Unit 6: Arrays
Introduction to Arrays

Adapted from:

1) Building Java Programs: A Back to Basics Approach by Stuart Reges and Marty Stepp

2) Runestone CSAwesome Curriculum

Textbook Reference

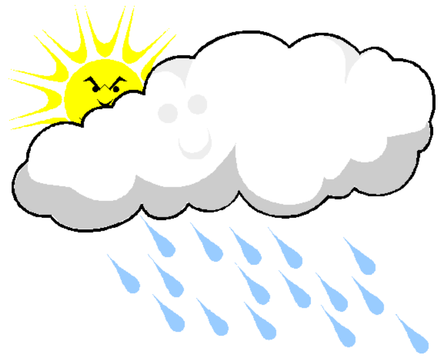
Online Textbook Think Java - 2nd Edition by Allen Downey and Chris Mayfield

For this lecture use Chapter 7 Chapter 12

Can we solve this problem?

- Consider the following program (input underlined):

```
How many days' temperatures? 7
Day 1's high temp: 45
Day 2's high temp: 44
Day 3's high temp: 39
Day 4's high temp: 48
Day 5's high temp: 37
Day 6's high temp: 46
Day 7's high temp: 53
Average temp = 44.6
4 days were above average.
```

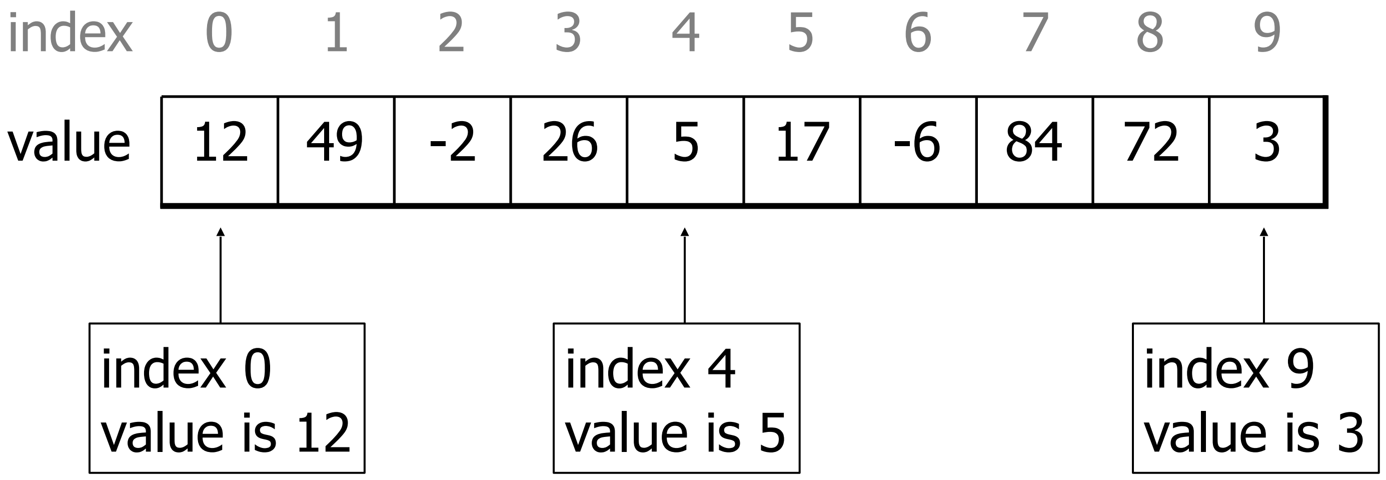


Do we want to store these in separate integer variables?

What if the user want to enter 1000 temperatures? (temp1, temp2,..temp1000?)

Arrays

- **array**: object that stores many values of the same type.
  - **value**: One value in an array.
  - **index**: A 0-based integer to access an element from an array.



Array declaration

type`[]` **name** `= new` **type**`[`**length**`];`

– Example:

```
int[] numbers = new int[10];
```

Note: **The size of an array is established at the time of creation and cannot be changed.** Array type can be primitive such as int and boolean or object reference type such as String or Point.

index	0	1	2	3	4	5	6	7	8	9
value	0	0	0	0	0	0	0	0	0	0

Array declaration, cont.

- The length can be any integer expression.

```
int x = 2 * 3 + 1;
int[] data = new int[x % 5 + 2];
```

- Each element initially gets a "zero-equivalent" value.

