Chapter 5: Classes and Objects in Depth

Introduction to methods

What are Methods

- Objects are entities of the real-world that interact with their environments by performing services on demand.
- Objects of the same class have:
  - the same characteristics: store the same type of data.
  - And the same behavior: provide the same services to their environment.
- Services that objects provide are called methods.

Why Methods

- Information hiding prevent the data an object stores from being directly accessed by outsiders.
- Encapsulation allows objects containing the appropriate operations that could be applied on the data they store.
- So, the data that an object stores would be accessed only through appropriate operations.

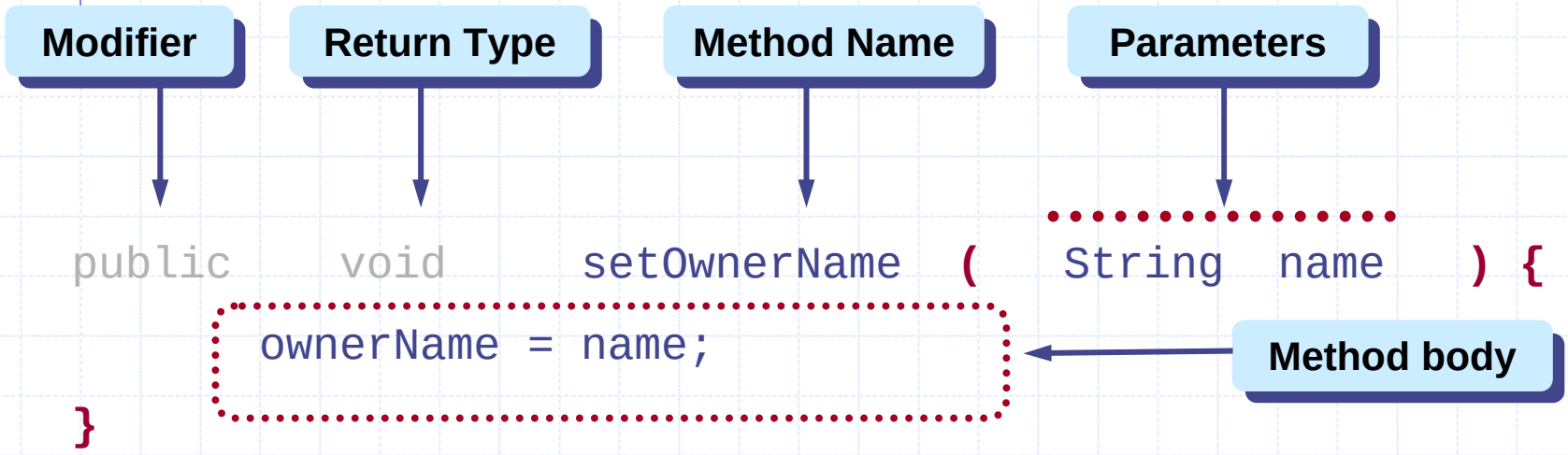
Method Declaration

- Method declaration is composed of:
  - Method header.
  - Method body

```
<method header> {
        <method body>
}
```

Method Declaration (cont.)

```
<modifiers>  <return type>  <method name>  ( <parameters>  ){
        <method body>
}
```



Method Header

```
<modifiers>  <return type>  <method name>  ( <parameters>  ){
        <method body>
}
```

- The ***modifiers*** represent the way the method is accessed.
- The ***return type*** indicates the type of value (if any) the method returns.
  - If the method returns a value, the type of the value must be declared.
  - Returned values can be used by the calling method.
  - Any method can return at most one value.
  - If the method returns nothing, the keyword ***void*** must be used as the ***return type***.
- The ***parameters*** represent a list of variables whose values will be passed to the method for use by the method.
  - They are optional.
  - A method that does not accept parameters is declared with an empty set of parameters inside the parentheses.

Types of methods

- There 3 different criteria defining types of methods:
  - Modifiers: this criteria is also composed of 3 sub-criteria:
    - Visibility: public or private (or protected in csc 113)
    - Shared between all instances or not: class member (static) or instance method.
    - Override able or not (final): to be discussed in CSC 113.
  - Return type: method with or without (void) return value.
  - Parameters: with or without parameters.

