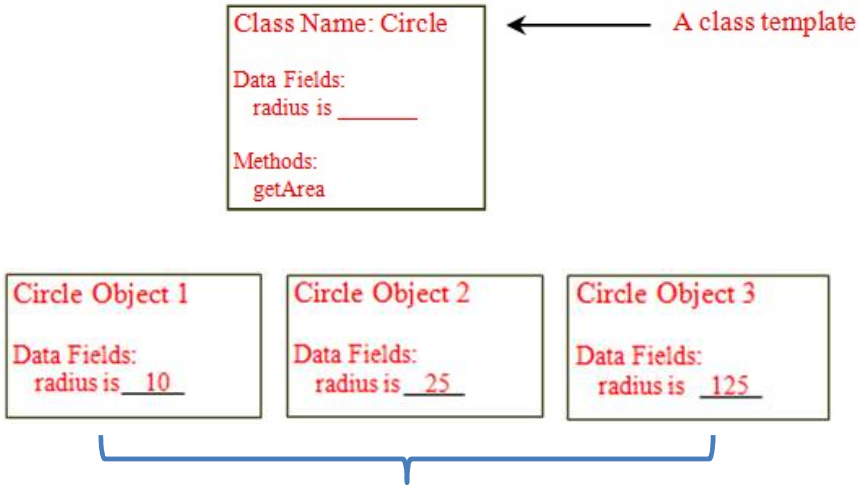
Objects and Classes cont.



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Circle Class

```
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

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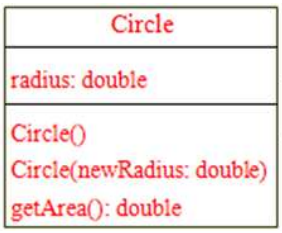
UML Class Diagram

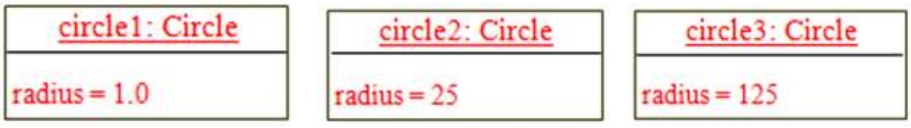
UML Class Diagram



Class name

Data fields

Constructors and methods



UML notation for objects

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Example: TV Class

TV	
`channel: int`	The current channel (1 to 120) of this TV.
`volumeLevel: int`	The current volume level (1 to 7) of this TV.
`on: boolean`	Indicates whether this TV is on/off.
`+TV()`	Constructs a default TV object.
`+turnOn(): void`	Turns on this TV.
`+turnOff(): void`	Turns off this TV.
`+setChannel(newChannel: int): void`	Sets a new channel for this TV.
`+setVolume(newVolumeLevel: int): void`	Sets a new volume level for this TV.
`+channelUp(): void`	Increases the channel number by 1.
`+channelDown(): void`	Decreases the channel number by 1.
`+volumeUp(): void`	Increases the volume level by 1.
`+volumeDown(): void`	Decreases the volume level by 1.

The + sign indicates a public modifier. →

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Constructors

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

```
Circle() {
}

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

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Constructors cont.

- A constructor with no parameters is referred to as a ***no-arg 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.

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Creating Objects Using Constructors

new ClassName();

Example:

new Circle();

new Circle(5.0);

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Default Constructor

❖ A class maybe defined **without** constructors.

❖ In this case, a **no-arg constructor** with an empty body is **implicitly** declared in the class.

❖ This constructor, called *a **default constructor***, is provided **automatically**

ONLY IF *no constructors are **explicitly** defined in the class*.

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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;

Example:

Circle myCircle;

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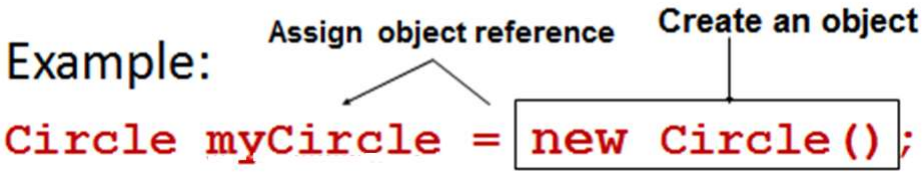
Declaring/Creating Objects in a Single Step

ClassName objectRefVar = new ClassName();

Example:



