EE3206
Java Programming and Applications

Lecture 2
Objects and Classes

Intended Learning Outcomes

- To understand relationship between objects and classes.
- To understand the use of constructors.
- To use private modifier to protect data fields
- To allow controlled access of private fields through getter or setter.
- To know the difference between instance and static variables and methods.
- To determine the scope of variables in the context of a class.
- To use the keyword *this* as the reference to the current running object
- To store and process objects in arrays.

Warm Up Exercise

- Before we continue, let's recall your memories…

- Problem:
  - In a 2D space, find the length of a line.
- What to do:
  1. Model the Point and Line objects in this problem domain
  2. Write the (business) logic to calculate the distance

```
public class WarmUp {
    public static void main(String[] args) {
        Point start = new Point(2, 2);
        Point end = new Point(3, 3);
        Line line = new Line(start, end);
        System.out.println("The length is " + line.findLength());
    }
}
```

Modeling Point and Line

```
class Point {
    int x;
    int y;

    Point(int n1, int n2) {
        x = n1;
        y = n2;
    }
}
```

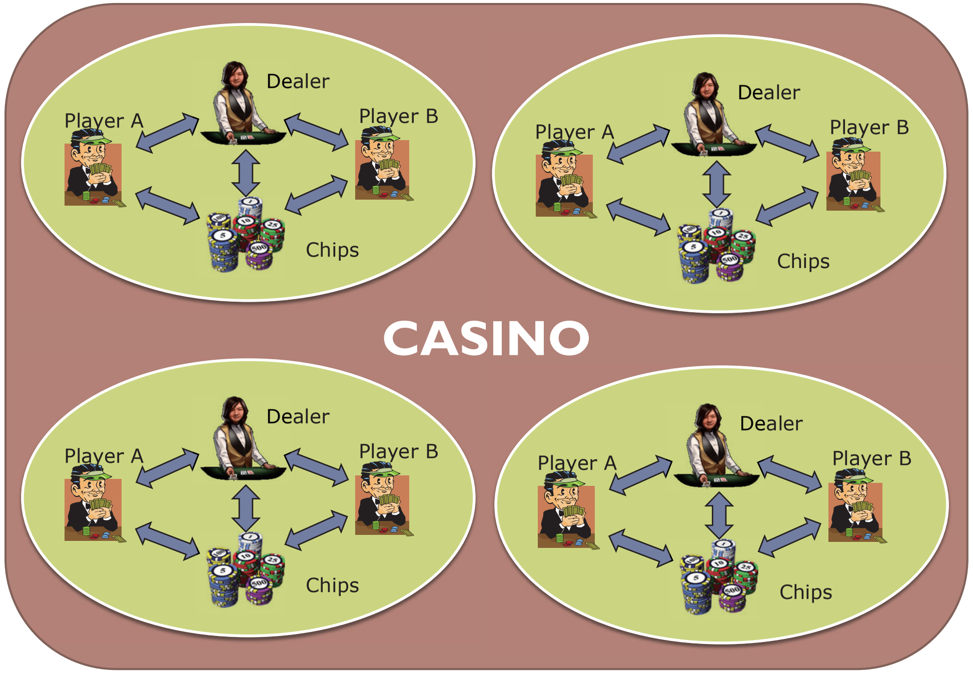
use

```
class Line {
    Point start;
    Point end;

    Line(Point n1, Point n2) {
        start = n1;
        end = n2;
    }

    double findLength() {
        return Math.sqrt(
         Math.pow(start.x - end.x, 2) +
         Math.pow(start.y - end.y, 2)
         );
    }
}
```

Raise of OOP

- Object-oriented programming (OOP) has roots that can be traced to the 1960s. As hardware and software became increasingly complex, quality was often compromised. Researchers studied ways to maintain software quality and developed object-oriented programming in part to address common problems by strongly emphasizing discrete, reusable units of programming logic.
- OOP involves programming using objects. An object represents an entity in the real world that can be distinctly identified.
  - For example, a student, a car, a circle, a button, and even a loan can all be viewed as objects.
- In OOP, each object is capable of receiving messages, processing data, and sending messages to other objects and can be viewed as an independent 'machine' with a distinct role or responsibility.
- Consider a casino game:
  - What else?
  - Table, Room, VipRoom, Account, Card, Dice, …etc
  - Game types – Slots, Black Jack, Poker…etc