Example of Methods with No-Parameters and No-Return value

```
import java.util.Scanner;

public class Course {
    // Attributes
    private String studentName;
    private String courseCode ;
    private static Scanner input = new Scanner(System.in); //Class att.
    // Methods
    public void enterDataFromKeyBoard() {
        System.out.print ("Enter the student name: ");
        studentName = input.next();

        System.out.print ("Enter the course code: ");
        courseCode = input.next();
    }

    public void displayData() {
    System.out.println ("The student name is: " + studentName);
    System.out.println ("The the course code is: "+ courseCode);
    }

}
```

Message Passing Principle or Method Invocation

- Message passing is the principle that allows objects to communicate by exchanging messages.
- Passing a message to an object means ordering this latter to execute a specific method.
- Passing messages to objects is also known as method invocation.

Method Invocation

- Invoking a method of a given object requires using:
  - the instance variable that refers to this object.
  - the dot (.) operator as following:

    instanceVariable.methodName(arguments)

```
public class CourseRegistration {
    public static void main(String[] args) {
         Course course1, course2;
//Create and assign values to course1
         course1 = new Course( );
         course1.enterDataFromKeyBoard();   course1.display();
//Create and assign values to course2
         course2 = new Course( );
         course2.enterDataFromKeyBoard();   course2.display();

    }
}
```

Method Invocation Execution Schema

```
class Client {

    public static void
           main(String[] arg) {

      X obj = new X();
      // Block statement 1

      obj.method();
      // Block statement 2
    }

    . . .
 }
```

The client

```
class X {

    . . .

    public void method() {

        // Method body
    }

    . . .
 }
```

Block statement 1 executes

The method Invocation

Passing Parameters if exist

The method body starts

The method body finishes

Return result if any

Block statement 2 starts

The client

Returning a Value from a Method

- A method returns to the code that invoked it when it:
  - completes all the statements in the method,
  - reaches a return statement, or
  - throws an exception (covered in CSC 113),
- If the method returns a value:
  - The caller must declare a variable of the same type of the return value.
  - The caller assigns the return value to the variable:

```
variableName = instanceVariable.methodName(args);
```

The *return* keyword

- The *method's return type* is declared in its method declaration.
- The *return* statement is used within the body of the method to return the value.
- Any method declared *void* doesn't return a value.
  - It does not need to contain a return statement.
  - It may use a return statement to branch out of a control flow block and exit the method. The return statement is simply used like this:

    return;
  - Return a value from a such method, will cause a compiler error.
- Any method that is not declared void:
  - must contain a return statement with a corresponding return value, like this:
    - return returnValue;
  - The data type of the return value must match the method's declared return type.
  - you can't return an integer value from a method declared to return a boolean.

Example of a Method with Return value

```
public class Student {
    // Attributes
    private String studentName;
    private int midTerm1, midTerm2, lab, final ;
    // Methods

    public int computeTotalMarks() {
        int value = mid1 + mid2 + lab + final;

        return value;
    }
}
```

```
public class TestStudent {
    public static void main (String [] args) {
        Student st = new Student();
        int total;

        …

        total = st.computeTotalMarks();
        System.out.println(total);
    }
}
```

Template for Methods with Return value

```
public class ClassName {
    // Attributes
    ...
    // Methods
    ...
    public returnType methodName(…) {
        returnType variableName;
        // 1 - calculate the value to return
        // 2 - assign the value to variableName
        return variableName;
    }
}
```

```
public class ClientClass {
    public static void main (String [] args) {
        ClassName instanceVariable = new ClassName();
        returnType receivingVaraiable;

        ...

        receivingVaraiable = instanceVariable.methodName(…);

        ...
    }
}
```

Passing Information to a Method

- The declaration for a method declares the number and the type of the data-items to be passed for that method.
- ***Parameters*** refers to the list of variables in a method declaration.
- ***Arguments*** are the actual values that are passed in when the method is invoked.
- When you invoke a method, the arguments used must match the declaration's parameters in type and order

Arguments and Parameters

- An argument is a value we pass to a method.
- A parameter is a placeholder in the called method to hold the value of the passed argument.

