CMSC 202H

ArrayList, Multidimensional Arrays

What's an Array List

- **`ArrayList`** is
  - a class in the standard Java libraries that can hold any type of object
  - an object that can grow and shrink while your program is running (unlike arrays, which have a fixed length once they have been created)
- In general, an **`ArrayList`** serves the same purpose as an array, except that an **`ArrayList`** can change length while the program is running

The `ArrayList` Class

- The class `ArrayList` is implemented using an array as a private instance variable
  - When this hidden array is full, a new larger hidden array is created and the data is transferred to this new array

Using the **`ArrayList`** Class

- In order to make use of the **`ArrayList`** class, it must first be imported

```
import java.util.ArrayList;
```

- An **`ArrayList`** is created and named in the same way as object of any class:

```
ArrayList aList = new ArrayList();
```

(Note that what we are teaching here is an obsolete, simplified form of ArrayList you can use *for now;* for documentation, see: http://download.oracle.com/javase/1.4.2/docs/api/java/util/ArrayList.html. Later, we will learn the proper form, after covering Generics.)

Adding elements to an `ArrayList`

- The `add` method is used to add an element at the "end" of an `ArrayList`

```
list.add("something");
```

  - The method name `add` is overloaded
  - There is also a two argument version that allows an item to be added at any currently used index position or at the first unused position

How many elements?

- The **`size`** method is used to find out how many indices already have elements in the **`ArrayList`**

```
int howMany = list.size();
```

- The **`set`** method is used to replace any existing element, and the **`get`** method is used to access the value of any existing element

```
list.set(index, "something else");
String thing = (String) list.get(index);
```

Note that the returned value must be cast to the proper type

- **`size`** is NOT capacity
  - size is the number of elements currently stored in the ArrayList
  - Capacity is the maximum number of elements which can be stored. Capacity will automatically increase as needed

ArrayList code Example

```
public static void main( String[ ] args)
{
   ArrayList myInts = new ArrayList();
   System.out.println( "Size of myInts = " + myInts.size());
   for (int k = 0; k < 10; k++)
        myInts.add( 3 * k );
   myInts.set( 6, 44 );
   System.out.println( "Size of myInts = " + myInts.size());
   for (int k = 0; k < myInts.size(); k++)
        System.out.print( myInts.get( k ) + ", "  );
}
// output
Size of myInts = 0
Size of myInts = 10
0, 3, 6, 9, 12, 15, 44, 21, 24, 27
```

Methods in the Class **`ArrayList`**

- The tools for manipulating arrays consist only of the square brackets and the instance variable **`length`**
- **`ArrayLists`**, however, come with a selection of powerful methods that can do many of the things for which code would have to be written in order to do them using arrays

ArrayList Constructors

- **Constructors:**
  - **ArrayList**()
    - Constructs an empty list with an initial capacity of ten.
  - **ArrayList**(int initialCapacity)
    - Constructs an empty list with the specified initial capacity.

(Constructor and method descriptions borrowed from Sun javadoc pages)

ArrayList Methods

- **Method Summary** (incomplete)
  - void **add**(int index, Object element)
    - Inserts the specified element at the specified position in this list.
  - boolean **add**(Object o)
    - Appends the specified element to the end of this list.
  - int **size**()
    - Returns the number of elements in this list.

ArrayList Methods (cont)

- Object **set**(int index, Object element)
  - Replaces the element at the specified position in this list with the specified element.
- Object **get**(int index)
  - Returns the element at the specified position in this list.
- Object **remove**(int index)
  - Removes the element at the specified position in this list. protected
- void **removeRange**(int fromIndex, int toIndex)
  - Removes from this List all of the elements whose index is between fromIndex, inclusive and toIndex, exclusive.

ArrayList Methods (cont)

- void **clear**()
  - Removes all of the elements from this list.
- Object **clone**()
  - Returns a shallow copy of this ArrayList instance.
- int **indexOf**(Object elem)
  - Searches for the first occurence of the given argument, testing for equality using the equals method.
- int **lastIndexOf**(Object elem)
  - Returns the index of the last occurrence of the specified object in this list.

