# CMSC 202

ArrayList

# 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, except that you specify the base type as follows:

```
ArrayList<BaseType> aList =
                    new ArrayList<BaseType>();
```

# Creating an `ArrayList`

- An initial capacity can be specified when creating an `ArrayList` as well
  - The following code creates an `ArrayList` that stores objects of the base type `String` with an initial capacity of 20 items

```
ArrayList<String> list = new ArrayList<String>(20);
```

  - Specifying an initial capacity does not limit the size to which an `ArrayList` can eventually grow
- Note that the base type of an ArrayList is specified as a *type parameter*

# 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 = list.get(index);
```

- **`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

```
// Note the use of Integer, rather than int
public static void main( String[ ] args)
{
   ArrayList<Integer> myInts = new ArrayList<Integer>(25);
   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

# Some Methods in the Class `ArrayList` (Part 1 of 11)

**Display 14.1 Some Methods in the Class ArrayList**

| CONSTRUCTORS |
| --- |
| `public ArrayList<Base_Type>(int initialCapacity)`<br>Creates an empty `ArrayList` with the specified *Base_Type* and initial capacity. |
| `public ArrayList<Base_Type>()`<br>Creates an empty `ArrayList` with the specified *Base_Type* and an initial capacity of 10. |

(continued)

# Some Methods in the Class `ArrayList` (Part 2 of 11)

**Display 14.1 Some Methods in the Class `ArrayList`**

**ARRAYLIKE METHODS**

```
public Base_Type set( int index, Base_Type newElement)
```

Sets the element at the specified `index` to `newElement`. Returns the element previously at that position, but the method is often used as if it were a `void` method. If you draw an analogy between the `ArrayList` and an array `a`, this statement is analogous to setting `a[index]` to the value `newElement`. The `index` must be a value greater than or equal to `0` and less than the current size of the `ArrayList`. Throws an `IndexOutOfBoundsException` if the `index` is not in this range.

```
public Base_Type get(int index)
```

Returns the element at the specified index. This statement is analogous to returning `a[index]` for an array `a`. The `index` must be a value greater than or equal to `0` and less than the current size of the `ArrayList`. Throws `IndexOutOfBoundsException` if the `index` is not in this range.

(continued)

# Some Methods in the Class `ArrayList` (Part 3 of 11)

**Display 14.1 Some Methods in the Class `ArrayList`**

**METHODS TO ADD ELEMENTS**

```
public boolean add(Base_Type newElement)
```

Adds the specified element to the end of the calling `ArrayList` and increases the `ArrayList`'s size by one. The capacity of the `ArrayList` is increased if that is required. Returns `true` if the add was successful. (The return type is `boolean`, but the method is typically used as if it were a `void` method.)

```
public void add( int index, Base_Type newElement)
```

Inserts `newElement` as an element in the calling `ArrayList` at the specified index. Each element in the `ArrayList` with an index greater or equal to `index` is shifted upward to have an index that is one greater than the value it had previously. The `index` must be a value greater than or equal to `0` and less than *or equal* to the current size of the `ArrayList`. Throws `IndexOutOfBoundsException` if the index is not in this range. Note that you can use this method to add an element after the last element. The capacity of the `ArrayList` is increased if that is required.

(continued)

# Some Methods in the Class `ArrayList` (Part 4 of 11)

**Display 14.1 Some Methods in the Class `ArrayList`**

**METHODS TO REMOVE ELEMENTS**

```
public Base_Type remove(int index)
```

Deletes and returns the element at the specified index. Each element in the `ArrayList` with an index greater than `index` is decreased to have an index that is one less than the value it had previously. The `index` must be a value greater than or equal to `0` and less than the current size of the `ArrayList`. Throws `IndexOutOfBoundsException` if the `index` is not in this range. Often used as if it were a `void` method.

