



Java Arrays, Objects, Methods

Course Topics

Elements of the Java Platform

The Java Language

► *Java Arrays, Objects, Methods*

Java's Object Orientation and I/O

Interfaces, Graphical User Interfaces, and Applets

Topics this week:

- Last Week
- Last Week - Control Flow - Branching
- Control Flow - Loops
- Creating Multiple Student Objects
- Java Objects
- References to and Creating Objects
- Creating collections of objects
- What is an "array"?
- Arrays
- Creating an array
- Arrays Can Be Made of Any Type or Class
- Array Manipulation
- Saving Multiple Student Objects
- Objects - Instances of classes
- Java Methods
- Introduction to Inheritance
- Inheritance Example
- Assignment for next time

- Minimal Employee class



Java Arrays, Objects, Methods

Last Week

The Java Language:

The syntax and constructs for writing Java code

The Java Platform

Java Program (application, applet, servlet) bytecode
Java Application Programming Interface (standard packages; also bytecode)
Java Virtual Machine (executes bytecode)
Hardware, e.g., your PC, OSF1, workstations, rings, ...

Primitive Data Types

- byte
- short
- int
- long
- double
- float
- char
- boolean

String is a built-in Object type, not a Primitive

User Defined Objects

Creating and initializing *instances* of classes



Last Week - Control Flow - Branching

"if" statements

```
if (expression that evaluates to a boolean result) {
    // Perform the enclosed statements if true
    ...
}
else {
    // Perform the enclosed statements if not true
    ...
}
```

"switch" statements

```
switch (expression that results in an integer value) {
case 42: // or whatever a possible value of expression is
    ...
    break;
case 39: // or whatever another possible value is
    ...
    break;
...
default: // (optional) catch all other values
    ...
    break;
}
```



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Control Flow - Loops

"for" loops

Perform group of statements *for* a number of times

```
for (initialization ; expression that evaluates to boolean ; increment) {  
    // Code that executes each time through the loop ...  
}
```

"while" loops

Perform group of statements *while* a condition is satisfied

```
while (expression that evaluates to boolean ) {  
    // Code that executes each time through the loop ...  
}
```

"do ... while" loops

Perform group of statements *while* a condition is satisfied

```
do {  
    // Code that executes each time through the loop ...  
} while (expression that evaluates to boolean );
```

Question: *How is while different from do ... while*



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Creating Multiple Student Objects

```

/** Encapsulate information relating to a single student.
** @author: Jonathan Doughty
**/

public class StudentGroup {

    public static void main(String[] args) {
        if ((args.length == 0) || (args.length % 2) != 0) {
            System.out.println("usage java StudentGroup [student names]");
        }
        else {
            StudentGroup.makeSomeStudents(args);
        }
    }

    public static void makeSomeStudents(String[] arguments) {

        CSStudent aStudent;
        int nextId = 0;

        for (int arg = 0; arg < arguments.length; arg++) {

            // Each time through the loop a new CSStudent object is
            // created and its reference is assigned to the aStudent
            // field.

            String name = arguments[arg];
            String id = String.valueOf(nextId);
            nextId++;

            aStudent = new CSStudent( name, id);
            aStudent.setGrade(100);

            // Ask each Student to identify itself
            System.out.println(aStudent);
        }

        // Question: Do any of the CSStudent objects created still
        // exist?
    }
}

```



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Java Objects

Classes

***Definition:** A class is a blueprint or prototype that defines the variables and methods common to all objects of a certain kind.*

from: *The Java Tutorial*, Campione & Walrath, 1998

Objects - Instances of classes

***Definition:** An object is a software bundle of variables (fields) and related methods.*

from: *The Java Tutorial*, Campione & Walrath, 1998

Objects *instantiate* classes

Objects are created (via **new**) from the template that a class defines.

Question: *Why define classes and create object types?*



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References to and Creating Objects

Primitives come into existence by declaring them

```
int     count;  
float   distance;  
boolean guilty;  
char    letter;
```

Declaring an Object type establishes space for an Object *reference*

But does not, by itself, create the object itself.

Objects must be declared and then *instantiated*

Creating (Instantiating) and Using Objects

```
Insect bug;    // declare name for Insect reference  
bug = new Insect(); // create and save the instance
```



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Creating collections of objects

Several ways to create a group of objects, all of the same type:

Individual instance variables:

```
Student aStudent;  
Student anotherStudent;  
Student yetAnotherStudent;  
...  
aStudent = new Student();  
aStudent.setName("Fred Flintstone");  
anotherStudent = new Student();  
anotherStudent.setName("Wilma Flintstone");  
yetAnotherStudent = new Student();  
yetAnotherStudent.setName("Barney Rubble");
```

Arrays

To be discussed in a few minutes

One of Java's "Collections" classes

```
java.util.Vector;  
java.util.Hashtable;  
java.util.LinkedList;  
java.util.HashMap;  
java.util.ArrayList;
```

We won't be covering the Collection classes in this course.