Dealer
Player A
Player B
Chips



Programming Paradigms

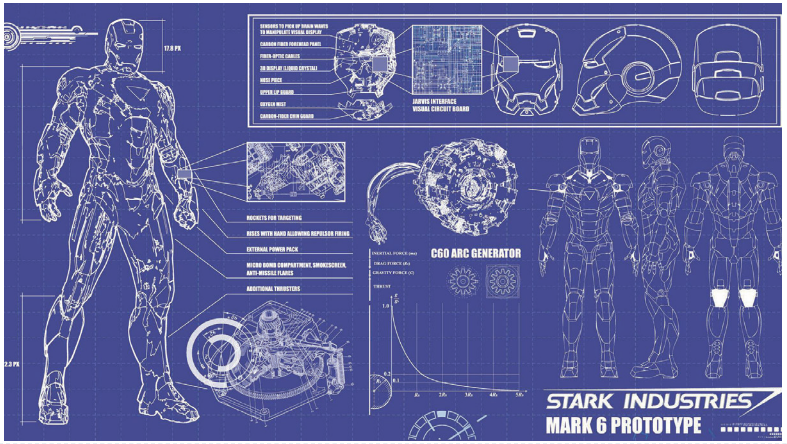
OOP	Procedural Programming
Programming task is broken down into objects that expose behavior (methods) and data (attributes)	Programming task is broken down into a collection of variables, data structures, and subroutines
Program is viewed as a collection of objects interacting with each other	Program simply contains a series of computational steps to be carried out
Self-contained module, an object operates on its own data structure	Uses procedures to operate on data structures

Objects

- An object has a unique identity, state, and behaviors.
  - The identity is the name of an object.
    - Student peter = new Student(); // object name
  - The state of an object consists of a set of data fields (also known as properties) with their current values.
    - peter.age // data field
    - peter.sid
    - peter.gpa
  - The behavior of an object is defined by a set of methods.
    - peter.graduate() // methods
    - peter.promoteToNextYear()

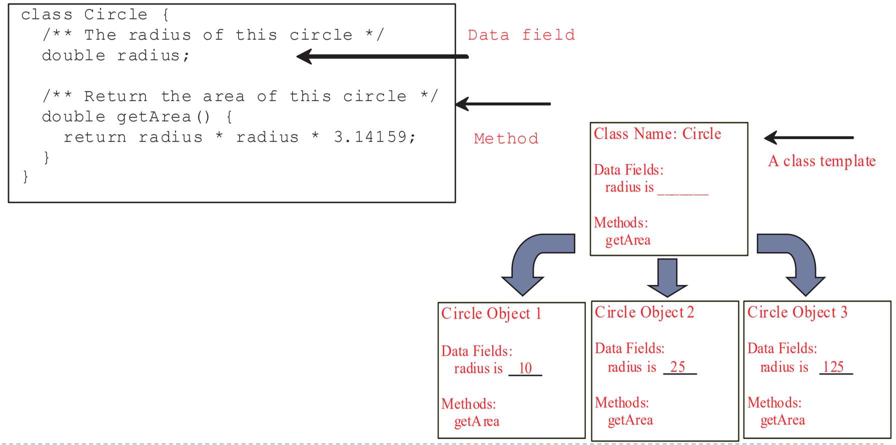
Relationship between Classes and Objects

- What about classes then?
  - Class is the blueprint for constructing objects



Classes

- Class is a construct that defines objects of the same type.
- A class tells what its objects possess.



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

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

Constructors

- A class provides a special type of methods, known as constructors, which are automatically invoked when an object is created.
- Constructors must have the same name as the class itself.
- Constructors do not have a return type — not even void.
- A constructor with no parameters is called **"no-arg" constructor**.

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

  /** Construct a circle object */
  Circle() {
   // no-arg constructor
   // initialize data fields with default values
  }

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

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

Using Constructors

- Constructors cannot be invoked directly as a normal method. They are invoked using the new operator when an object is created.
  - new ClassName();
    - new Student(); // correct
    - Student.Student(); // wrong
    - peter.Student(); // wrong
- Constructors play the role of initializing objects. You should place your code of initialization inside a constructor.
  - new Circle(); // without args
  - new Circle(5.0); // with args

Default Constructor

- A class may be declared without constructors. In this case, a no-arg constructor with an empty body is implicitly declared in the class.
  - Automatically inserted by compiler

- This constructor, called a default constructor, is provided automatically only if no constructors are explicitly declared in the class.