(continued)

# Some Methods in the Class `ArrayList` (Part 5 of 11)

**Display 14.1 Some Methods in the Class `ArrayList`**

```
protected void removeRange(int fromIndex, int toIndex)
```

Deletes all the element with indices *i* such that `fromIndex` $\leq i <$ `toIndex`. Element with indices greater than or equal to `toIndex` are decreased appropriately.

```
public boolean remove(Object theElement)
```

Removes one occurrence of `theElement` from the calling `ArrayList`. If `theElement` is found in the `ArrayList`, then each element in the `ArrayList` with an index greater than the removed element's index is decreased to have an index that is one less than the value it had previously. Returns `true` if `theElement` was found (and removed). Returns `false` if `theElement` was not found in the calling `ArrayList`.

```
public void clear()
```

Removes all elements from the calling `ArrayList` and sets the `ArrayList`'s size to zero.

(continued)

# Some Methods in the Class `ArrayList` (Part 6 of 11)

**Display 14.1 Some Methods in the Class `ArrayList`**

| SEARCH METHODS |
| --- |
| `public boolean contains(Object target)`<br><br>Returns `true` if the calling `ArrayList` contains `target`; otherwise, returns `false`. Uses the method `equals` of the object `target` to test for equality with any element in the calling `ArrayList`. |
| `public int indexOf(Object target)`<br><br>Returns the index of the first element that is equal to `target`. Uses the method `equals` of the object `target` to test for equality. Returns `–1` if `target` is not found. |
| `public int lastIndexOf(Object target)`<br><br>Returns the index of the last element that is equal to `target`. Uses the method `equals` of the object `target` to test for equality. Returns `–1` if `target` is not found. |

(continued)

# Some Methods in the Class `ArrayList` (Part 7 of 11)

**Display 14.1 Some Methods in the Class `ArrayList`**

| MEMORY MANAGEMENT (SIZE AND CAPACITY) |
| --- |
| `public boolean isEmpty()`<br><br>Returns `true` if the calling `ArrayList` is empty (that is, has size `0`); otherwise, returns `false`. |

(continued)

# Some Methods in the Class `ArrayList` (Part 8 of 11)

**Display 14.1 Some Methods in the Class `ArrayList`**

```
public int size()
```

Returns the number of elements in the calling `ArrayList`.

```
public void ensureCapacity(int newCapacity)
```

Increases the capacity of the calling `ArrayList`, if necessary, in order to ensure that the `ArrayList` can hold at least `newCapacity` elements. Using `ensureCapacity` can sometimes increase efficiency, but its use is not needed for any other reason.

```
public void trimToSize()
```

Trims the capacity of the calling `ArrayList` to the `ArrayList`'s current size. This method is used to save storage space.

(continued)

# Some Methods in the Class `ArrayList` (Part 9 of 11)

**Display 14.1 Some Methods in the Class `ArrayList`**

MAKE A COPY

```
public Object[] toArray()
```

Returns an array containing all the elements on the list. Preserves the order of the elements.

```
public Type[] toArray(Type[] a)
```

Returns an array containing all the elements on the list. Preserves the order of the elements. *Type* can be any class types. If the list will fit in `a`, the elements are copied to `a` and `a` is returned. Any elements of `a` not needed for list elements are set to `null`. If the list will not fit in `a`, a new array is created.

(As we will discuss in Section 14.2, the correct Java syntax for this method heading is

```
public <Type> Type[] toArray(Type[] a)
```

However, at this point we have not yet explained this kind of type parameter syntax.)

(continued)

# Some Methods in the Class `ArrayList` (Part 10 of 11)

**Display 14.1 Some Methods in the Class `ArrayList`**

```
public Object clone()
```

Returns a shallow copy of the calling `ArrayList`. Warning: The clone is not an independent copy. Subsequent changes to the clone may affect the calling object and vice versa. (See Chapter 5 for a discussion of shallow copy.)

(continued)

# Some Methods in the Class `ArrayList` (Part 11 of 11)

**Display 14.1 Some Methods in the Class `ArrayList`**

**EQUALITY**

```
public boolean equals(Object other)
```

If `other` is another `ArrayList` (of any base type), then `equals` returns `true` if and only if both `ArrayLists` are of the same size and contain the same list of elements in the same order. (In fact, if `other` is any kind of *list*, then `equals` returns `true` if and only if both the calling `ArrayList` and `other` are of the same size and contain the same list of elements in the same order. *Lists* are discussed in Chapter 16.)