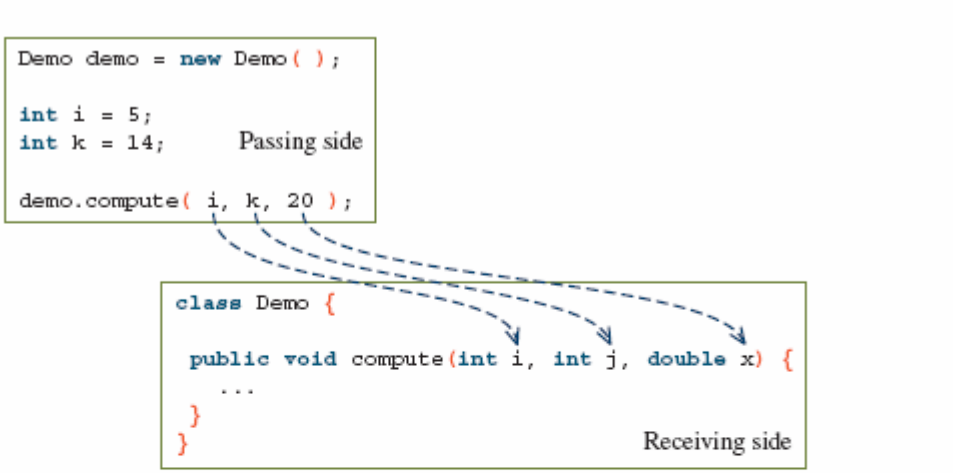
```
class Sample {

    public static void
           main(String[] arg) {

      Account acct = new Account();
      . . .

      acct.add(400);
      . . .
    }

    . . .
 }
```

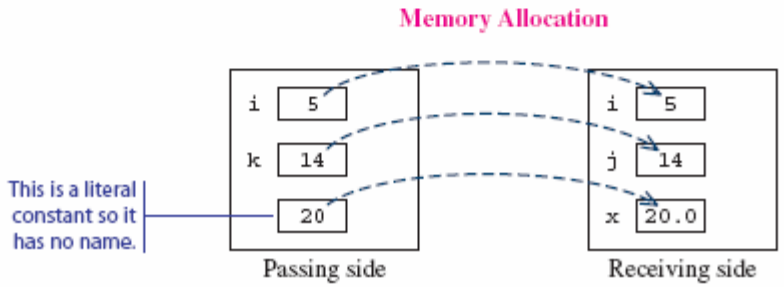
argument

```
class Account {

    . . .

    public void add(double amt) {

        balance = balance + amt;
    }

    . . .
 }
```

parameter

Matching Arguments and Parameters





- The number or arguments and the parameters must be the same
- Arguments and parameters are paired left to right
- The matched pair must be assignment-compatible (e.g. you cannot pass a double argument to a int parameter)

Parameter Passing

- When a method is called:
  - The parameters are created.
  - The values of arguments are copied into the parameters' variables.
  - The variables declared in the method body (called local variables) are created.
  - The method body is executed using the parameters and local variables.
- When the method finishes:
  - Parameters and local variables are destroyed.

Passing Objects to a Method

- As we can pass primitive data type values, we can also pass object references to a method using instance variables.
- Pass an instance variable to a method means passing a reference of an object.
  - It means that the corresponding parameter will be a copy of the reference of this objects.
    - Because the passing parameter mechanism copies the value of the argument (which is an object reference) into the parameter.
  - The argument and its corresponding parameter refer to the same object.
    - The object is not duplicated.
    - There are two instance variables (the argument and the parameter) referring to the same object.

How Private Attributes could be Accessed

- Private attributes are not accessible from outside.
  - Except from objects of the same class.
- They are accessible:
  - From inside: from the object containing the data itself.
  - From objects of the same class.
- They are accessible from outside using accessor operations.
  - Getters
  - Setters

```
class Course {

    // Data Member
    private String studentName;
    private String courseCode ;

}
```

```
public class CourseRegistration {
    public static void main(String[] args) {
        Course course1, course2;
//Create and assign values to course1
        course1 = new Course( );
        course1.courseCode= "CSC112";
        course1.studentName= "Majed AlKebir";

//Create and assign values to course2
        course2 = new Course( );
        course2.courseCode= "CSC107";
        course2.studentName= "Fahd AlAmri";

        System.out.println(course1.studentName + " has the course "+
                                                course1.courseCode);
        System.out.println(course2.studentName + " has the course "+
                                                course2.courseCode);

    }
}
```

