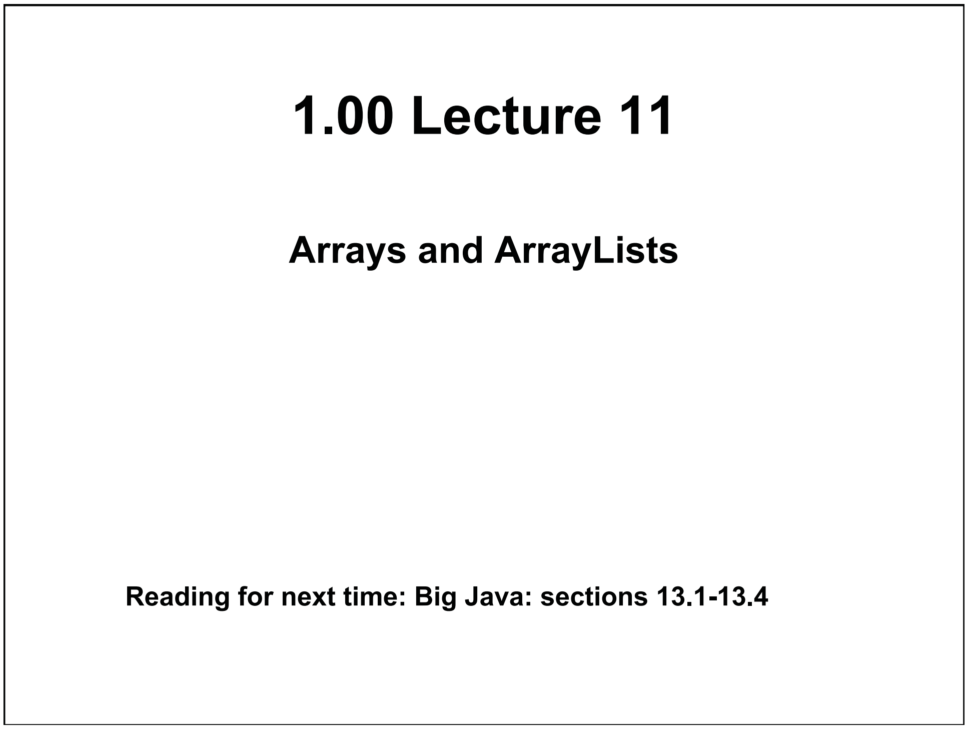
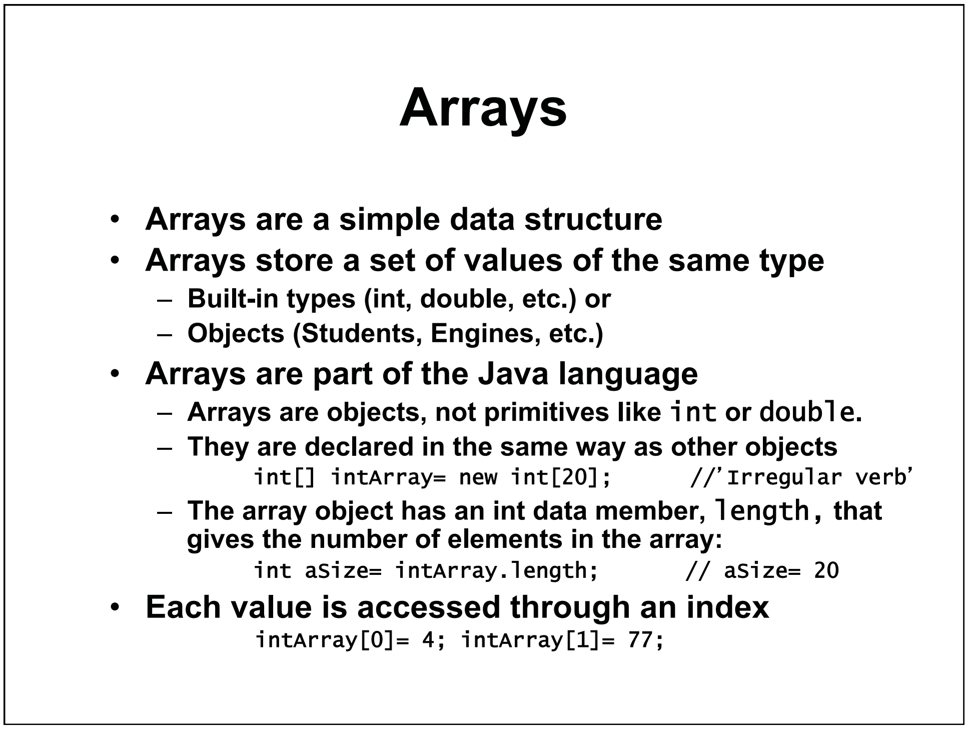


1.00 Lecture 11

Arrays and ArrayLists

Reading for next time: Big Java: sections 13.1-13.4



Arrays

- **Arrays are a simple data structure**
- **Arrays store a set of values of the same type**
  - – Built-in types (int, double, etc.) or
  - – Objects (Students, Engines, etc.)
- **Arrays are part of the Java language**
  - – Arrays are objects, not primitives like `int` or `double`.
  - – They are declared in the same way as other objects

