Computer Science II

Data Structures

Instructor

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Office hours: 10:30 AM – 12:00 PM

Mondays and Fridays

Course Webpage

homepage.cs.uiowa.edu/~ghosh/2116.html

Course Syllabus

- Constructs in Java, the language we will use
- Algorithm complexity and Big-O notation
- Arrays, Linked lists
- Solving problems using recursion
- Stacks, queues, lists and trees
- Searching and sorting
- Priority queues, hash tables, binary search trees
- Graphs and basic algorithms on graphs

Teaching Assistants

- Kyle Diederich
- Adrian Pereira
- Thamer Alsulaiman
- Dhuv Vyas

About this course

Main class (AAA) and six sections A01-A06

Discussion sections meet on Thursdays only.

You must go to your own section.

Textbook

Goodrich, Tamassia, and Goldwasser: *Data Structures and Algorithms in Java* (Sixth edition), Wiley, ISBN 978-1-118-77133-4.

Prerequisites

Computer Science I (CS: 1210 / 22C:016/ ENGR 2730)

(Note: CS 2210: Discrete Structures is a corequisite, if not taken as a prerequisite earlier)

Grading

Eight Home assignments (30%)

Two quizzes (2x5%= 10%)

Two in-class midterms (2x20%=40%), and

(Monday, Sep 26 and on **Monday, Oct 31**)

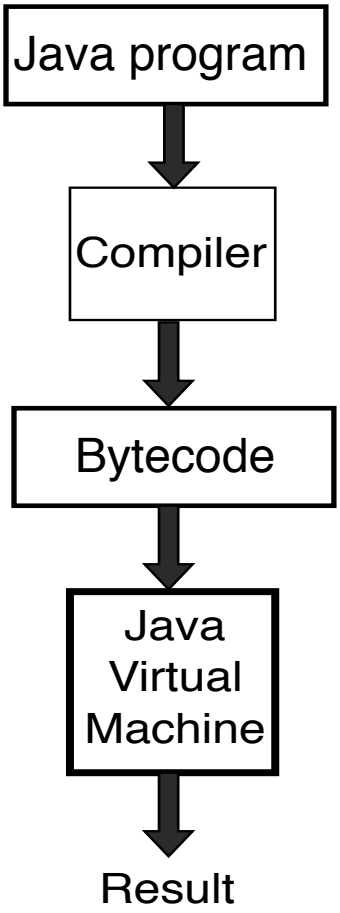
One Final exam (20 %)

Limited collaboration is OK, assuming you have first spent some time (about 60 minutes) working on the problem yourself. However, your solution should not be a copy (whole or in part) of a fellow student.

Late Homework Policy

Q*uota of two days* for the entire semester

How Java works



Which IDE will we use?

We will use **NetBeans.**

You can download it on your machines.

They are installed in all lab machines. WE will demonstrate it today in the class.

Object-oriented programming

An Object is a repository of data

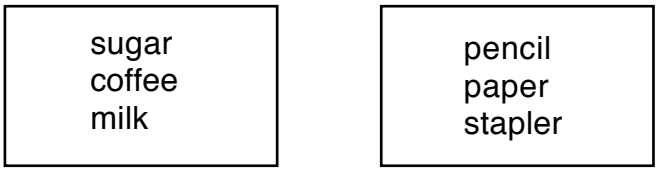
Typed data. Always declare before you use.

Primitive types. int, char, boolean, float etc

Class. A **template** for **creating objects**

Think of **shoppingList** as a class. We can define two objects for this class.