The "For Each" Loop

- The **`ArrayList`** class is an example of a *collection* class
- Starting with version 5.0, Java has added a new kind of for loop called a *for-each* or *enhanced for* loop
  - This kind of loop has been designed to cycle through all the elements in a collection (like an **`ArrayList`**)

“for-each” example

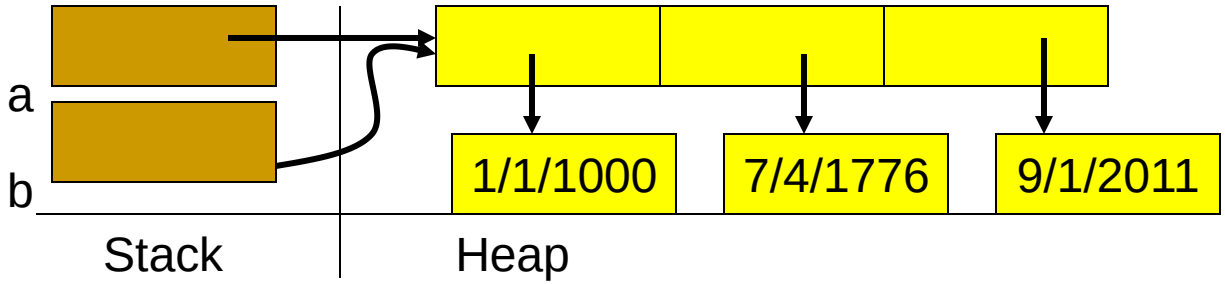
```
public class ForEach
{
   public static void main(String[ ] args)
   {
        ArrayList list = new ArrayList();
        list.add(new Date(1, 1, 1000));
        list.add(new Date(7, 4, 1776));
        list.add(new Date(9, 1, 2011));

        // “for each object, i, in list”
        for( Object i : list )
           System.out.println( i );
   }
}
//-- Output ---
1/1/1000
7/4/1776
9/1/2011
```

Copying an ArrayList

```
// create an ArrayList of Dates (assume we have some around)
ArrayList a = new ArrayList( );
a.add(d1); a.add(d2); a.add(d3);
```

- Assignment doesn't work
  - As we've seen with any object, using assignment just makes two variables refer to the same ArrayList.