Java Arrays, Objects, Methods

What is an "array"?

A graphic representation

A variable (field, reference)



```
int    answer;  
CSStudent aStudent;
```

An array



```
int[] answers = new int[4];  
CSStudent[] someStudents = new CSStudent[4];
```



Java Arrays, Objects, Methods

Arrays

Arrays themselves are *objects* in Java

Even arrays of primitive data types.

```
int intArray[];

intArray = new int[4];

float[] fnumbers = new float[8];

CSStudent studentArray[] = new CSStudent[10];
```

Note the last declaration and instantiation of an *array* of CSStudent objects

Note that array declarations use [], not ()

Question: *How many CSStudent objects are created by the declaration?*

Since arrays are *objects* they inherit all the characteristics of *java.lang.Object*

All array objects also have some other characteristics; i.e., each array has an associated field named length.

Notice it is a field named *length*, unlike the instance method named *length()* associated with String objects.



Java Arrays, Objects, Methods

Creating an array

... is like creating an object from a class:

- declaration - assigns a name to the reference
- instantiation - creates space for the object
- initialization - gives the objects values for the first time

Arrays of primitive data types are initialized to 0

```
int[] grades;  
  
grades = new int[60];
```

Arrays of Objects are initialized to **null**

```
Student[] students;  
  
students = new Student[60];
```

The *students* array has been declared and instantiated, but not yet initialized: no Student object references have been assigned to the array elements.

To initialize the array elements, you need to *instantiate* each individually:

```
for (int nextStudent = 0; nextStudent < 10; nextStudent++ ) {  
    students[nextStudent] = new CSStudent();  
}
```



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Arrays Can Be Made of Any Type or Class

"Declaring a variable of array type does not create an array object or allocate any space for array components. It creates only the variable itself, which can contain a reference to an array."

from: *Java Language Specification*, Gosling, Joy, and Steel, 1996

- Arrays are created (instantiated) with **new**, just like other objects.
- Once an array is created, its length never changes.

Question: *Any idea why?*

Examples

```
int[] intArray = new int[4]; // elements initially set to 0

CreditCard cards[] = new CreditCard[MAXCARDS];
    // elements initially set to null
    // notice the [] can be placed with the field name
    // or the type; though the latter is "better"
```

*Tip: If you need a collection's size to change consider using **java.util.Vector** or another collection class instead of arrays*



Java Arrays, Objects, Methods

ArrayExample.java

```

/** An Example of some array manipulation
**/

public class ArrayExample {

    public static void main (String args[]) {

        int numberOfElements = 0;
        if (args.length > 0) {
            // Use value from command line
            numberOfElements = Integer.parseInt(args[0]);
        }

        ArrayExample anExample = new ArrayExample();

        anExample.initializeArray(numberOfElements);

        // Notice that method calls can be included in other method
        // calls: in this case, returning primitive values that will
        // be converted to String objects.

        System.out.println("sum = " + anExample.Sum() +
            " average = " + anExample.Average() );
    }

    private int[] intArray; // all instance (non static) methods
                           // have access to this 'instance' variable

    /** Initialize the array (which will be made big enough to hold
        size entries) contents with some numbers */
    public void initializeArray(int size) {

        intArray = new int[size];

        int startValue = size * 3;           // pick any number

        for (int i = 0; i < intArray.length; i++) {
            intArray[i] = startValue; // put current number in next slot
            startValue = startValue - 2; // and calculate next number
        }
    }

    /** Calculate the sum of the array contents */
    public long Sum() {
        int index;
        int arrayLen;
        long sum = 0;

        // All arrays have a length field that specifies how many
        // elements the array contains

        arrayLen = intArray.length;

        // Calculate the sum the values in all array elements

        for (index = 0; index < arrayLen; index++) {
            sum += intArray[index];
        }
        return sum;
    }

    /** Calculate the average of the array contents */
    public double Average() {

        // Notice that Average calls Sum() to total the values in the
        // array, rather than duplicating that calculation here. What
        // is going on with the "(double)" ?

        double average = (double) Sum() / intArray.length;
        return average;
    }
}

```



Java Arrays, Objects, Methods

Array Manipulation

In class example of some array manipulation

Write a Java class named Arrays.java. This class should have the following methods.