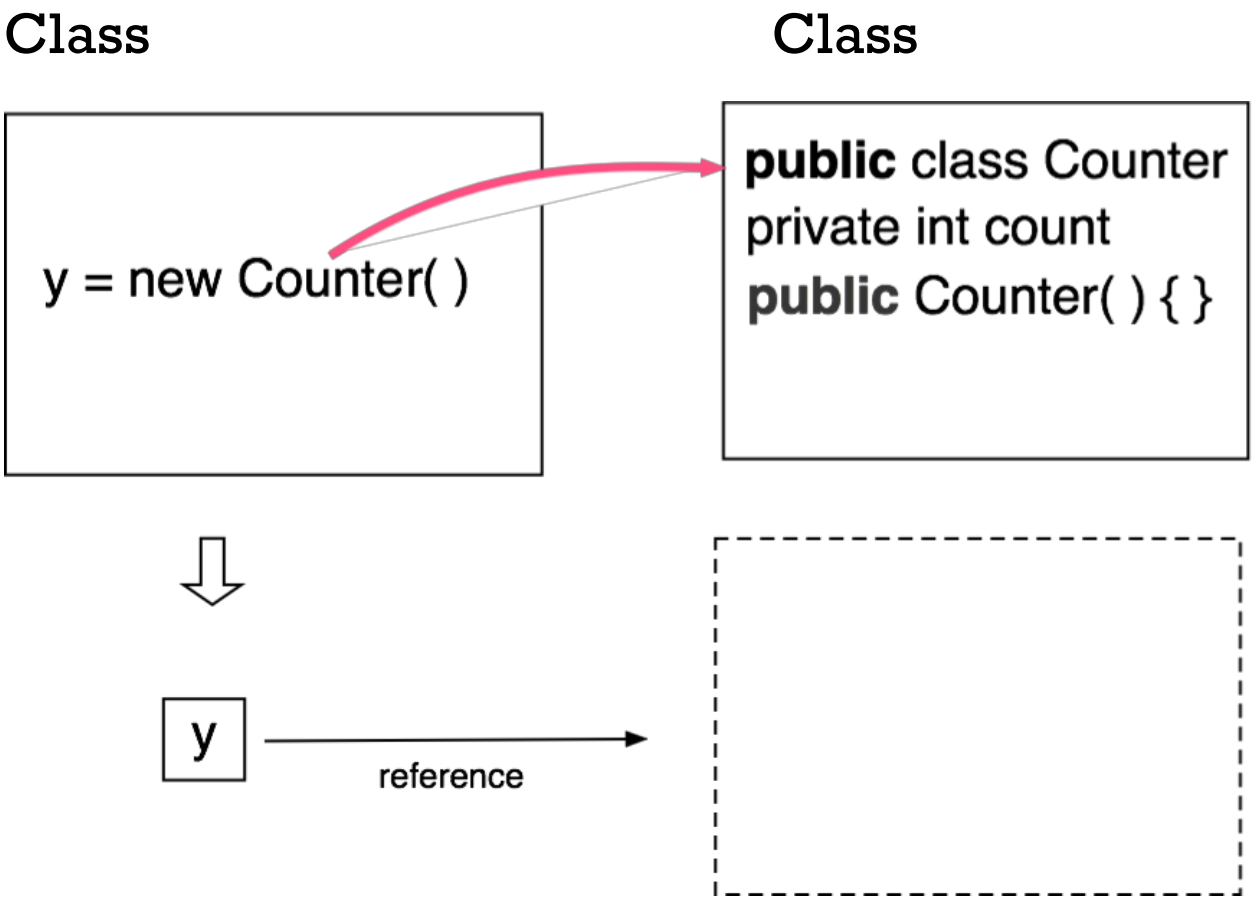
Example:



myList yourList

Object *myList* belongs to the **Class ShoppingList.**

A Class denotes the type of object


Class
Class
y = new Counter( )
public class Counter
private int count
public Counter( ) { }
y
reference

```
Class Human{
Public int age;
Public String name;
Public void introduce() {
System.out.println(“I’m” + name + “and I’m”
+ age  +  “ years old”)
 }
}
```

Now, continue as

```
Human Alice = new Human();// Create Alice
Alice.age = 21;        // Set Alice’s fields
Alice.name = “Alice”;
Alice.introduce( );
```

Structure of a Java program

```
public class MyFirstJavaProgram {
public static void main(String []args) {
System.out.println("Hello World");
    }
}
```

Class = blueprint of an object
Class name starts with a capital letter

Object = instance of a class, created using a constructor

Instance variables = Unique set of variables for an object

Methods = Actions to manipulate data
Method name starts with lower case letters

Program file name = Must exactly match the class name. Saved as *filename*.java

Package = a group of related class definitions

What are public, private, protected?

These are Access Control Modifiers.