# More example code

```
// Note the use of Integer instead of int
public static void main( String[ ] args)
{
   ArrayList<Integer> myInts = new ArrayList<Integer>(25);
   System.out.println( "Size of myInts = " + myInts.size());
   for (int k = 0; k < 10; k++)
        myInts.add( 3 * k );
   myInts.set( 6, 44 );
   myInts.add( 4, 42 );
   myInts.remove( new Integer(99) );
   System.out.println( "Size of myInts = " + myInts.size());
   for (int k = 0; k < myInts.size(); k++)
        System.out.print( myInts.get( k ) + ", "  );
   if (myInts.contains( 57 ) ) System.out.println("57 found");
   System.out.println ("44 found at index " + myInts.indexOf(44));
}
```

# Why are Some Parameters of Type `Base_Type` and Others of type `Object`

- When looking at the methods available in the `ArrayList` class, there appears to be some inconsistency
  - In some cases, when a parameter is naturally an object of the base type, the parameter type is the base type
  - However, in other cases, it is the type `Object`
- This is because the `ArrayList` class implements a number of interfaces, and inherits methods from various ancestor classes
  - These interfaces and ancestor classes specify that certain parameters have type `Object`

# 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

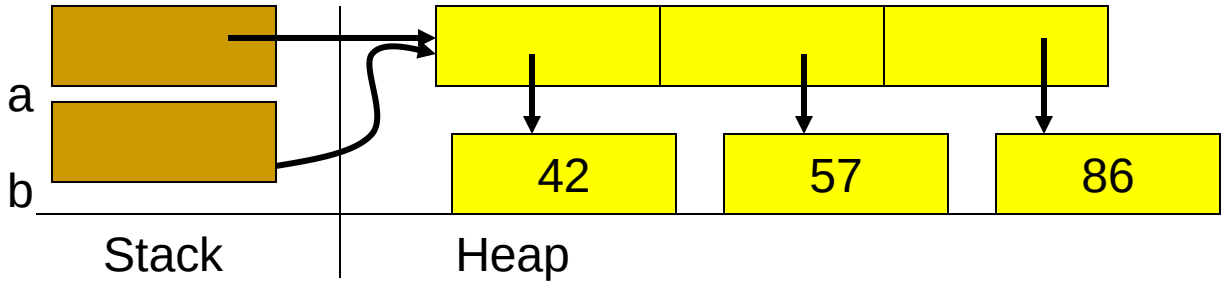
```
public class ForEach
{
   public static void main(String[ ] args)
   {
        ArrayList<Integer> list = new ArrayList<Integer>;
        list.add( 42 );
        list.add( 57 );
        list.add( 86 );

        // “for each Integer, i, in list”
        for( Integer i : list )
           System.out.println( i );
   }
}
//-- Output ---
42
57
86
```

# Copying an ArrayList

```
// create an ArrayList of Integers
ArrayList<Integer> a = new ArrayList<Integer>( );
a.add(42); a.add(57); a.add(86);
```