Declaring Objects

- Similar to declaring a variable of primitive data types, you can declare a reference variable for an object, using the syntax:
  - ClassName objectRefVar;
  - Example:
  - Circle myCircle; // used to hold the reference value, similar to a C/C++ pointer

- To reference an object, assign the object to a reference variable.
  - ClassName objectRefVar = new ClassName();
  - Example:
  - Circle myCircle = new Circle(); // RHS creates an object and return its reference value

- If a reference type variable does not reference any object, the data field holds a special literal value, null.
  - Circle myCircle; // declaration only, implicitly null
  - Circle myCircle = null; // equivalent

Accessing Objects

- Referencing the object's data:
  - objectRefVar.data
  - Example:
  - double myRadius = myCircle.radius;

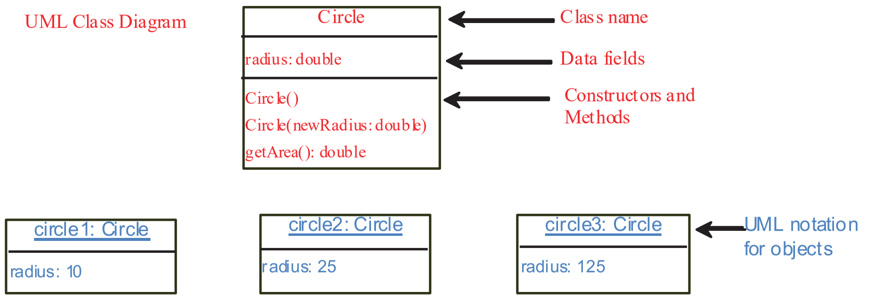
- Invoking the object's method:
  - objectRefVar.methodName(arguments)
  - Example:
  - myCircle.getArea();

- Objective:
  - Demonstrate creating objects, accessing data, and using methods.

TestCircle1

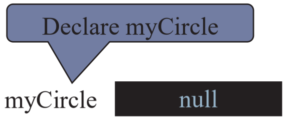
UML Class Diagram

- Unified Modeling Language (UML) is a standardized specification language for object modeling.
- It is a general-purpose modeling language that includes a graphical notation used to create an abstract model of a system, referred to as a *UML model.*



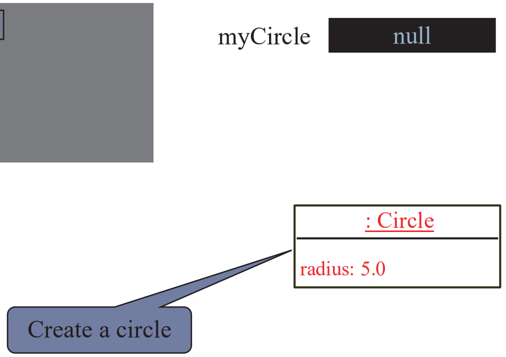
Initializing Objects

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

Circle yourCircle = new Circle();

yourCircle.radius = 100;
```



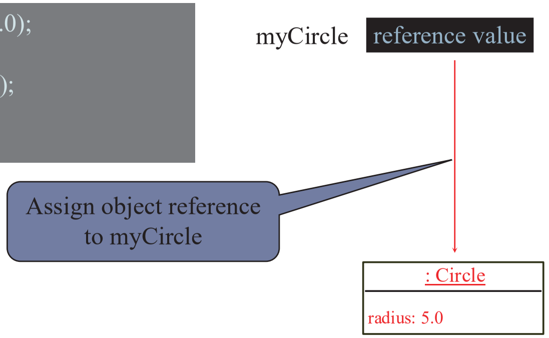
Initializing Objects

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

Circle yourCircle = new Circle();

yourCircle.radius = 100;
```