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Accessing Object's Members

- Referencing the object's data:

  objectRefVar.data

  e.g., **myCircle.radius**

- Invoking the object's method:

  objectRefVar.methodName(arguments)

  e.g., **myCircle.getArea()**

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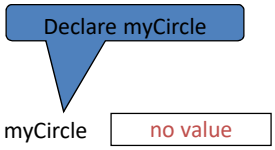
Trace Code

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

Circle yourCircle = new Circle();

yourCircle.radius = 100;
```

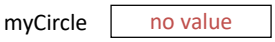


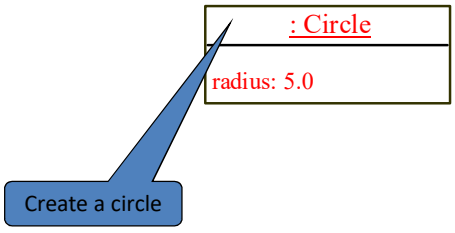
Trace Code, cont.

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

Circle yourCircle = new Circle();

yourCircle.radius = 100;
```





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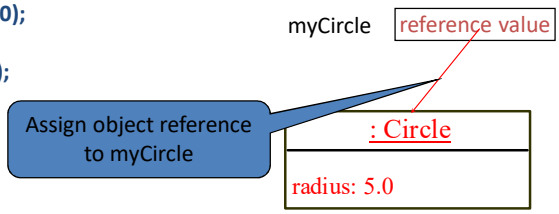
Trace Code, cont.

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

Circle yourCircle = new Circle();

yourCircle.radius = 100;
```



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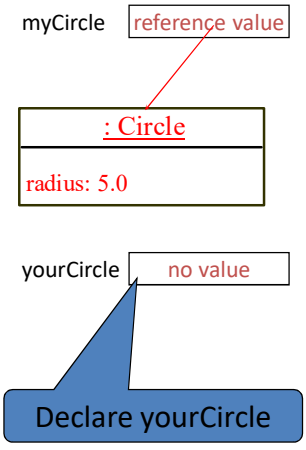
Trace Code, cont.

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

Circle yourCircle = new Circle();

yourCircle.radius = 100;
```



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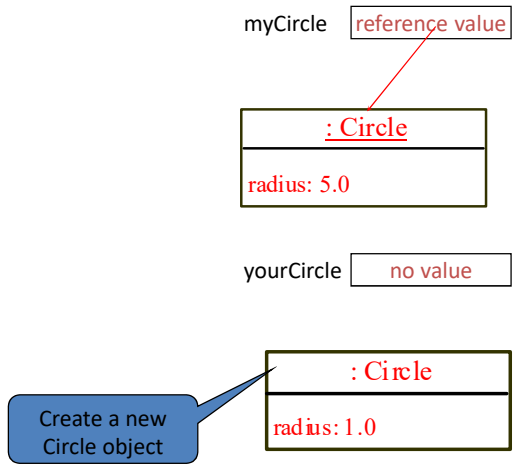
Trace Code, cont.

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

Circle yourCircle = new Circle();

yourCircle.radius = 100;
```



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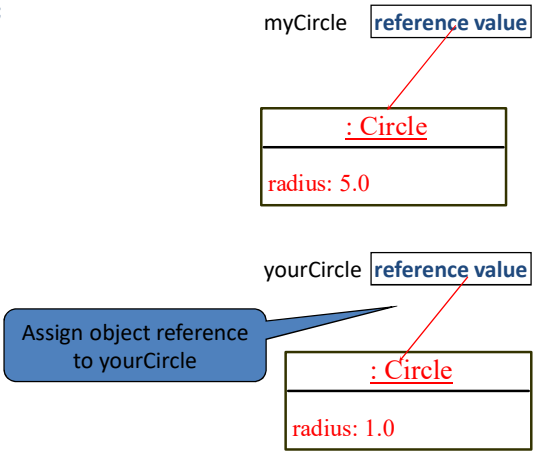
Trace Code, cont.

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

Circle yourCircle = new Circle();

yourCircle.radius = 100;
```



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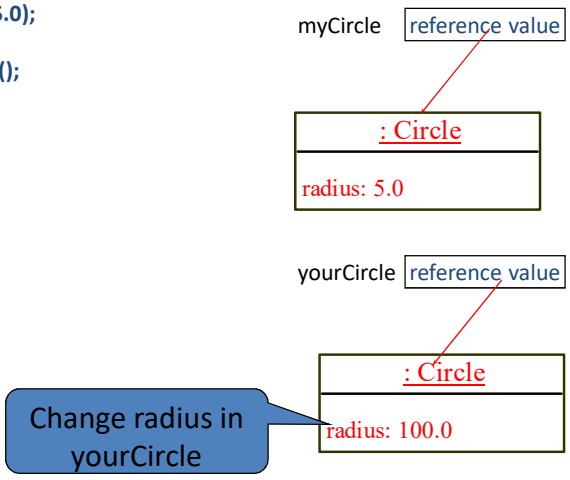
Trace Code, cont.