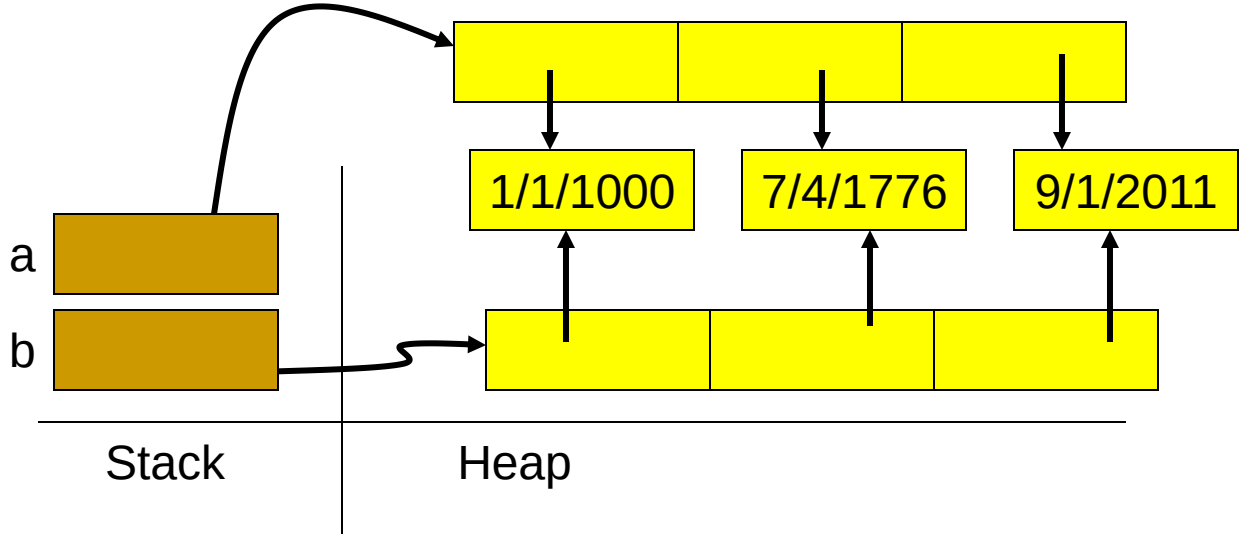
```
ArrayList b = a;
```



Copying an ArrayList

ArrayList's clone( ) method makes a shallow copy

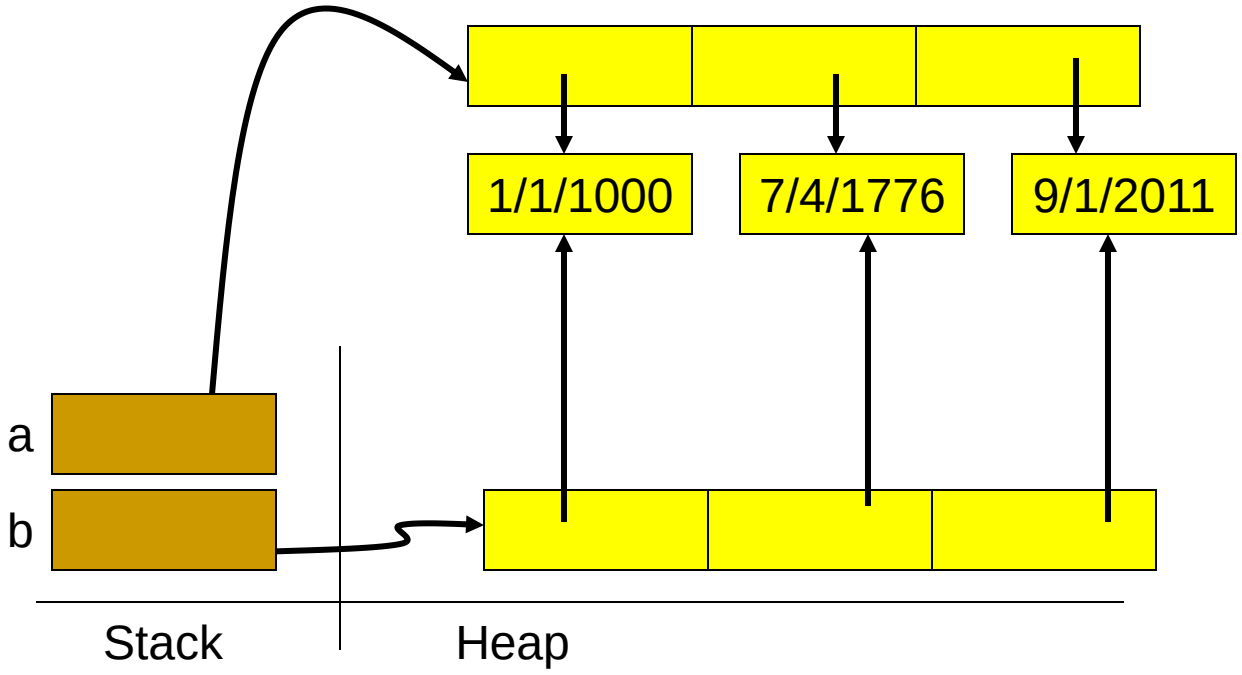
```
ArrayList b = a.clone( );
```



Copying an ArrayList

We need to manually make a deep copy

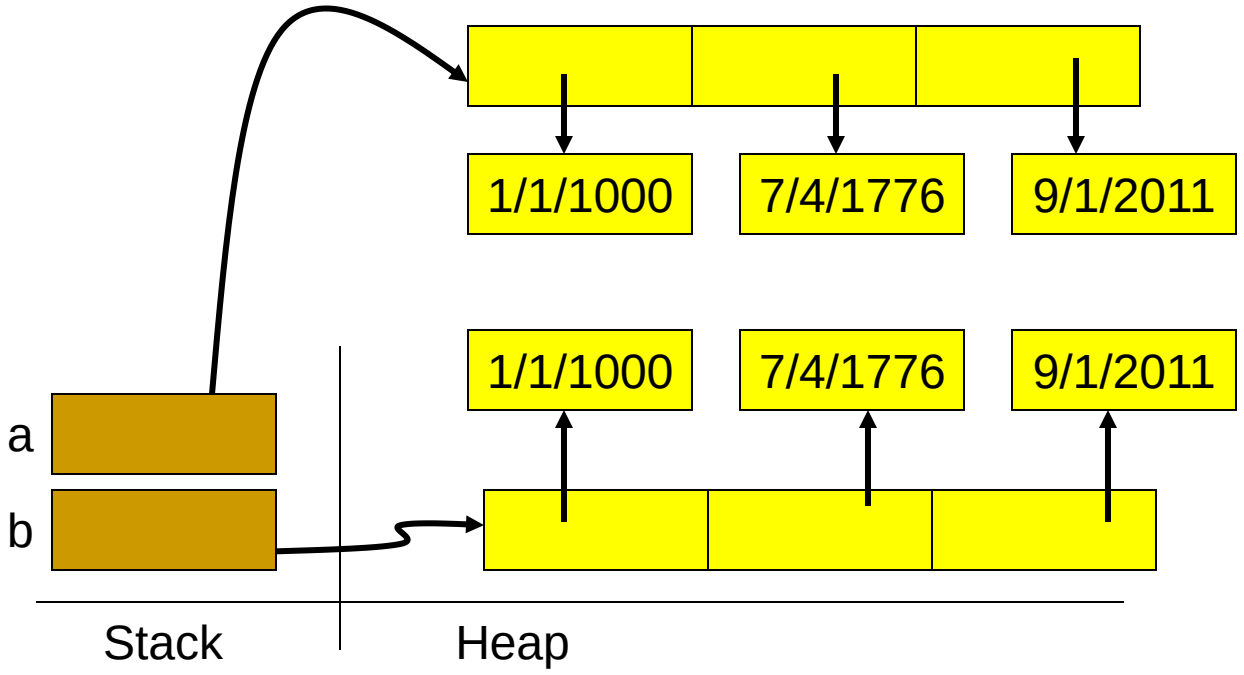
```
ArrayList b = a.clone( );
```



Copying an ArrayList

We need to manually make a deep copy

```
ArrayList b = a.clone( );
for( int k = 0; k < b.size( ); k++) {
   Date origDate = (Date) b.get(k);
   b.set(k, new Date(origDate));
}
```



`ArrayList` vs `Array`

Why use an array instead of an **`ArrayList`**

1. An **`ArrayList`** is less efficient than an array
2. **`ArrayList`** does not have the convenient square bracket notation
3. The elements of an **`ArrayList`** must be a class type (or other reference type). It cannot be a primitive type. (Although wrappers, auto boxing, and auto unboxing make this less of an issue with Java 5)

`ArrayList` vs `Array`

Why use an `ArrayList` instead of an array?

1. Arrays can't grow. Their size is fixed at compile time.
   - `ArrayList` grows and shrinks as needed while your program is running
2. You need to keep track of the actual number of elements in your array (recall partially filled arrays).
   - `ArrayList` will do that for you.
3. Arrays have no methods (just `length` instance variable)
   - `ArrayList` has powerful methods for manipulating the objects within it

Some Warnings

- This lecture describes an obsolete form of ArrayList
  - The original form of ArrayList stored Object elements, so you had to constantly do casts
  - The addition of ***generics*** to the language completely changed the use of *collections* like ArrayLists
  - To keep a modicum of backwards compatibility, *raw types* allow ArrayLists to be used as originally designed