Private: Visible to the class only

Public: Visible to the world

No modifier: Visible to the package, the default

Protected: Visible to the package and all subclasses

Access Control

Modifier	*Same class*	*Same package*	*Subclass*	*Universe*
`private`	✓			
default	✓	✓		
`protected`	✓	✓	✓	
`public`	✓	✓	✓	✓

Organization of a class

1. Constants
2. Instance variables
3. Constructors
4. Methods

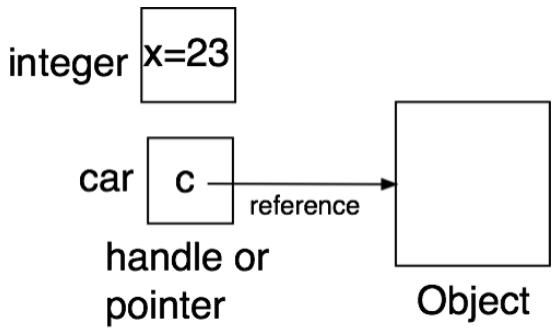
```
public class Counter {
  private int count;                                  // a simple integer instance variable
  public Counter( ) { }                               // default constructor (count is 0)
  public Counter(int initial) { count = initial; }          // an alternate constructor
  public int getCount( ) { return count; }                   // an accessor method
  public void increment( ) { count++; }                       // an update method
  public void increment(int delta) { count += delta; }        // an update method
  public void reset( ) { count = 0; }                         // an update method
}
```

More on Types

Primitive types. Integer, Boolean, character etc

Boolean	"true" or "false"	
Char	A character (like 's')	
Byte	8-bit integer	-128 to +127
Short	16-bit integer	-32768 to + 32767
Int	32-bit integer	
Long	64-bit integer	
Float	32-bit floating-point number	
Double	32-bit floating-point number	

Reference variables. A variable whose **type** is a **class** is called a reference variable.



c = new Car( )

myList = new ShoppingList( )

Method

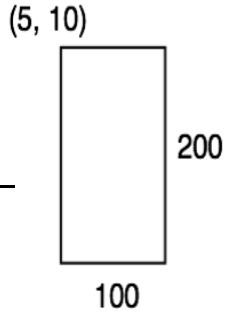
A **Method** is a procedure or a function that operates on an object to produce a result.

An ***accessor method*** returns a value. An ***update method*** only makes changes in the fields, but no value (void) is returned.

Objects are manipulated by methods.

Consider a Rectangle class, and an object R belonging to this class

```
Rectangle R;
R = new Rectangle(5,-10,100,200);
int w = R.getWidth(); // This is OK
```



In the above example, **getWidth** is a method that returns the width of the rectangle.

Note. If you write

```
Rectangle R;
int w = R . getWidth(); // This is wrong!
```

It will not work since R is just the name of a handle. The object has not been created yet.

Static modifier (of a method or a variable)

The value is associated with the entire class, and not to a particular instance of it)

Abstract method

Contains only the signature but no body

Final method

Attributed to a variable that does not change.

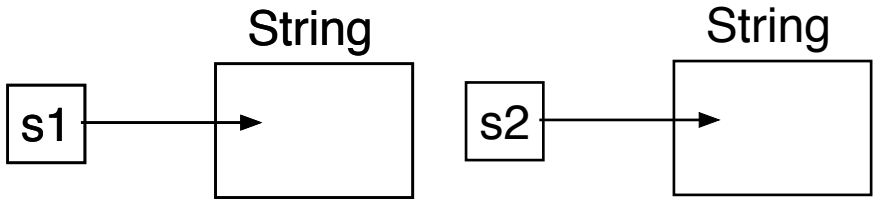
A final method cannot be overridden by a subclass.

Objects and Methods

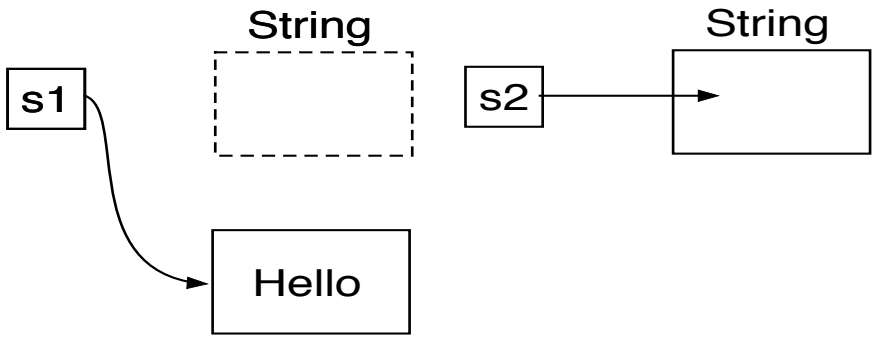
Let us start with strings (sequence of characters).