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

Circle yourCircle = new Circle();

yourCircle.radius = 100;
```



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Reference Data Fields

- The data fields can be of reference types.
  - If a data field of a **reference** type does not reference any object, the data field holds a special literal value, **null**.
  - 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
    boolean isScienceMajor; // default false
    char gender; // default value '\u0000'
}
```

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

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Example

- 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);
  }
}
```

Compilation error: variables not initialized

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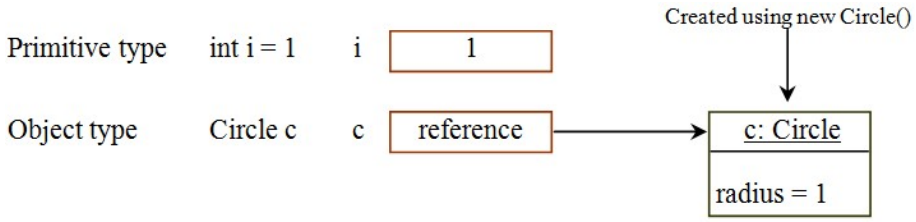
Differences between Variables of Primitive Data Types and Object Types



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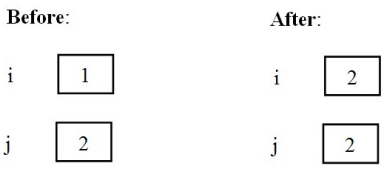
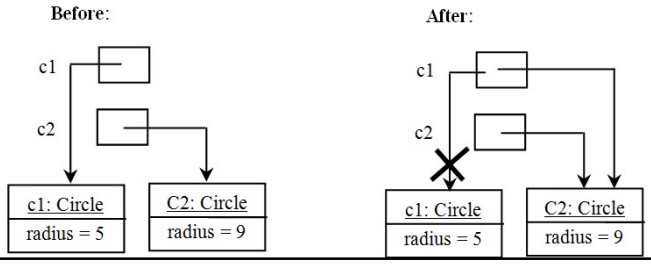
Copying Variables of Primitive Data Types and Object Types

Primitive type assignment **i = j**



Object type assignment **c1 = c2**



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Garbage Collection

❖ As shown in the previous figure, after the assignment statement **c1 = c2**, **c1** points to the same object referenced by **c2**.

❖ The object previously referenced by **c1** is no longer referenced.

❖ This object is known as **garbage**.

❖ Garbage is automatically collected by **JVM**.

The Date Class

❖ 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**.

The + sign indicates public modifer →

java.util.Date	
+Date()	Constructs a Date object for the current time.
+Date(elapseTime: long)	Constructs a Date object for a given time in milliseconds elapsed since January 1, 1970, GMT.
+toString(): String	Returns a string representing the date and time.
+getTime(): long	Returns the number of milliseconds since January 1, 1970, GMT.
+setTime(elapseTime: long): void	Sets a new elapse time in the object.

The Date Class Example

❖ For example, the following code:

```
java.util.Date date = new java.util.Date();
System.out.println( date.toString() );
```

- displays a string like:

Mon Nov 04 19:50:54 IST 2013

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The Random Class

❖ 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()	Constructs a Random object with the current time as its seed.
+Random(seed: long)	Constructs a Random object with a specified seed.
+nextInt(): int	Returns a random int value.
+nextInt(n: int): int	Returns a random int value between 0 and n (exclusive).
+nextLong(): long	Returns a random long value.
+nextDouble(): double	Returns a random double value between 0.0 and 1.0 (exclusive).
+nextFloat(): float	Returns a random float value between 0.0F and 1.0F (exclusive).
+nextBoolean(): boolean	Returns a random boolean value.

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The Point2D Class

Java API has a convenient **Point2D** class in the **javafx.geometry** package for representing a point in a two-dimensional plane.

javafx.geometry.Point2D	
+Point2D(x: double, y: double)	Constructs a Point2D object with the specified *x*- and *y*-coordinates.
+distance(x: double, y: double): double	Returns the distance between this point and the specified point (*x*, *y*).
+distance(p: Point2D): double	Returns the distance between this point and the specified point p.
+getX(): double	Returns the *x*-coordinate from this point.
+getY(): double	Returns the *y*-coordinate from this point.
+toString(): String	Returns a string representation for the point.

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Instance (Object) Variables, and Methods

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

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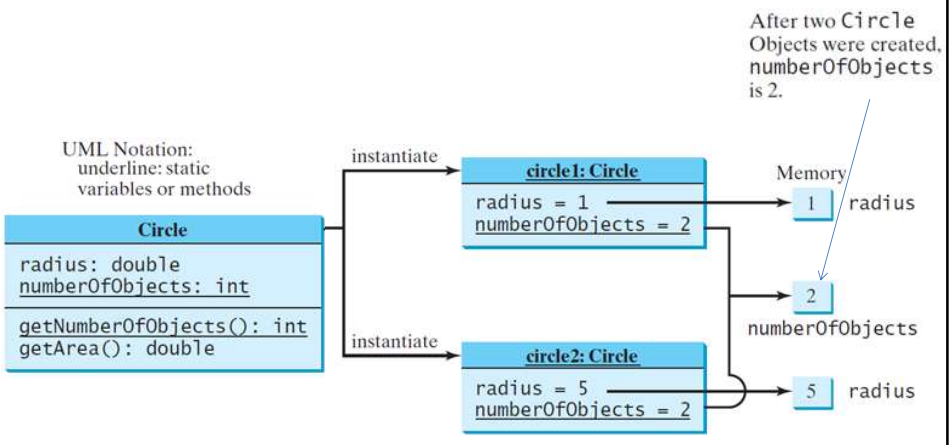
Static Variables, Constants, and Methods

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

Static



Static Variable

- It is a variable which belongs to the **class** and not to the **instance** (**object**).
- Static variables are **initialized only once**, at the start of the execution.
  - Static variables will be initialized first, before the initialization of any instance variables.
- A **single copy** to be shared by all instances of the class.
- A static variable can be **accessed directly** by the **class name** and doesn't need any object.

Syntax : ***<class-name>.<static-variable-name>***

Static Method

- It is a method which **belongs to the class** and **not** to the instance (**object**).
- A static method **can access only static data**. It can not access non-static data (instance variables).
- A static method **can call only** other **static methods** and can not call a non-static method from it.
- A static method can be **accessed directly** by the **class name** and doesn't need any object.

  Syntax : ***<class-name>.<static-method-name>(..)***
- A static method cannot refer to "**this**" or "**super**" keywords in anyway.

Note: main method is static, since it must be accessible for an application to run, before any instantiation takes place.

Static example

```
class Student {
int a; //initialized to zero
static int b; //initialized to zero only when class is loaded
  Student(){
   //Constructor incrementing static variable b
   b++;
  }

   public void showData(){
      System.out.println("Value of a = "+a);
      System.out.println("Value of b = "+b);
   }
//public static void increment(){
//a++;
//}

}
class Demo{
   public static void main(String args[]){
     Student s1 = new Student();
     s1.showData();
     Student s2 = new Student();
     s2.showData();
     //Student.b++;
     //s1.showData();
   }
}
```

```
C:\WINDOWS\system32\cmd.exe
C:\workspace>java Demo
Value of a = 0
Value of b = 1
Value of a = 0
Value of b = 2
```

Visibility Modifiers

❖ **By default** (when no visibility modifiers are used), the ***class***, ***variable***, or ***method*** can be accessed by any class in the same **package**.

☞ **public** modifier: The ***class***, ***data***, or ***method*** is visible to any class in any package.

☞ **private** modifier: The ***data*** or ***method*** can be accessed only by the declaring class.

- ❖ The **get** and **set** methods are used to read and modify private properties.

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```
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();
  }
}
```

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

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```
package p1;

class C1 {
  ...
}
```

```
package p1;

public class C2 {
  can access C1
}
```

```
package p2;

public class C3 {
  cannot access C1;
  can access C2;
}
```

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

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NOTE

❖ An object **cannot** access its private members, as shown in (**b**). It is OK, however, if the object is declared in its own class, as shown in (**a**).