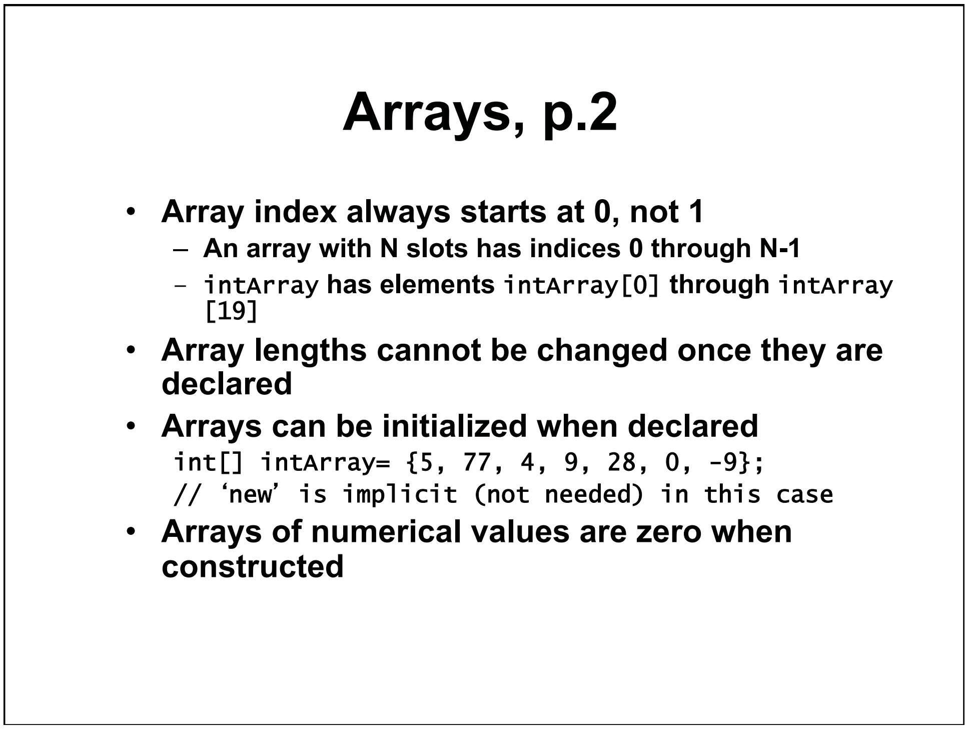
```
        int[] intArray= new int[20];      //'Irregular verb'
```

  - – The array object has an int data member, `length,` that gives the number of elements in the array:

```
        int aSize= intArray.length;      // aSize= 20
```

- **Each value is accessed through an index**

```
        intArray[0]= 4; intArray[1]= 77;
```

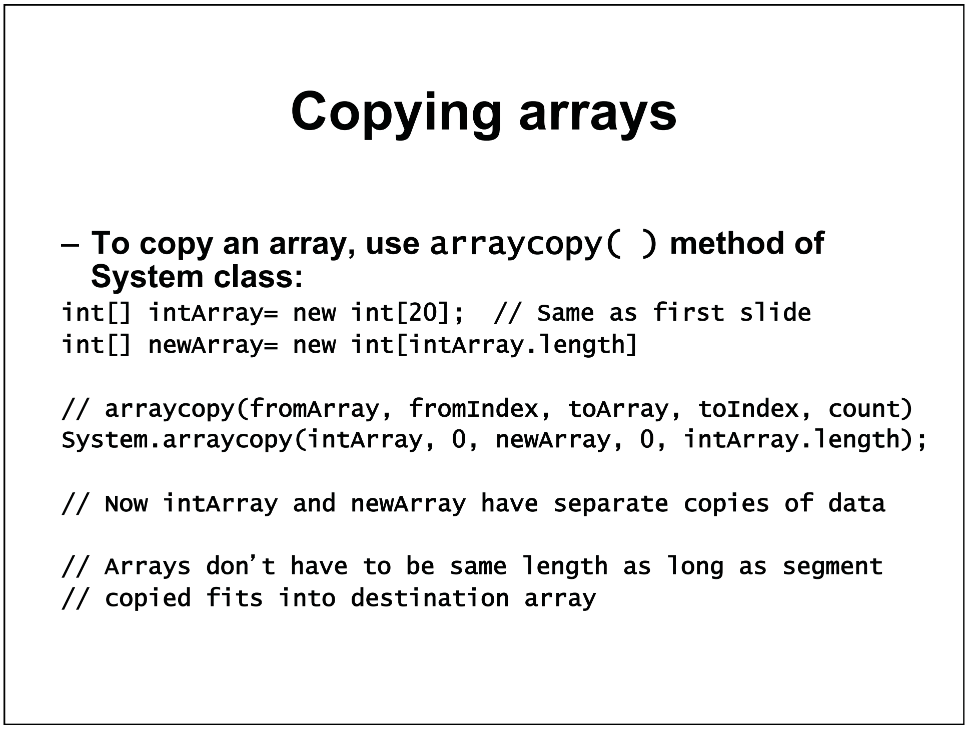


Arrays, p.2

- Array index always starts at 0, not 1
  - An array with N slots has indices 0 through N-1
  - `intArray` has elements `intArray[0]` through `intArray [19]`
- Array lengths cannot be changed once they are declared
- Arrays can be initialized when declared

```
int[] intArray= {5, 77, 4, 9, 28, 0, -9};
// 'new' is implicit (not needed) in this case
```