Constructors are used to initialize a new object or a variable, and always use the name of the class.

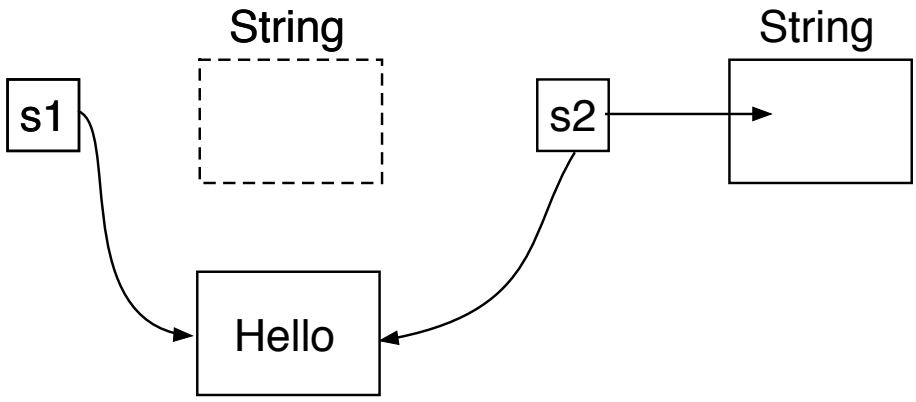
```
String s1;                  // Declare a string variable
s1 = new String ( );        //Assign a value, an empty string
String s2 = new String ( ); // Short cut
```




```
s1 = "Hello";       //See below
```



s2 = s1; // See below, both point to the same string



So, how to make a separate string s2 with "Hello"?

s2 = **new** String (s1); or

s2 = "Hello";

Java strings are immutable objects, so instead of modifying a string create a new one. Let us look at a method:

```
s2 = s1.toUppecase( )// toUppercase is a method
// Here, s2 will be a new string "HELLO"
String s3 = s2. concat("!") // s3 = s2 +"!"
```

That is, s3 becomes a new string “HELLO!”

Java will also allow

s2 = s2 + ‘!’ // Now s2 = “HELLO!”

But it involves copying the old string and adding ‘!’ to it to generate a new string, and then switch the reference from s the handle s2. It is inefficient for long strings.

The **StringBuilder** class allows efficient editing of strings, and in essence creates a mutable string. We will discuss it later.

Arrays

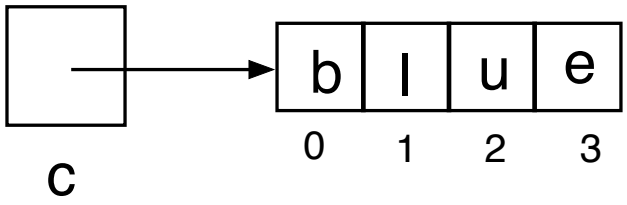
Consists of a numbered list of variables. An array variable is a reference variable. So

```
int[ ] X;
```

Is only a declaration, and no allocation is made. To construct an array by allocation space in the memory, use the new operator

```
int[ ]  X  =  new int[8]
```

and then initialize it.