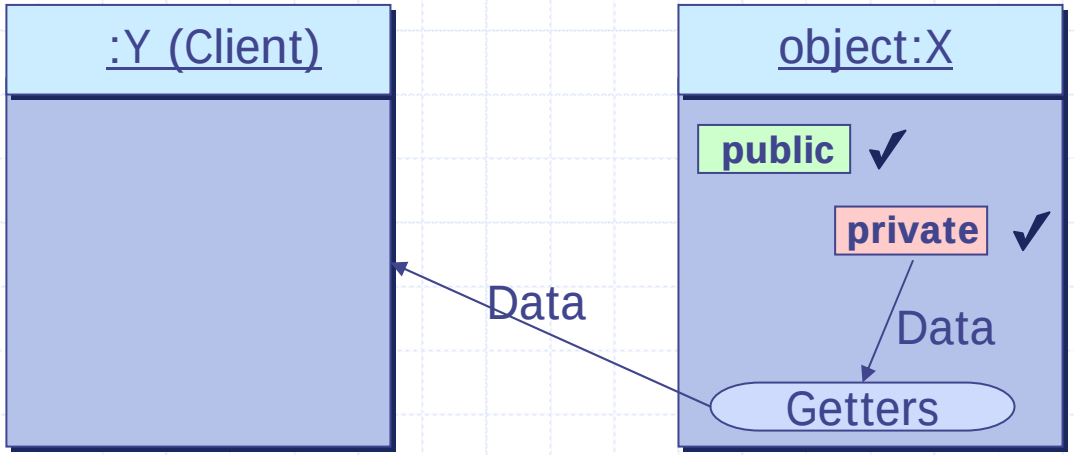
Getters

The object point of view

- Are operations performed by the object returning to outsiders data retrieved from the object state.

The user point of view

- Are services called from outside allowing to retrieve data from the object state.



Getters are:
- Public
- With no parameters
- With return value

Template for Getters

```
public class ClassName {
    private dataType1 attribute1;
    . . .
    private dataTypen attributen;
    . . .

    public dataType1 getAttribute1() {
        return attribute1;
    }
    . . .
    public dataTypen getAttributen() {

        return attributen;
    }
    . . .
 }
```

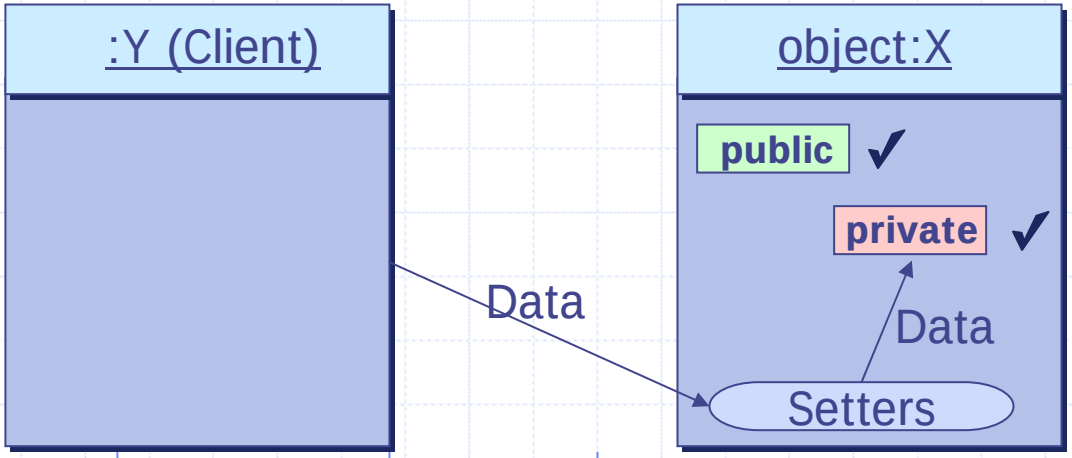
Setters

The object point of view

- Are operations performed by the object allowing to receive and store in the object state the data provided by outsiders.

The user point of view

- Are services used by outsiders allowing to provide to the object the data that should be stored in the object state.