- Arrays of numerical values are zero when constructed



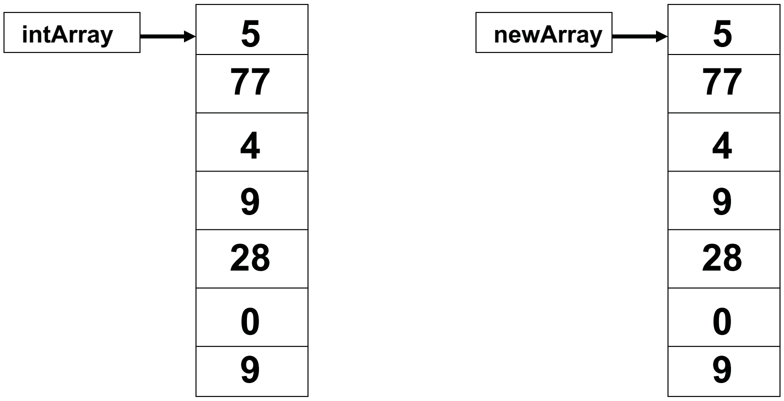
Copying arrays

– To copy an array, use `arraycopy( )` method of System class:

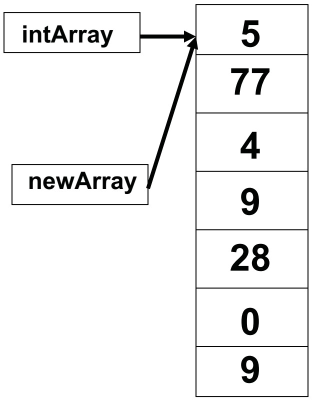
```
int[] intArray= new int[20];  // Same as first slide
int[] newArray= new int[intArray.length]

// arraycopy(fromArray, fromIndex, toArray, toIndex, count)
System.arraycopy(intArray, 0, newArray, 0, intArray.length);

// Now intArray and newArray have separate copies of data

// Arrays don't have to be same length as long as segment
// copied fits into destination array
```

Copying entire array

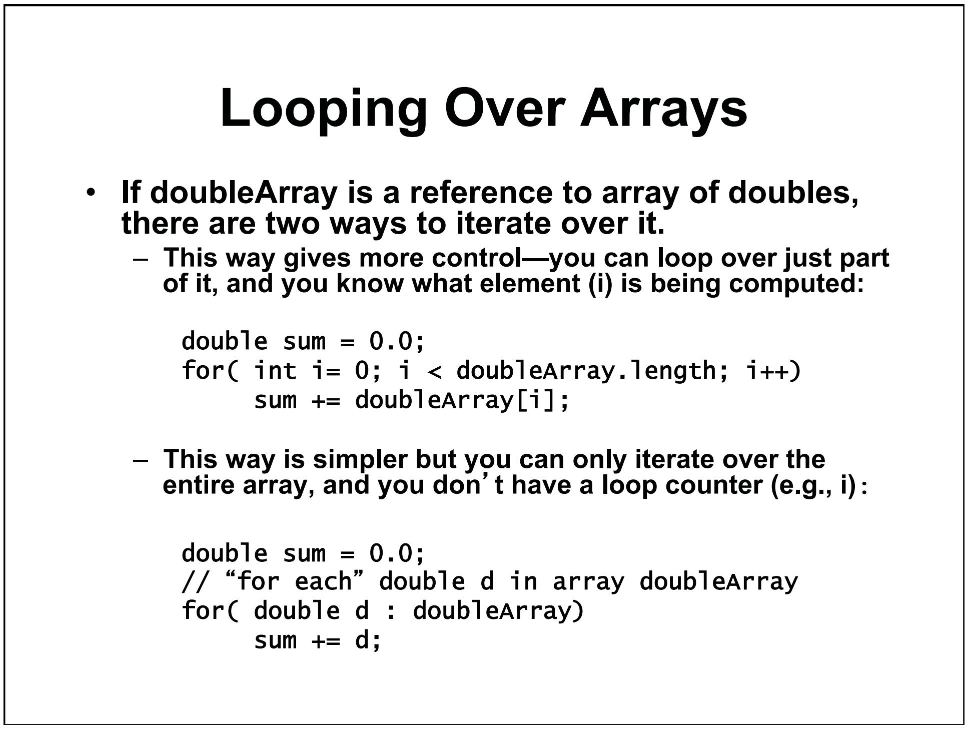
```
int[ ] intArray= { 5, 77, 4, 9, 28, 0, 9 };
int[ ] newArray = new int[ intArray.length ];
System.arraycopy(intArray, 0, newArray, 0, intArray.length)
```



Copying an array reference



```
int[ ] intArray= {5, 77, 4, 9, 28, 0, 9};
int[ ] newArray = intArray;
```