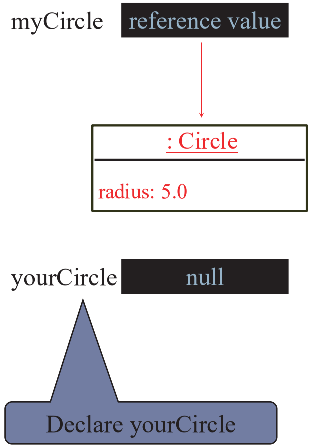
Initializing Objects

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

Circle yourCircle = new Circle();

yourCircle.radius = 100;
```

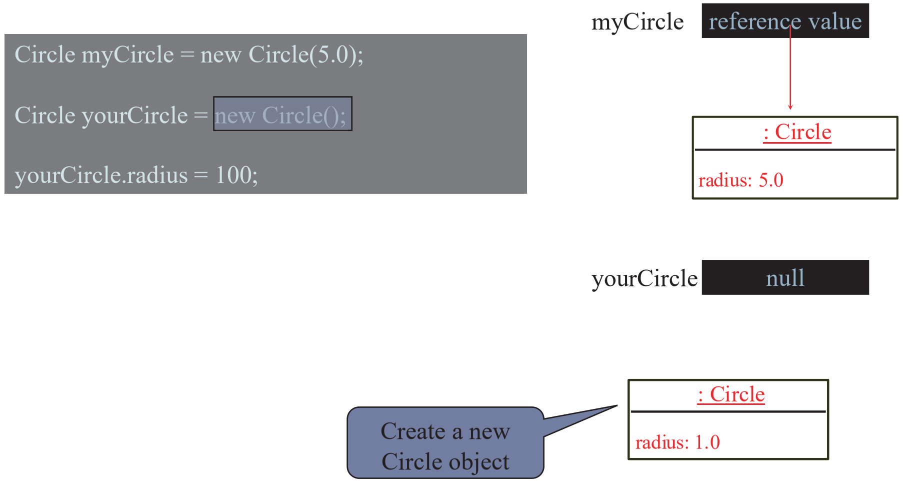


Initializing Objects

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

Circle yourCircle = new Circle();

yourCircle.radius = 100;
```