1. `public void listArgs(String [] args)`
To list out the arguments in an array of Strings
2. `public long product(int [] intArray)`
To compute the product of the integers in the array `intArray`
3. `public static void main(String[] args)`
Should have the following code:

```
if (args.length == 0) {
    System.out.println("usage: Arrays [integers]");
}
else {
    Arrays inst = new Arrays();
    inst.listArgs(args);

    int input[] = new int[args.length];
    for (int i = 0; i < args.length; i++) {
        input[i] = Integer.parseInt(args[i]);
    }
    System.out.print("product = ");
    long answer = inst.product(input);
    System.out.println(answer);
}
```



Java Arrays, Objects, Methods

Saving Multiple Student Objects

Also demonstrates one class using instances of another

```

/** A class that will make use of another class.
**/
public class CSClass {

    public static void main(String[] args) {
        if (args.length == 0) {
            System.out.println("usage java CSClass [student names]");
        }
        else {
            int numberOfStudents = args.length;
            CSClass cs161 = new CSClass( numberOfStudents );
            cs161.enroll( args );
            cs161.assignLabPartners();
            cs161.listRoster();
        }
    }

    // Instance fields
    CSStudent students[] = null;
    int last = 0;

    public CSClass( int number ) {
        students = new CSStudent[ number ];
    }

    public void enroll(String[] names) {
        int numberOfStudents = names.length;
        int id = 0;

        for (int arg = 0; arg < numberOfStudents; arg++) {

            String name = names[arg];

            id++; // assign next id
            String idString = String.valueOf(id); // as a String

            CSStudent aStudent = new CSStudent( name, idString);

            aStudent.setGrade(100);

            // save the reference to the current student in the next array slot
            students[last] = aStudent;
            last++;
        }
    }

    public void assignLabPartners() {

        // Assign every other pair of students as lab partners
        int next = 0;
        int pairs = last / 2;
        while (pairs > 0) {
            students[next].setLabPartner( students[next+1] );
            students[next+1].setLabPartner( students[next] );
            next += 2;
            pairs--;
        }

        // If there were an odd number of students in the array the
        // last one won't have a lab partner.
    }

    public void listRoster() {
        for (int i = last - 1; i >= 0; i--) {
            // Ask each Student to identify itself, last to first
            System.out.println(students[i]);
        }
    }
}

```

And the complete `CSStudent.java` that's been used in preceding examples

```

/** Encapsulate information relating to a single student.
** @author: Jonathan Doughty
**/

public class CSStudent {

    // Instance variables (fields) that will be associated with
    // each student

    private String GMU_Id;
    private String name;
    private int homeworkGrade;
    private CSStudent labPartner;

    // Constructors for the class

    private CSStudent() { // why do you think this is?
    }

    public CSStudent( String name, String id ) {
        this.name = name;
        GMU_Id = id;
    }

    // An accessor method to set the Student's name field; not
    // needed any more but left in because a student's name could
    // change.
    public void setName( String studentName ) {
        name = studentName;
    }

    // An accessor method to return this Student's name
    public String getName() {
        return name;
    }

    // An accessor method to set the Student's GMU_Id field (probably
    // no longer necessary)
    public void setId( String id ) {
        GMU_Id = id;
    }

    // An accessor method to set the Student's homeworkGrade field
    public void setGrade( int grade ) {
        homeworkGrade = grade;
    }

    // An accessor method to assign this Student's lab partner
    public void setLabPartner( CSStudent s ) {
        labPartner = s;
    }

    // Using the toString method to enable an instance of an
    // object to identify itself usefully.
    public String toString() {

        // Since I'm going to be returning a String made up of various
        // pieces, I build up those pieces in a StringBuffer.

        StringBuffer sb = new StringBuffer();
        sb.append(name);
        sb.append(" Id# ");
        sb.append(GMU_Id);
        if (labPartner != null) {
            // Notice I don't just use labPartner.toString(). If I did
            // I would create an infinite loop: each lab partner calls
            // its lab partner's toString() which calls its lab
            // partner's toString() ... Instead, I just get and append
            // the lab partner's name.
            sb.append(" lab partner=");
            sb.append( labPartner.getName());
        }
        return sb.toString();
    }
}

```



Java Arrays, Objects, Methods

Objects - Instances of classes

Definition: An object is a software bundle of fields and related methods.

- Notice how each Student object in the previous examples had a name, an id value, a grade, and in the last example, an associated lab partner (another Student.)
- Each Student also had some methods that could be "called on" an instance of the Student class: e.g., setGrade(), setLabPartner()



Java Arrays, Objects, Methods

Java Methods

There are two categories of methods you can write in Java:

Class Methods

- Methods that are associated with a class.
- They are typically "convenience" or utility methods.
- Qualifying a method with the keyword **static** is what makes a method a class method.

In the earlier Student examples,

```
public static void makeSomeStudents( ... )
```

were all *Class* methods.