Setters are:
- Public
- With 1 parameter
- With no return value

Template for Setters

```
public class ClassName {
    private dataType1 attribute1;
    . . .
    private dataTypen attributen;
    . . .

    public void setAttribute1(dataType1 param){
        attribute1 = param;
    }
    . . .
    public void setAttributen(dataTypen param) {
        attributen = param;
    }
    . . .
}
```

```
public class Course {

    // Attributes
    private String studentName;
    private String courseCode ;

    ...
    public String getStudentName() {
        return studentName;
    }
    public String getCourseCode() {
        return courseCode;
    }
    ...
    public void setStudentName(String val) {
        studentName = val;
    }
    public void setCourseCode(String val) {
        courseCode = val;
    }

}
```

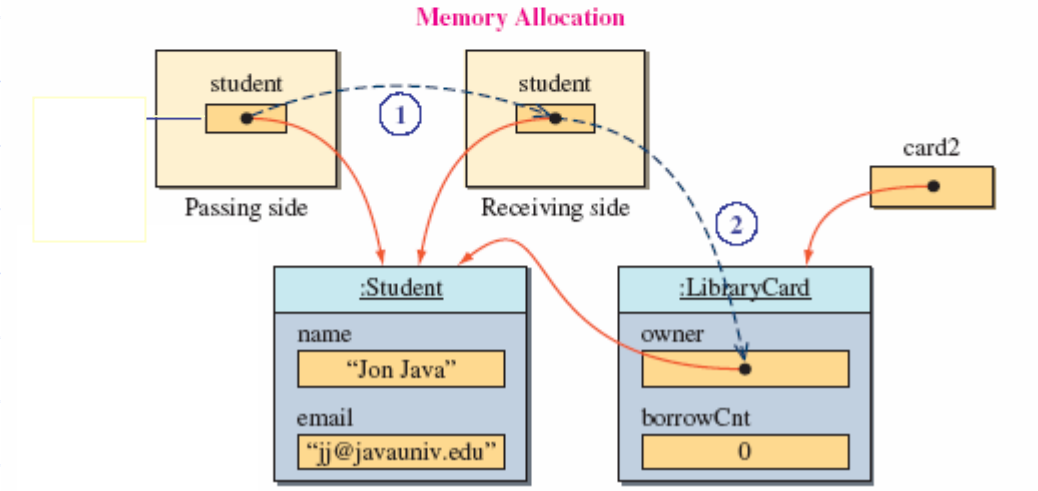
```
public class CourseRegistration {
    public static void main(String[] args) {
        Course course1, course2;
//Create and assign values to course1
        course1 = new Course( );
        course1.setCourseCode("CSC112");
        course1.setStudentName("Majed AlKebir");

//Create and assign values to course2
        course2 = new Course( );
        course2.setCourseCode("CSC107");
        course2.setStudentName("Fahd AlAmri");

        System.out.println(course1.getStudentName() +
                " has the course " +  course1.getCourseCode());
        System.out.println(course2.getStudentName() +
                " has the course " + course2.getCourseCode());

    }
}
```

Passing an Object to a Setter

```
LibraryCard card2;     Passing side

card2 = new LibraryCard( );

card2.setOwner(student);
```

```
class LibraryCard {

 public void setOwner(Student student) {
    owner = student;
 }
}
```