  - Important: just because you *can* mix types together does *not* mean you should!

The `Vector` Class

- The Java standard libraries have a class named **`Vector`** that behaves almost exactly the same as the class **`ArrayList`**
- In most situations, either class could be used, however the **`ArrayList`** class is newer (Java 5), and is becoming the preferred class

Multidimensional Arrays

Multidimensional Arrays

- Review of 1-dimensional arrays:
- To declare and initialize:

```
int[] myArray = new int[4];
```

- To access:

```
myArray[3] = myArray[3] + 1;
```

- To use as an object:

```
for (i = 0; I < myArray.length; i++) {
```

- To demonstrate that it's a reference variable:

```
myArray = null;
// Now, "myArray[3]" would cause an error
```

Multidimensional Arrays

- Extending to 2-dimensional arrays:
- To declare and initialize:

```
int[][] myArray = new int[3][4];
// How would you declare 2-dim arrays in C?
```

- To access:

```
myArray[1][3] = myArray[1][3] + 1;
```

- To use as an object:

```
numRows = myArray.length;
// Following assumes rectangular matrix
numCols = myArray[0].length;
```

Multidimensional Arrays

- But in Java, a 2D array is actually a reference-to-an-array-of-references:

```
// Can do:
myArray[1] = null;
myArray[1][3] = 47; // This will cause error
// but myArray[0][3] still okay

// Can also make it a "ragged" array:
myArray[1] = new int[20];

// What do you think following does?
myArray = new int[10][];

// …and what would this do?
myArray = new int[40];
```

Multidimensional Arrays

- Luckily, if you don't want to get fancy, you can pretend that it's simply a 2-D array
- Even if you do create complex, dynamically allocated, ragged arrays, you don't have to worry about memory management