Instance Methods

- Methods that are associated with the instances of a class, objects of the class data type.
- They are used to ask an object to do something, e.g., assign itself a value, perform some operation, return some internal information, identify itself, etc.

In the Student and CSCClass examples, methods such as

```
public void setGrade( ... )  
public void getName( ... )  
public void listRoster()  
public String toString( ... )
```

were all *instance* methods.



Java Arrays, Objects, Methods

Introduction to Inheritance

You say one class **extends** another when you want to *re-use* most of the capabilities of a class, but want to add some additional capabilities, over-ride some, or provide other specialization.



Inheritance Example

```
/** encapsulate the characteristics of a Grad student
** @author: Jonathan Doughty
**/

public class CSGradStudent extends CSStudent {

    private static final int MAX = 100;
    private CSStudent [] taFor;
    private int nextStudent = 0;

    // A constructor that will create student objects with specified name and id
    public CSGradStudent( String studentName, String id) {
        super(studentName, id);
        taFor = new CSStudent[MAX];
    }

    // Other methods here unique to CSGradStudents

    public void writeThesis() {
        // mumble
    }

    public String toString() {
        StringBuffer result = new StringBuffer("CSGradStudent ");
        result.append( super.toString() );
        if (nextStudent > 0) {
            result.append("TA for:\n");
            for (int i = 0; i < nextStudent; i++) {
                result.append( taFor[i].getName());
                result.append("\n");
            }
        }
        return result.toString();
    }
}
```



Java Arrays, Objects, Methods

Assignment for next time

Reading

- Chapter 6 - Inheritance - through the section "Constructors in Derived Classes" that ends on page 301 (you may skip the remainder of Chapter 6)
- Chapter 9 - Streams and File I/O - Up to but not including the Programming Example that starts at the bottom of page 495.

Homework

Goal:

- Write a second Java class and use the two classes written so far, this week's uses last's.

Purpose:

- Learn about instances of classes and storing them in an array. on them.
- To start building solutions from smaller pieces: Java classes; to get those pieces to interact.

For this assignment you will write a Java class named Boss. This class will make use of the Employee class created last week. If you have not completed that assignment yet, you may use the minimal version on the next page to do this week's assignment.

- Your Boss class should have the following *instance* variables:
 - a bossName

- an *array* named `employees` in which to store `Employee` objects
- an `int` field named `count` to store the number of `Employees` who the `Boss` has.
- Write methods with the following signatures
 - a main method to start things off with the signature:

```
public static void main (String [] args)
```

see below for what main should do.

- a public constructor for the class that will insure that `Boss` objects always have a `name` field with the signature.

```
public Boss( String name )
```

This constructor should also instantiate an array to store `Employee` objects (at least 60) and initialize the count of employee's to 0. It should *not* initialize the array contents; just create the array.

- a method to add an `Employee` object to the array of `Employees` with the signature

```
public void hire( Employee emp )
```

This method should increase the count of `Employees` associated with the `Boss` as each `Employee` is added.

- a method that will cause the `Boss` to hire a group of people. This method should have the signature

```
public void staffUp()
```

This method should create a number of `Employee` objects (at least 5) and then use the `hire` method to add them to the boss. You may use any names and id values you choose. One way to initialize a group of names to use would be to get them from an array that is initialized like:

```
String [] names = {"John", "Paul", "George", "Ringo", "Fred" };
```

You may use these names or any of your choosing and any technique of your choosing to give each Employee a different name as an input parameter for your Employee constructor. Use any id values you choose.

- a method to print out the Boss name followed by the names of the Employees who are managed by a Boss *in an order different than they were added*. This method should have the signature

```
public void list()
```

- The main method for this class should:
 1. create a single instance of the Boss class,
 2. call the staffUp method on the Boss object
 3. call the list method on the Boss object

Do only what is asked above. Do not add any extra code to prompt for input or otherwise add capabilities not asked for. Be sure to create methods with the signatures requested. Output similar to the following is all the Boss class needs to produce:

```
Boss Bruce:  
Fred  
Ringo  
George  
Paul  
John
```

Hint: To start, create the outline of your class definition by defining empty methods with the signatures listed above. Compile it to be sure the outline is in the right form. Then go back and start filling in the details of each method. Compile often so you can correct errors easily.



Java Arrays, Objects, Methods

Minimal Employee class

The following is a minimal Employee class that you may use to do this week's assignment to write a Boss class. This does not fulfill all the requirements of last week's assignment

```
/** A minimal Employee class to support doing the homework that  
** requires you to write a Department class.  
**/  
public class Employee1 {  
  
    private String empName;  
    private String empId;  
  
    public Employee1(String name, String id) {  
        empName = name;  
        empId = id;  
    }  
  
    public String getName() {  
        return empName;  
    }  
}
```