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

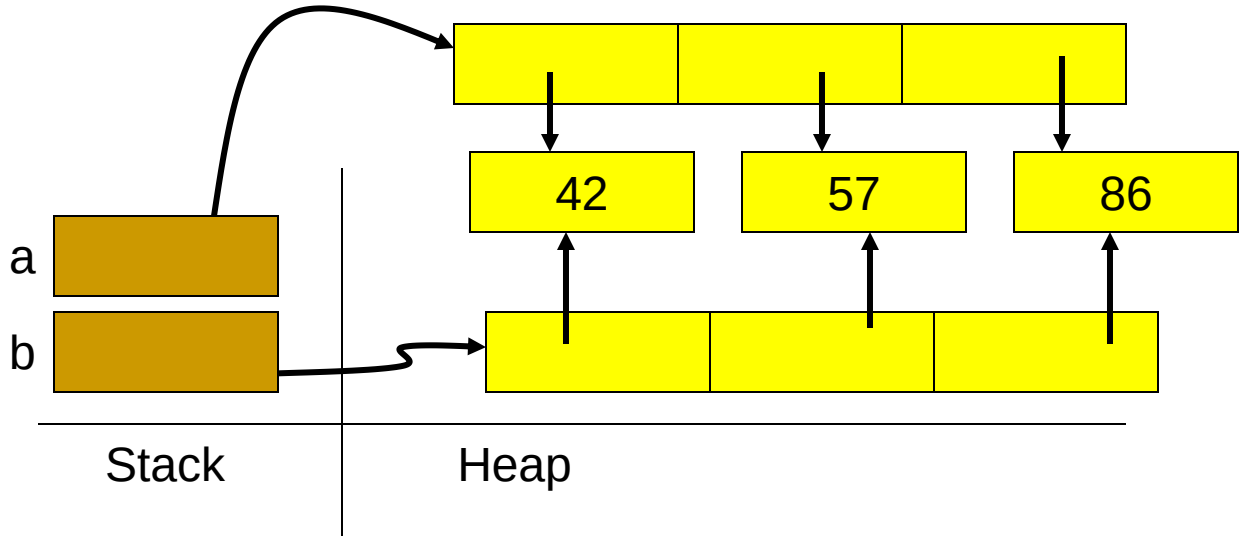
```
ArrayList<Integer> b = a;
```



# Copying an ArrayList

ArrayList's clone( ) method makes a shallow copy

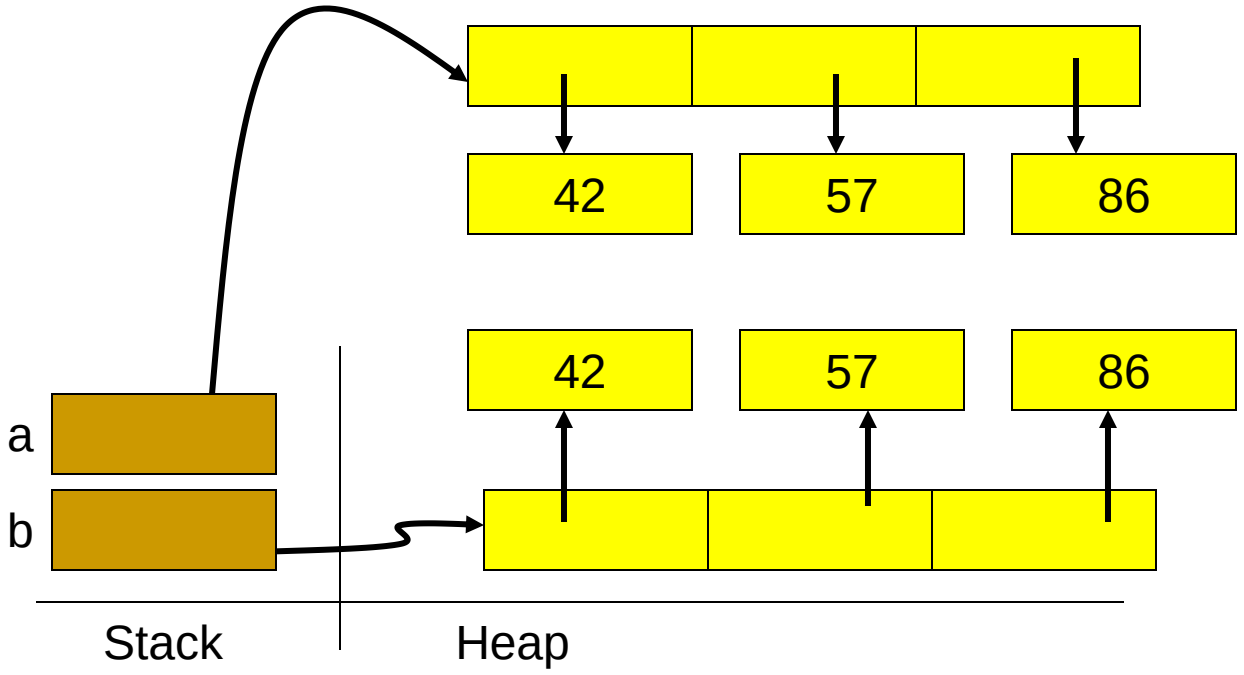
```
ArrayList<Integer> b = a.clone( );
```



# Copying an ArrayList

We need to manually make a deep copy

```
ArrayList<Integer> b = a.clone( );
for( int k = 0; k < b.size( ); k++)
   b.set(k, a.get(k));
```



# `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 base type 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 a non-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

# 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