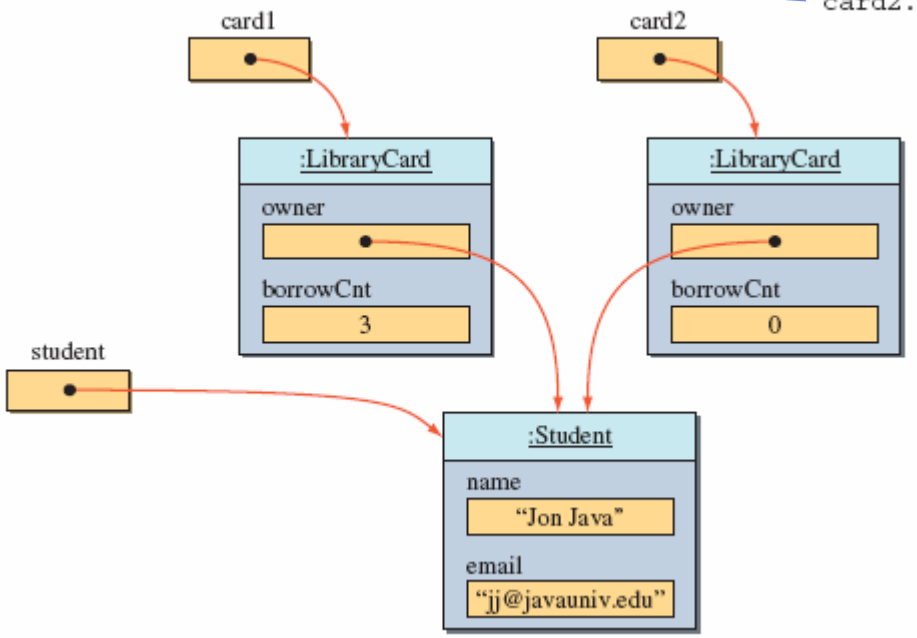
Receiving side



Using Setters and sharing the same Object

- The same Student object reference is passed to card1 and card2 using setters

```
Student     student;
LibraryCard card1, card2;

student = new Student( );
student.setName('Jon Java');
student.setEmail('jj@javauniv.edu");

card1 = new LibraryCard( );
card1.setOwner(student);
card1.checkOut(3);

card2 = new LibraryCard( );
card2.setOwner(student); //the same student is the owner
                         //of the second card, too
```



- Since we are actually passing the same object reference, it results in the owner of two LibraryCard objects referring to the same Student object

Class Constructors

- A class is a blueprint or prototype from which objects of the same type are created.
- Constructors define the initial states of objects when they are created.
  - ***ClassName x = new ClassName();***
- A class contains at least one constructor.
- A class may contain more than one constructor.

The Default Class Constructor

- If no constructors are defined in the class, the default constructor is added by the compiler at compile time.
- The default constructor does not accept parameters and creates objects with empty states.
  - ***ClassName x = new ClassName();***

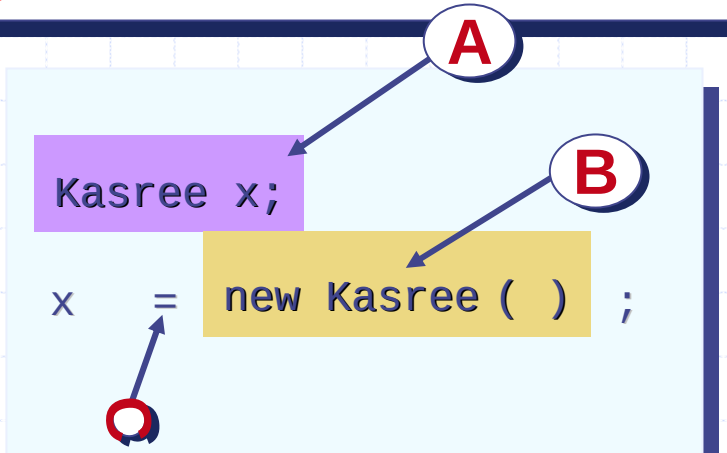
Class Constructors Declaration

```
public  <constructor name>  ( <parameters>  ){
        <constructor body>
}
```

- The ***constructor name***: a constructor has the name of the class .
- The ***parameters*** represent values that will be passed to the constructor for initialize the object state.
- Constructor declarations look like method declarations—except that they use the name of the class and have no return type.

Example of a Constructor with No-Parameter

```
public class Kasree {
    private int bast;
    private int maquam;
    public Kasree() {
        bast = 0; maquam =1;
    }
    . . .
}
```