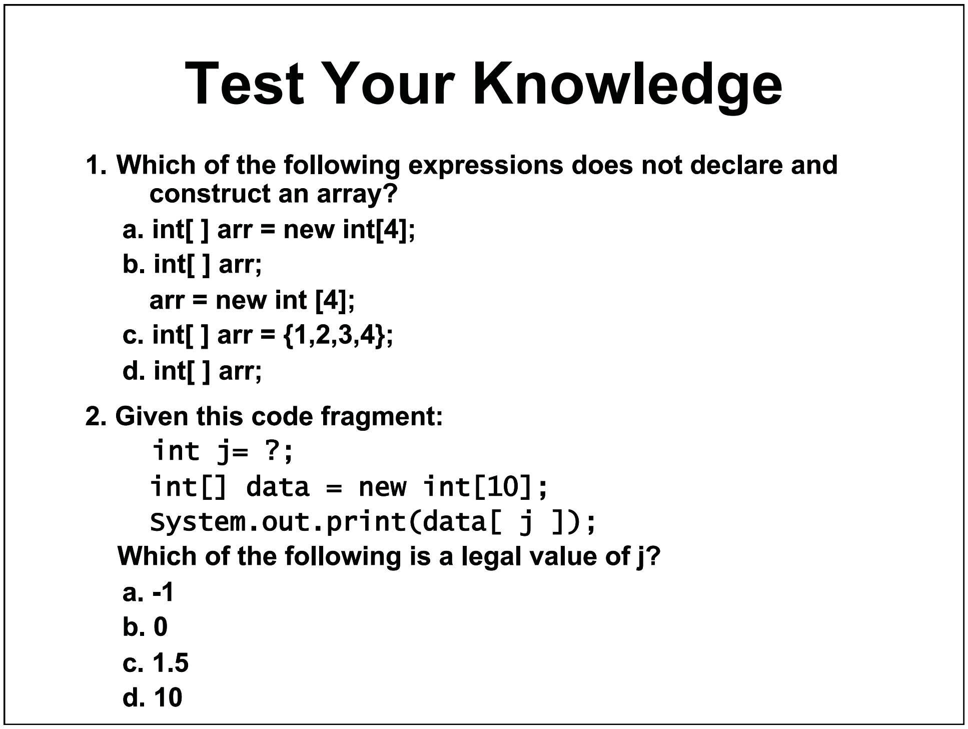
Looping Over Arrays

- **If doubleArray is a reference to array of doubles, there are two ways to iterate over it.**
  - **This way gives more control—you can loop over just part of it, and you know what element (i) is being computed:**

```
double sum = 0.0;
for( int i= 0; i < doubleArray.length; i++)
     sum += doubleArray[i];
```

  - **This way is simpler but you can only iterate over the entire array, and you don't have a loop counter (e.g., i):**

```
double sum = 0.0;
// “for each” double d in array doubleArray
for( double d : doubleArray)
     sum += d;
```



Test Your Knowledge

1. Which of the following expressions does not declare and construct an array?

a. int[ ] arr = new int[4];

b. int[ ] arr;
arr = new int [4];

c. int[ ] arr = {1,2,3,4};

d. int[ ] arr;

2. Given this code fragment:

```
int j= ?;
int[] data = new int[10];
System.out.print(data[ j ]);
```

Which of the following is a legal value of j?

a. -1

b. 0

c. 1.5

d. 10

Test Your Knowledge

3. Given this code fragment:

```
 int[] arrayA = new int[4];
int[] arrayB;
arrayB = arrayA;
arrayB[2]=4;
arrayA[0]=arrayB[2];
```

What are the values of the elements in array A?

a. unknown

b. 0,0,0,0

c. 4,0,4,0

d. 4,0,0,0

4. How many objects are present after the following code fragment has executed?

```
double[] arrayA=new double[10];
double[] arrayB;
arrayB = arrayA;
```

a. 1

b. 2

c. 10

d. 20

Test Your Knowledge

5. For which of these applications an array is NOT suitable?

a. Holding the scores on 4 quarters of a Basketball game

b. Holding the name, account balance and account number of an individual

c. Holding temperature readings taken every hour through a day

d. Holding monthly expenses through a year

6. Given the following code fragment:

```
int[] data = {1,3,5,7,11};
for(______________________)
System.out.println(data
    [index] );
```

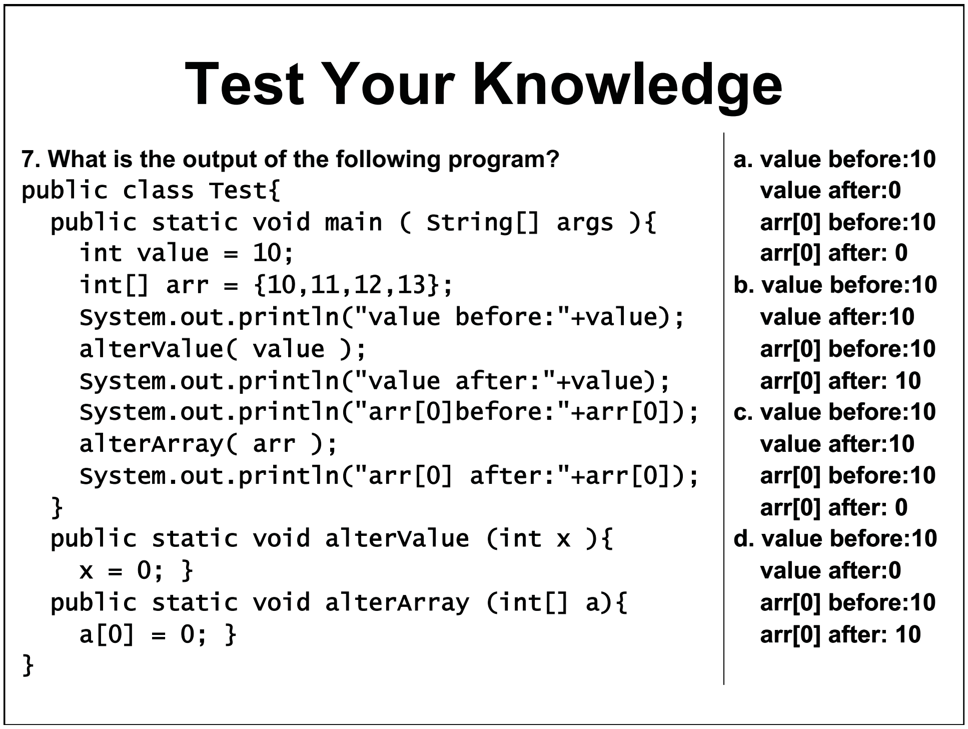
Fill in the blanks so that the program prints out every element in the array in order