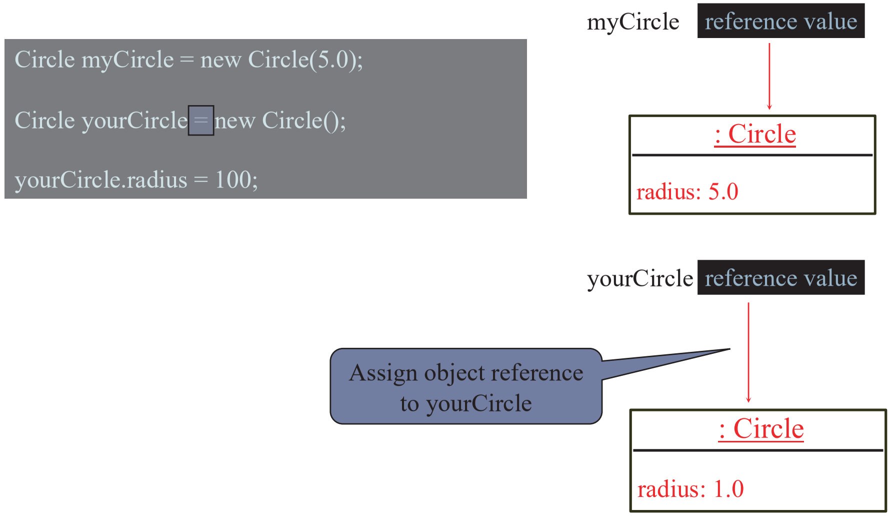


Initializing Objects



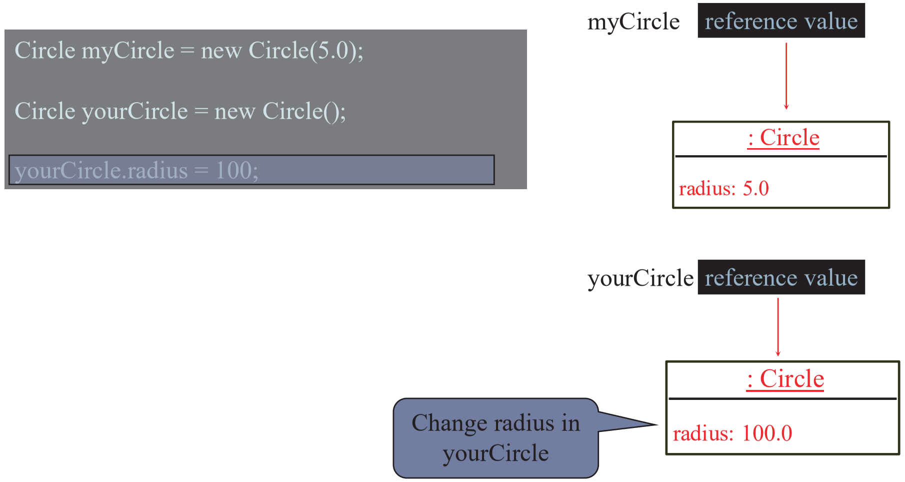
```
Circle myCircle = new Circle(5.0);

Circle yourCircle = new Circle();

yourCircle.radius = 100;
```

Initializing Objects



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

Circle yourCircle = new Circle();

yourCircle.radius = 100;
```

Initializing Objects



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

Circle yourCircle = new Circle();

yourCircle.radius = 100;
```

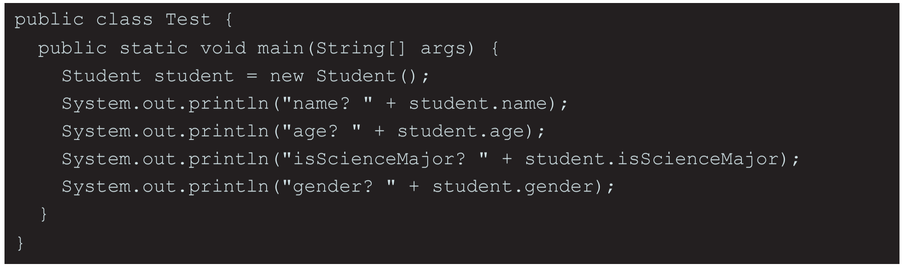
Data Fields

- Data fields refer to those variables declared in a class (whereas variables declared in methods are local variables)
  - The data fields can be of primitive types or reference types.
  - We have mentioned that String is a reference types.
  - For example, the following Student class contains mixed types of data field.

```
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 Value for a Data Field

- All data fields have a default value.
  - reference type = null
  - numeric type = 0
  - boolean type = false
  - char type = '\u0000'   //16 bits unicode value in hex format



```
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);
  }
}
```

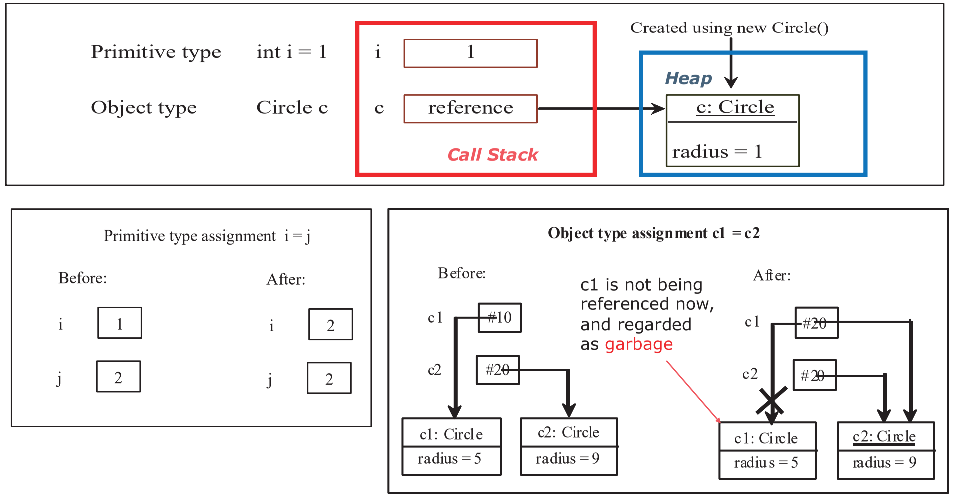
No Default Value for Local Variables

- However, Java assigns no default value to local variables inside 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

Difference between Primitive Type and Object Type



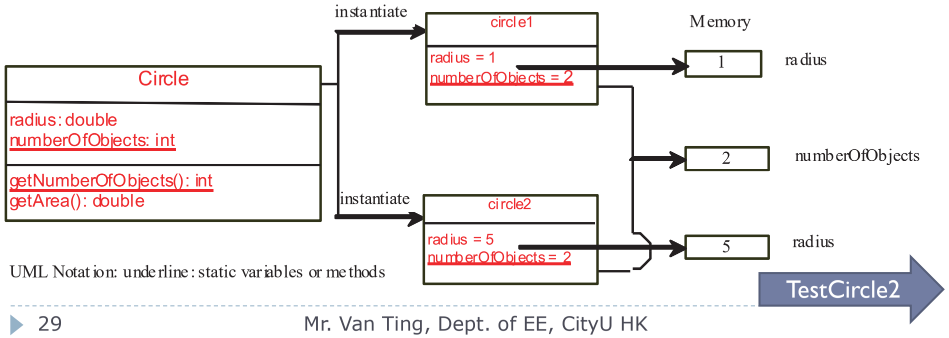
Garbage Collection

- 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.
  - You don't need to acquire/release memory by yourself.
- TIP: 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.
- For example:

```
Circle c = new Circle();
…
…                 // after some operations and no need c anymore
c = null;
```

Static Modifier – Share Property

- Static modifier can be used in variables and methods.
- They are not copied to each instances but registered in the class only.
- Static variable/method can be accessed through a class reference.
  - E.g. ClassName.varName / ClassName.methodName()
- Static variables are shared by all the instances of the same class.
  - Each object has it's own radius (instance variable), but both circle1 and circle2 share the same numberOfObjects (class variable).



UML Notation: underline: static variables or methods

Visibility Modifiers

- Package level (no visibility modifier)
  - By default, the class, variable or method can be accessed by any class in the same package.
- Public level (modifier: **public**)
  - No restriction of access
  - The class, variable or method is visible to any class in any package.
- Private level (modifier: **private**)
  - The variable or method can be accessed only by the declaring class itself.

Restricting Accessibility

- Example1

package p1;

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

  public void m1() {
    can access x, y, z
  }
  void m2() {
    can access x, y, z
  }
  private void m3() {
    can access x, y, z
  }
}
```

```
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();
  }
}
```

- Ex2

package p1;

```
class C1 {
  ...
}
```

```
public class C2 {
  can access C1
}
```

package p2;

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

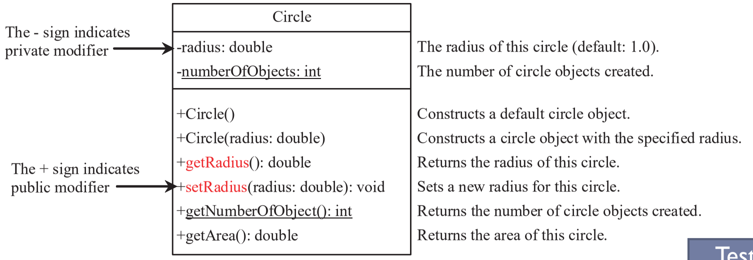
Problem of Public Properties

- I have a bank account object, says `myAccount`
- Users can read my balance by
  - `myAccount.balance`
- They can also change it by
  - `myAccount.balance = 999999`

- Scenario 1: I only want to let users read my balance. I don't want them to change it!
- Scenario 2: I allow users to update my balance only if they are authorized to do so.

Data Encapsulation

- **Data encapsulation**, also known as data hiding, is the mechanism whereby the implementation details of a class are kept hidden from the user. The user can only perform a restricted set of operations on the hidden (private) members of the class by executing special (public) methods. As a result:
  - Data fields are being protected from illegal access
  - Maintenance of a class becomes easier in the long run
- We can then allow controlled access through public methods of the same class. These methods are called getter and setter (aka accessor and mutator). They are used to read and modify private properties.



The - sign indicates private modifier

The + sign indicates public 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.

TestCircle3

Immutable Objects and Classes

- 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 setRadius method in the preceding example, the Circle class would be immutable because radius is private and cannot be changed without a set method.