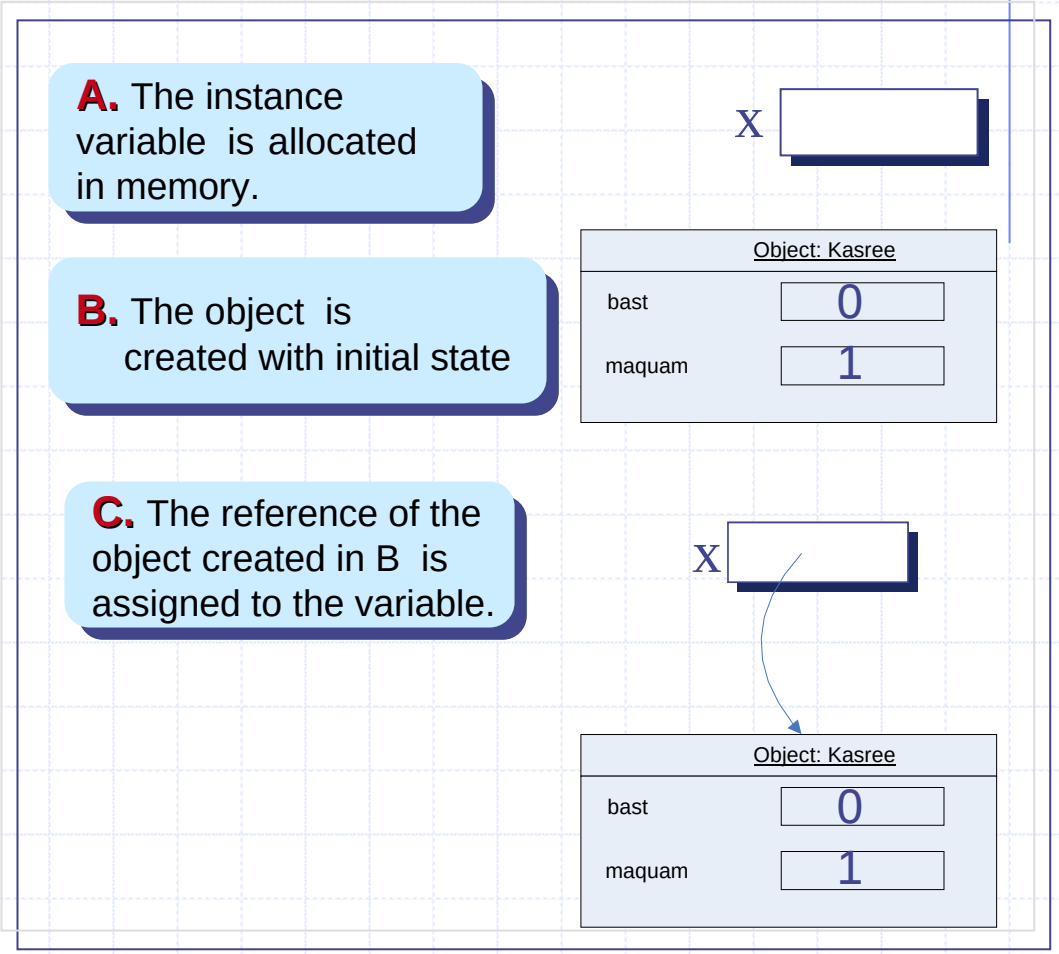


Code

A. The instance variable is allocated in memory.

B. The object is created with initial state

C. The reference of the object created in B is assigned to the variable.



State of Memory

Class with Multiple Constructors

```
public class Kasree {
    private int bast;
    private int maquam;

    public Kasree() {
        bast = 0; maquam =1;
    }
    public Kasree(int a, int b) {
        bast = a;
        if (b != 0) maquam = b;
        else maquam = 1;
    }
    . . .
}
```

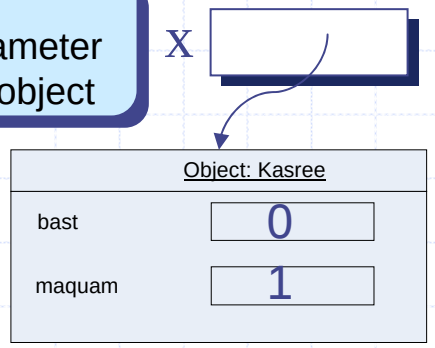
```
Kasree x , y;

x   =  new Kasree()

y   = new Kasree(4, 3);
```

A

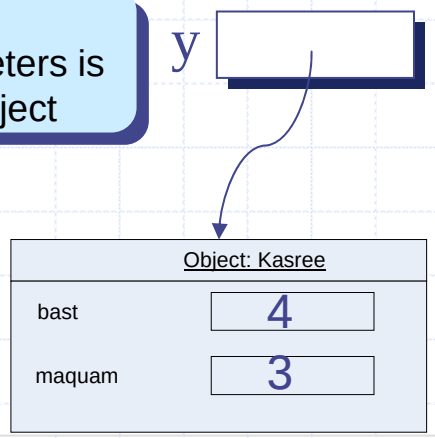
B

Code

A. The constructor declared with no-parameter is used to create the object



B. The constructor declared with parameters is used to create the object



State of Memory

Overloading

- Two of the components of a method declaration comprise the *method signature:*
  - the method's name
  - and the parameter types.
  - The signature of the constructors declared above are:
    - Kasree()
    - Kasree(int, int)
- *overloading* methods allows implementing different versions of the same method with different *method signatures*.
  - This means that methods within a class can have the same name if they have different parameter lists.

Overloading (cont.)

- Overloaded methods are differentiated by:
  - the number,
  - and the type of the arguments passed into the method.
- You cannot declare more than one method with:
  - the same name,
  - and the same number and type of parameters.
- The compiler does not consider return type when differentiating methods.
  - No declaration of two methods having the same signature even if they have a different return type.