a. int index = 4; index>0; index--

b. int index=0; index<4; index++

c. int index=0; index<data.length(); index++

d. int index=0; index<data.length; index++



Test Your Knowledge

7. What is the output of the following program?

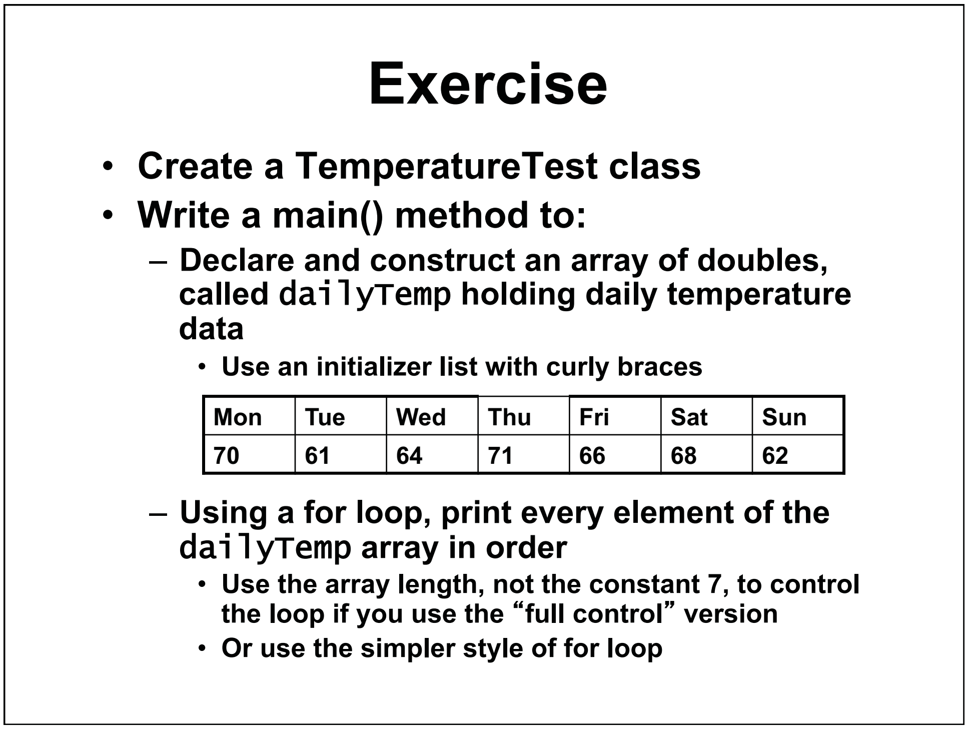
```
public class Test{
  public static void main ( String[] args ){
    int value = 10;
    int[] arr = {10,11,12,13};
    System.out.println("value before:"+value);
    alterValue( value );
    System.out.println("value after:"+value);
    System.out.println("arr[0]before:"+arr[0]);
    alterArray( arr );
    System.out.println("arr[0] after:"+arr[0]);
  }
  public static void alterValue (int x ){
    x = 0; }
  public static void alterArray (int[] a){
    a[0] = 0; }
}
```

a. value before:10
value after:0
arr[0] before:10
arr[0] after: 0

b. value before:10
value after:10
arr[0] before:10
arr[0] after: 10

c. value before:10
value after:10
arr[0] before:10
arr[0] after: 0

d. value before:10
value after:0
arr[0] before:10
arr[0] after: 10



Exercise

- **Create a TemperatureTest class**
- **Write a main() method to:**
  - **Declare and construct an array of doubles, called `dailyTemp` holding daily temperature data**
    - **Use an initializer list with curly braces**

Mon	Tue	Wed	Thu	Fri	Sat	Sun
70	61	64	71	66	68	62

  - **Using a for loop, print every element of the `dailyTemp` array in order**
    - **Use the array length, not the constant 7, to control the loop if you use the "full control" version**
    - **Or use the simpler style of for loop**

Exercise, p.2

- **In class TemperatureTest, write a static method to find average weekly temperature:**

```
public static double average(double[] aDouble) {
  // Declare a total variable, initialize it to 0
  // Loop thru aDouble and add each element to the total
  // Use the simple for (double d : aDouble) for loop
  // Divide by the number of elements, return the answer
}
```