```
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;
  }
}
```

(a) This is okay because object `c` is used inside the class `C`.

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

(b) This is wrong because `x` and `convert` are private in class `C`.

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Why Data Fields Should Be private?

❖ To protect data.

❖ To make code easy to maintain.

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Example of Data Field Encapsulation

The - sign indicates private modifier

Circle	
-radius: double	The radius of this circle (default: 1.0).
-numberOfObjects: int	The number of circle objects created.
+Circle()	Constructs a default circle object.
+Circle(radius: double)	Constructs a circle object with the specified radius.
+getRadius(): double	Returns the radius of this circle.
+setRadius(radius: double): void	Sets a new radius for this circle.
+getNumberOfObject(): int	Returns the number of circle objects created.
+getArea(): double	Returns the area of this circle.

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Overloading Methods/Constructors

- In a class, there can be **several methods with the same name**. However they **must** have **different *signature***.
- The signature of a method is comprised of its ***name***, its ***parameter types*** and the ***order of its parameter***.
- The signature of a method is **not** comprised of its ***return type*** nor ***its visibility*** nor its ***thrown exceptions***.

Passing Objects to Methods

- **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

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Passing Objects to Methods

```
public class TestPassObject {
  public static void main(String[] args) {
      Circle  myCircle = new Circle(1);
     // Print areas for radius 1, 2, 3, 4, and 5.
     int n = 5;
     printAreas(myCircle, n);
     System.out.println("\n" + "Radius is " + myCircle.getRadius());
     System.out.println("n is " + n);
  }

  /** Print a table of areas for radius */
  public static void printAreas( Circle c, int times) {
    System.out.println("Radius \t\tArea");
    while (times >= 1) {
        System.out.println(c.getRadius() + "\t\t" + c.getArea());
        c.setRadius(c.getRadius() + 1);
         times--;
     }
  }
}
```

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Array of Objects

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 as shown in the next figure.

circleArray references to the entire array.

circleArray[1] references to a Circle object.

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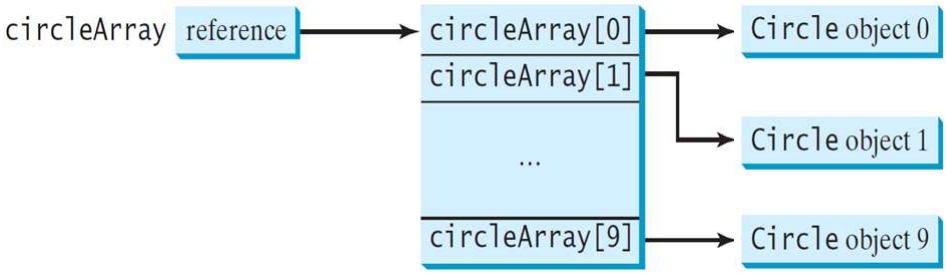
Array of Objects

Circle[] circleArray = new Circle[10];




```
circleArray[0] = new Circle();
circleArray[1] = new Circle();
        :
circleArray[9] = new Circle();
```

Immutable Objects and Classes

❖ If the contents of an object (instance) **can't** be changed once the object is created, the object is called an ***immutable object*** and its class is called an ***immutable class***.

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Immutable Objects and Classes

❖ If you delete the **set** method in the **Circle** class, the class would be **immutable** because **radius** is private and cannot be changed without a **set** method.

```
public class Circle {
  private double radius = 1;

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

  public void setRadius(double r) {
    radius = r;
  }
}
```

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Immutable Objects and Classes

- A class with **all private data** fields and without **set** methods is not necessarily immutable.
- For example, the following class **Student** has all **private** data fields and no **set** methods, but it is mutable!!!

Example

```
public class Student {
  private int  id;
  private java.util.Date   birthDate;
  public Student(int ssn, Date newBD) {
     id = ssn;
     birthDate = newBD;
   }
   public int getId() {     return id;    }
   public Date getBirthDate() {  return birthDate;   }
}
```

```
public class Test {
  public static void main(String[] args) {
     java.util.Date bd = new java.util.Date();
     Student student = new Student(111223333, bd);
     java.util.Date date = student.getBirthDate();
     date.setMonth(5); // Now the student birthdate is changed!
  }
}
```

What Class is Immutable?

- For a class to be immutable:
  - It must mark all data fields **private.**
  - Provide **no set** methods.
  - No **get** methods that would return a reference to a mutable data field object.

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Scope of Variables

- The scope of **instance** (object) 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.

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Scope of Variables

❖ What is the output?

```
public class A {
  int year = 2019;   // instance variable

  void p() {
     System.out.println("Year: "+ year);
     int year = 2020;   // local variable
     System.out.println("Year: "+ year);
  }
}
```

```
public class B {
  public static void main (String[] s) {
     A a = new A();
      a.p();
  }
}
```

The this Keyword

❖ 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.

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Reference the Hidden Data Fields

```
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

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Calling Overloaded Constructor

```
public class Circle {
  private double radius;

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

  public Circle() {
    this(1.0);
  }

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

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

this is used to invoke another constructor

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

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