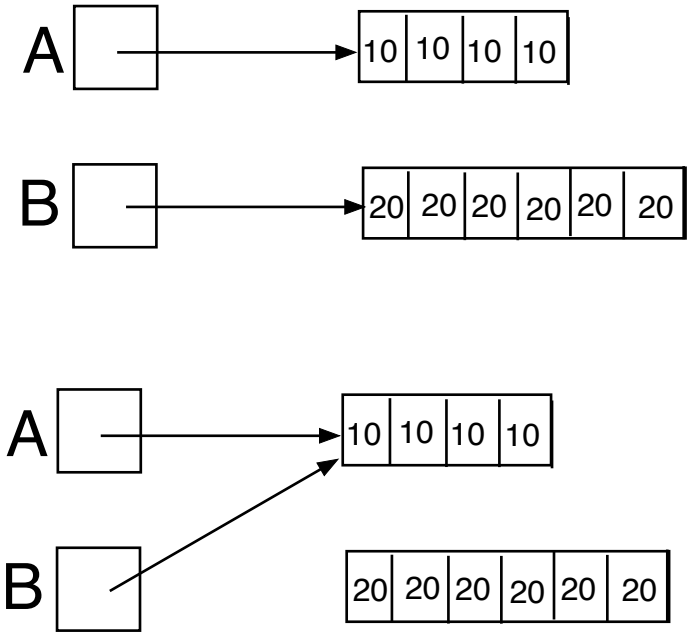



```
char [ ] c; // Creates an array of char
c = new char[4] // Creates array of size 4
c[0] = 'b';
c[1] = 'l';
c[2] = 'u'
c[3] = 'e'
```

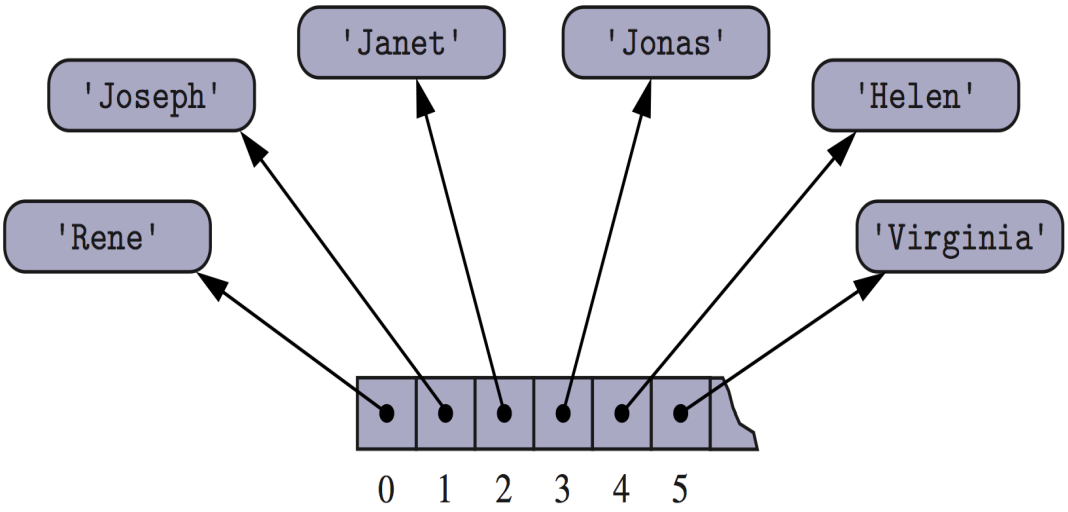
An array is an **immutable object**. The first index is always zero (not 1).

```
int[] A = new int[4] ;
int[] B = new int[6] ;
for (int i = 0 ; i < A.length ; i++) A[i] = 10 ;
for (int i = 0 ; i < B.length ; i++) B[i] = 20 ;
B = A; // what happens here? See below.
```

{Note: `A.length` gives the length of the array A}



An array can also contain reference to objects.




```
string[ ]  X  =    new string[6]

string[0] = Rene

string[1] = joseph
```