- **In the main() method, call the average method you just wrote**
  - **Pass the dailyTemp array as the argument**
  - **Print the average temperature in main() as:**
    - **Average weekly temperature: 66**

ArrayList Class

- **The ArrayList class IS COMPLETELY DIFFERENT THAN an array.**
  - **It's a more flexible way to store data**
  - **ArrayList can grow automatically as needed**
    - **Has `capacity` that is increased when needed**
    - **Has `size()` method that returns actual number of elements in the ArrayList**
  - **ArrayList can hold elements of different types**
    - **As long as each is an Object (reference),**
    - **Technically an ArrayList can't hold a basic type (int, double, etc.)**
    - **But, conversion of primitive to an object happens automatically. This is called "auto-boxing".**
    - **Wrapper classes allow objects (e.g., Boolean or Double) that hold basic types (e.g. boolean or double)**
  - **Think airplane vs bicycle as two ways to get from A to B**
    - **Bicycle is simple, airplane is complex, though both get you there**
    - **Squeeze hand brake doesn't apply to plane, adjust flaps to bicycle**
    - **So it is with arrays and ArrayLists: similar but quite different**

ArrayLists

- ArrayList class is not in the core Java language
  - It is in package java.util, which you must import:

```
import java.util.*;  // At top of program
```

- ArrayLists are slightly slower than arrays
  - This matters only in large numerical applications
- ArrayList class has many methods that provide functionality beyond what arrays provide
- You can declare an ArrayList as containing objects of a particular type. Example:

```
ArrayList<Point> pList = new
        ArrayList<Point>( );
```

Some Methods of ArrayList

boolean add (Object o)	Adds object to end, increases size by one. Always returns true
void add(int i, Object o)	Inserts o at index i moving subsequent elements to right
Object get(int i)	Returns object at index i
int indexOf(Object o)	Finds first occurrence of object; -1 if not found
boolean isEmpty( )	Returns true if ArrayList has no objects, false otherwise
void remove (int i)	Deletes obj at index i moving subsequent elements leftward
void remove (Object o)	Deletes first occurrence of o moving subsequent elements leftward
void set(int i,Object o)	Sets element at index i to be the specified object
int size( )	Returns size of ArrayList

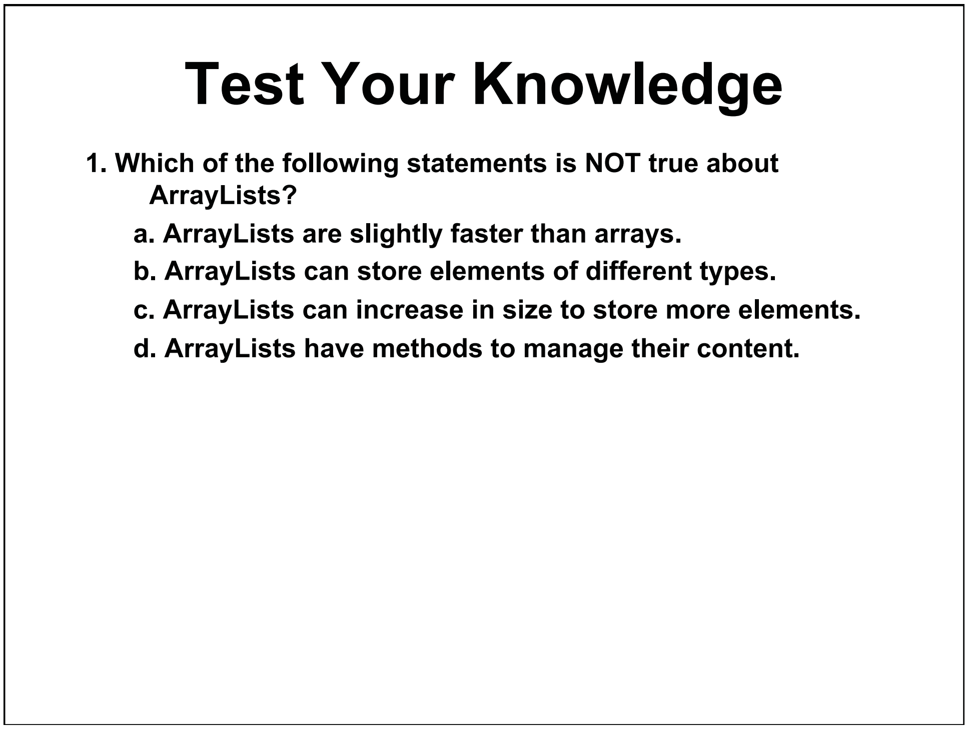
ArrayList Example

```
import java.awt.*;            // to use Point class
import java.util.*;           // to use ArrayList class

public class ArrayListTest {
  static final int M = 100;   // Max coordinate

  public static void main(String args[]) {
    Random r= new Random();
    int numPoints = r.nextInt(20);   // Max 20 points
    ArrayList<Point> points = new ArrayList<Point> ( );

    for (int i=0; i< numPoints; i++) {
       Point p = new Point( r.nextInt(M), r.nextInt(M));
       points.add(p);
    }

    System.out.println("ArrayList size: “ + points.size());
    for (Point pt : points)
       System.out.println(pt);
   }
}
```