Student is mutable or 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;
  }
}
```

What make Class Immutable?

- A class with all private data fields and without mutators is not necessarily immutable.
- For a class to be immutable, it must:
  - mark all data fields private;
  - provide no setter (mutator) methods;
  - ***provide no getter (accessor) methods that would return a reference to a mutable data field object.*

Scope of Variables in Class

- Data fields
  - The scope of data fields is the entire class. They can be declared anywhere inside a class, though this is not preferred (lower readability).
  - They are implicitly initialized with default value.
- Local variables
  - 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 Keyword - **this**

- The keyword *this* is a reference to the current object context (i.e. the executing object).
- It automatically available in any object context.
- Two common usages:
  - To explicitly refer to an instance's data field.
  - To invoke an overloaded constructor of the same class.

```
public class Circle {
  private double radius;

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

  public Circle() {
    this(1.0);
  }

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

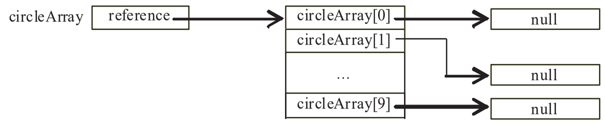
this must be explicitly used to reference the data field radius of the object being constructed

this is used to invoke another constructor

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

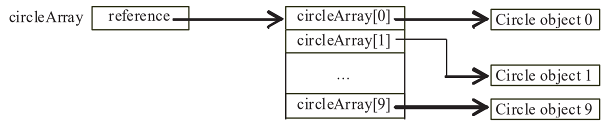
Array of Objects

- An array of objects is actually an array of reference variables.
  - Circle[] circleArray = new Circle[10]; // no circles !!!



- The above code only creates an Array object but not Circle objects. For each elements, you need to create them one by one:

for(int i=0; i<circleArray.length; i++)
  circleArray[i] = new Circle();



TotalArea

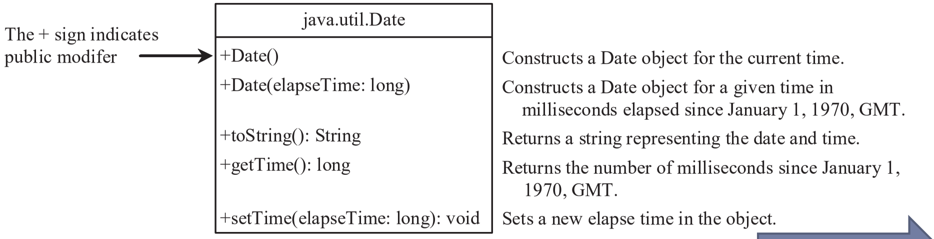
Introduction to Useful Classes

Date
Random

The Date Class

- You can use the java.util.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. For example,
  - java.util.Date date = new java.util.Date();
  - System.out.println(date.toString());

- The above code will output a string representation of the date like:
  - Wed Sep 30 14:35:46 CST 2009



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.

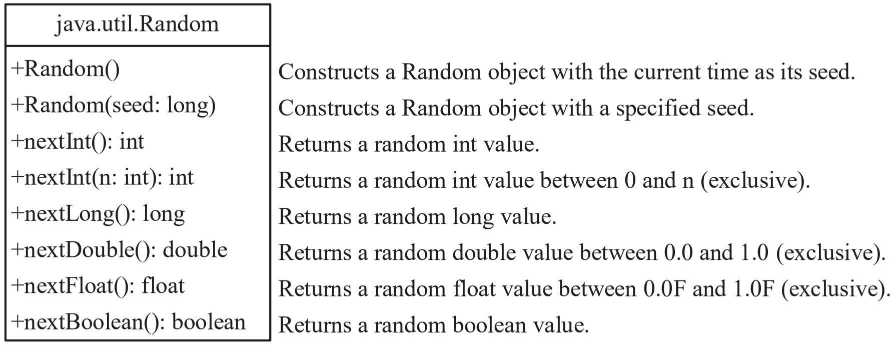
+getTime(): long Returns the number of milliseconds since January 1, 1970, GMT.

+setTime(elapseTime: long): void Sets a new elapse time in the object.

DateDemo

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.

Random Class Example

- If two Random objects have the same seed, they will generate identical sequences of numbers. For example, the following code creates two Random objects with the same seed 3.

```
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
```