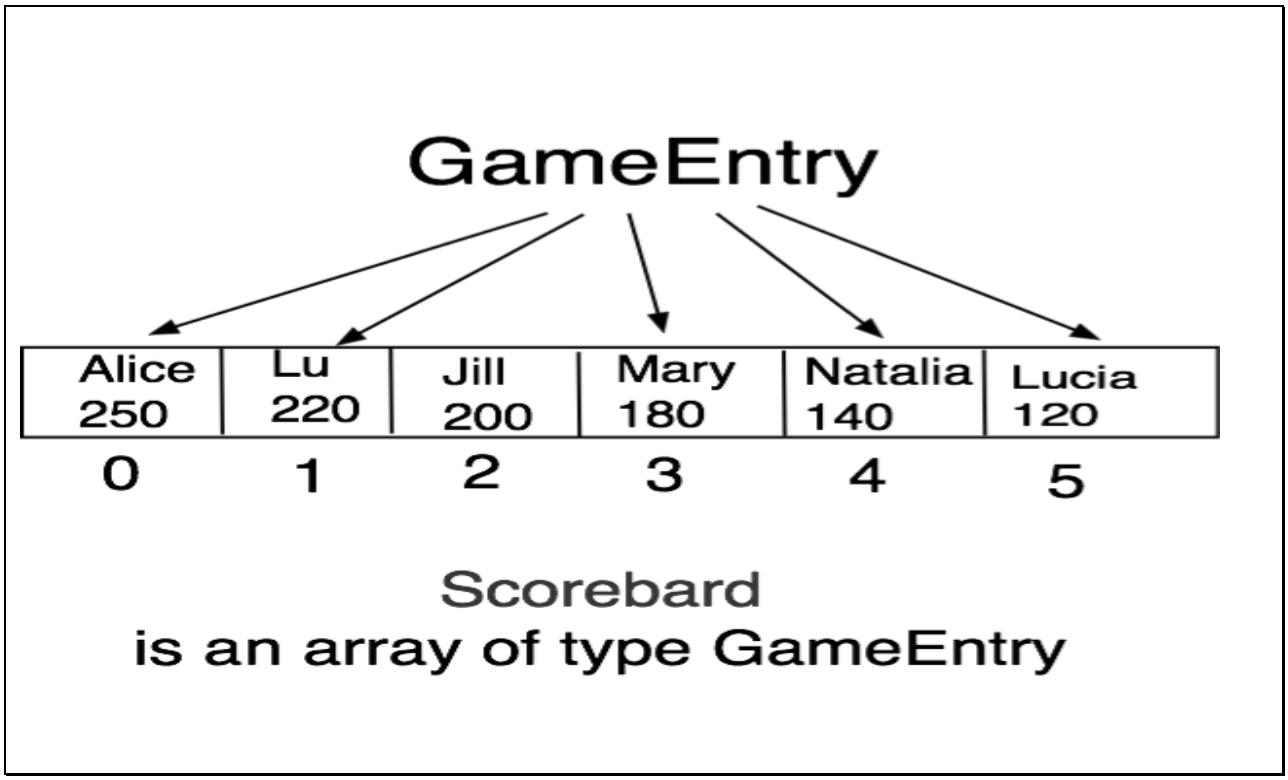
Multidimensional Arrays

```
int[][] myMatrix = new int[8][10] ;
```

Java will treat this as an array of arrays. So, myMatrix[7] will denote the seventh row of the (8x10) matrix.

```
class MultiDimArrayDemo {
      public static void main(String[] args) {
      String[][] names = {
            {"Mr. ", "Mrs. ", "Ms. "},
            {"Smith", "Jones", “Ford”}
      };
      // Mr. Smith
      System.out.println(names[0][0] + names[1][0]);
      // Ms. Jones
      System.out.println(names[0][2] + names[1][1]);
      // Mrs. Ford
      System.out.println(names[0][1] + names[1][2]);
      }
}
```

Example: Game entries



In an event in the Rio Olympics, we want to record the best six scores, sorted in the non-decreasing, and save them in an array.

Each array element is a **GameEntry** that consists of a pair: **name** and **score.**

Here is the GameEntry class.

```
1  public class GameEntry {
2    private String name;                          // name of the person earning tl
3    private int score;                            // the score value
4    /** Constructs a game entry with given parameters.. */
5    public GameEntry(String n, int s) {
6      name = n;
7      score = s;
8    }
9    /** Returns the name field. */
10   public String getName( ) { return name; }
11   /** Returns the score field. */
12   public int getScore( ) { return score; }
13   /** Returns a string representation of this entry. */
14   public String toString( ) {
15     return "(" + name + ",  " + score + ")";
16   }
17 }
```

Here is the Scoreboard class.

```
1   /** Class for storing high scores in an array in nondecreasing order. */
2   public class Scoreboard {
3     private int numEntries = 0;                  // number of actual entries
4     private GameEntry[ ] board;                  // array of game entries (names & sc
5     /** Constructs an empty scoreboard with the given capacity for storing entries.
6     public Scoreboard(int capacity) {
7       board = new GameEntry[capacity];
8     }
...     // more methods will go here
36  }
```

Think of how to update the scoreboard when a new score (Tammy 170) or (Hillary, 100) is recorded.