Automatic conversion of primitives to objects

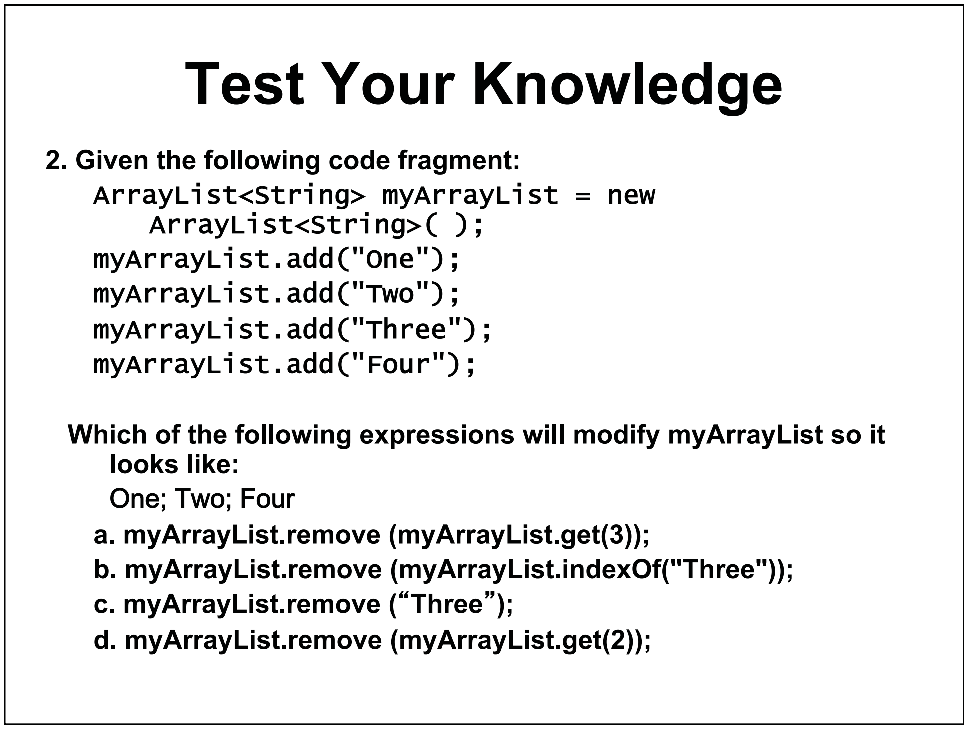
- Java has “boxing” and “unboxing”:
  - When necessary, the compiler converts a primitive (e.g., int or double) to the corresponding object type (e.g., Integer or Double)
- This lets us add primitive types to an ArrayList:

```
ArrayList<Integer> myAList = new
   ArrayList<Integer>( );
myAList.add(1);   // 1 is an int; it’s boxed
myAList.add(3);   // same as myAList.add(new
                  // Integer(3));
myAList.add(7);
// retrieves Integer, unboxes to int
int iValue = myAlist.get(1);
```



Test Your Knowledge

1. Which of the following statements is NOT true about ArrayLists?
   - a. ArrayLists are slightly faster than arrays.
   - b. ArrayLists can store elements of different types.
   - c. ArrayLists can increase in size to store more elements.
   - d. ArrayLists have methods to manage their content.



Test Your Knowledge

2. Given the following code fragment:

```
ArrayList<String> myArrayList = new
    ArrayList<String>( );
myArrayList.add("One");
myArrayList.add("Two");
myArrayList.add("Three");
myArrayList.add("Four");
```

Which of the following expressions will modify myArrayList so it looks like:

One; Two; Four

a. myArrayList.remove (myArrayList.get(3));

b. myArrayList.remove (myArrayList.indexOf("Three"));

c. myArrayList.remove (“Three”);

d. myArrayList.remove (myArrayList.get(2));

Test Your Knowledge

3. Given the following code fragment (same as question 2):

```
ArrayList<String> myArrayList = new
    ArrayList<String>( );
myArrayList.add("One");
myArrayList.add("Two");
myArrayList.add("Three");
myArrayList.add("Four");
```

Which of the following expressions will modify myArrayList so it looks like:

One; Two; Three; Five

a. myArrayList[3] = "Five"
b. myArrayList[4] = "Five"
c. myArrayList.set (myArrayList.indexOf("Four"), “Five”);
d. myArrayList.set (myArrayList.indexOf("Five"), “Four”);

Test Your Knowledge

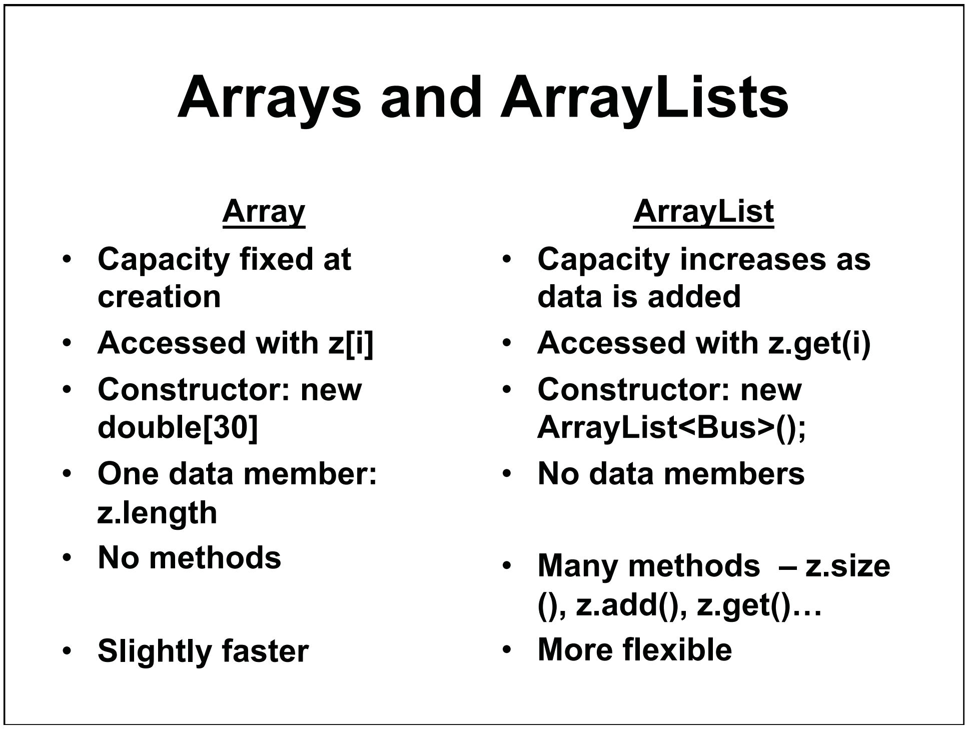
4. Given the following code fragment:

```
ArrayList<Integer> myArrayList = new
    ArrayList<Integer>( );
myArrayList.add(1);
myArrayList.add(3);
myArrayList.add(7);
```

Which of the following expressions will modify myArrayList so it looks like:

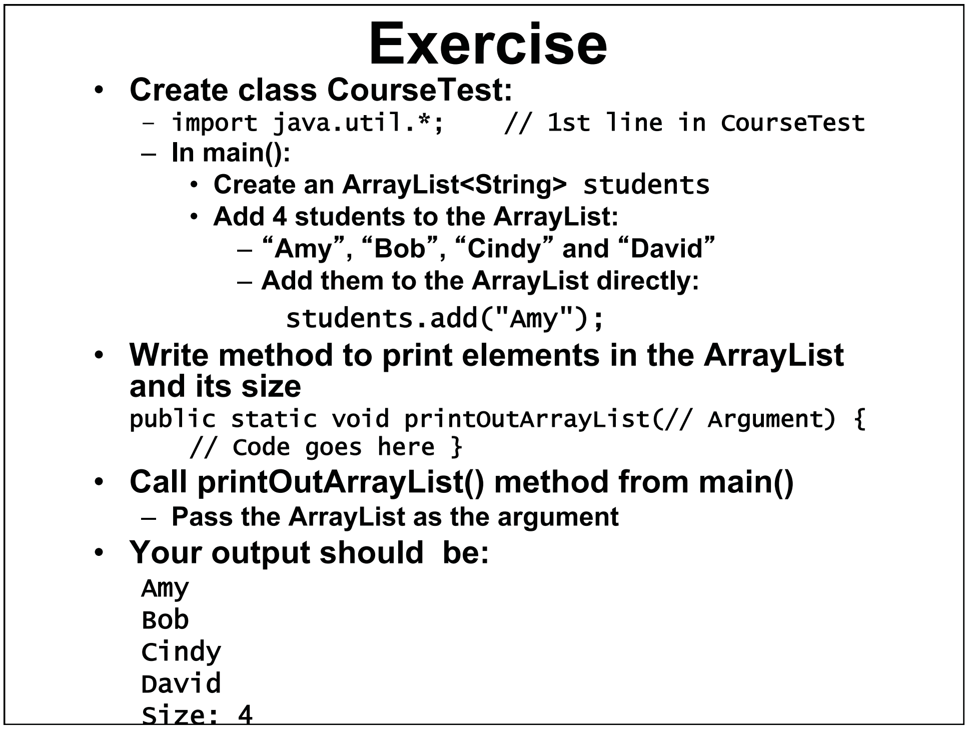
1 3 5 7

a. myArrayList.add (5);
b. myArrayList.add (2, 5);
c. myArrayList.add (4, 5);
d. myArrayList.add (3, 5);



Arrays and ArrayLists

Array	ArrayList
• Capacity fixed at creation	• Capacity increases as data is added
• Accessed with z[i]	• Accessed with z.get(i)
• Constructor: new double[30]	• Constructor: new ArrayList<Bus>();
• One data member: z.length	• No data members
• No methods	• Many methods – z.size (), z.add(), z.get()…
• Slightly faster	• More flexible



Exercise

- **Create class CourseTest:**
  - `import java.util.*;    // 1st line in CourseTest`
  - **In main():**
    - **Create an ArrayList<String>** `students`
    - **Add 4 students to the ArrayList:**
      - **“Amy”, “Bob”, “Cindy” and “David”**
      - **Add them to the ArrayList directly:**

```
students.add("Amy");
```

- **Write method to print elements in the ArrayList and its size**

```
public static void printOutArrayList(// Argument) {
    // Code goes here }
```

- **Call printOutArrayList() method from main()**
  - **Pass the ArrayList as the argument**
- **Your output should be:**

```
Amy
Bob
Cindy
David
Size: 4
```