Type	Default value
`int`	`0`
`double`	`0.0`
`boolean`	`false`
`String` or other object	`null` (means, "no object")

Accessing elements

```
name[index]                     // access
name[index] = value;            // modify
```

– Example:

```
numbers[0] = 27;
numbers[3] = -6;

System.out.println(numbers[0]);
if (numbers[3] < 0) {
    System.out.println("Element 3 is negative.");
}
```

index	0	1	2	3	4	5	6	7	8	9
value	**27**	0	0	**-6**	0	0	0	0	0	0

Arrays of other types

```
double[] results = new double[5];
results[2] = 3.4;
results[4] = -0.5;
```

index	0	1	2	3	4
value	0.0	0.0	**3.4**	0.0	**-0.5**

```
boolean[] tests = new boolean[6];
tests[3] = true;
```

index	0	1	2	3	4	5
value	false	false	false	**true**	false	false

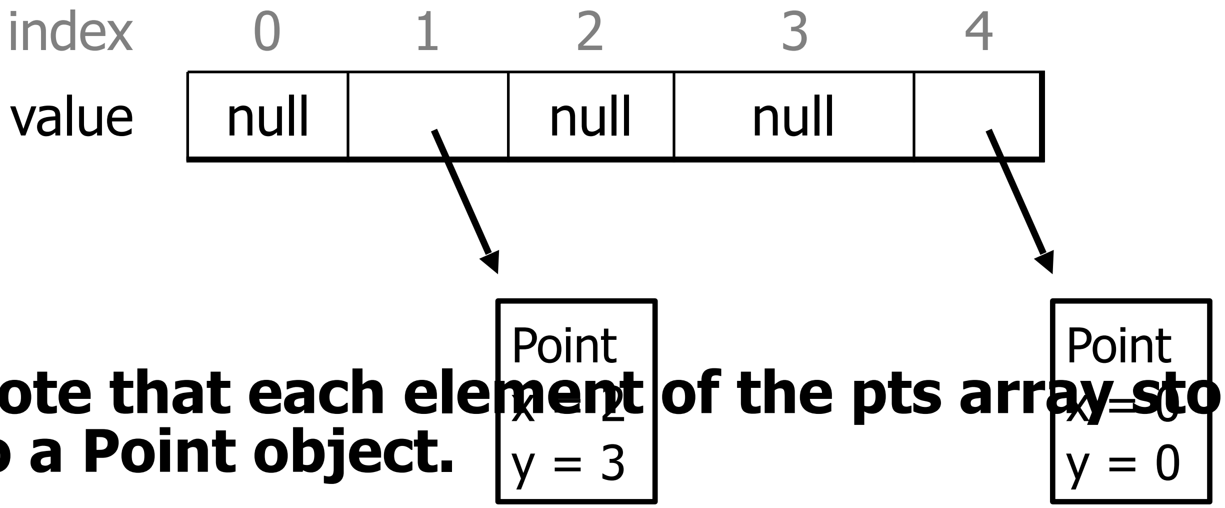
Arrays of other types

```
String[] words = new String[5];
words[1] = "hi";
words[3] = "hello";
```

index	0	1	2	3	4
value	null	**"hi"**	null	**"hello"**	null

Arrays of other types

```
Point[] pts = new Point[5];
pts[1] = new Point(2, 3);
pts[4] = new Point();
```



Note that each element of the pts array store the reference to a Point object.

Out-of-bounds

- Legal indexes: between **0** and the **array's length - 1**.
  - Reading or writing any index outside this range will throw an `ArrayIndexOutOfBoundsException`.

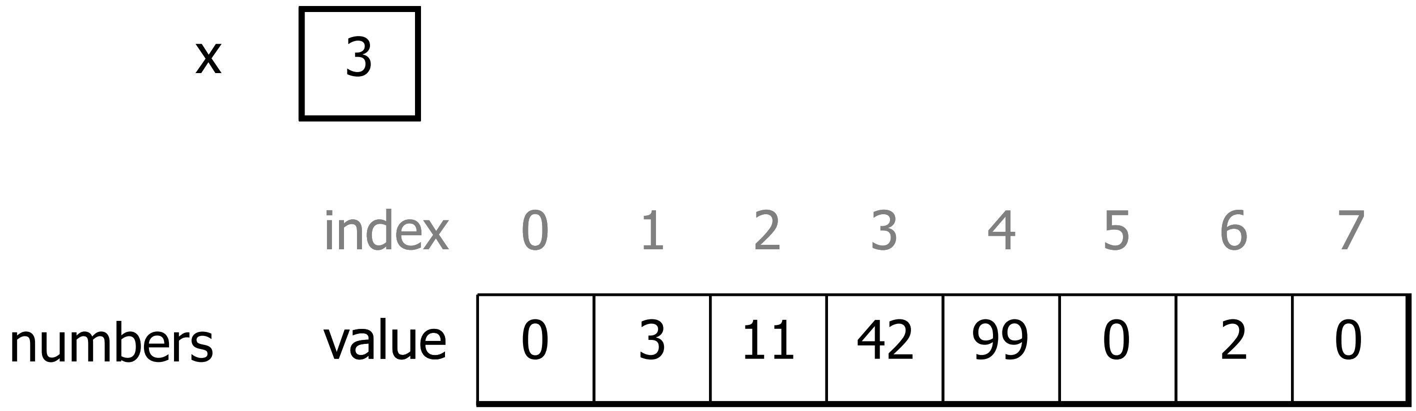
- Example:

```
int[] data = new int[10];
System.out.println(data[0]);        // okay
System.out.println(data[9]);        // okay
System.out.println(data[-1]);       // exception
System.out.println(data[10]);       // exception
```

index	0	1	2	3	4	5	6	7	8	9
value	0	0	0	0	0	0	0	0	0	0

Accessing array elements

```
int[] numbers = new int[8];
numbers[1] = 3;
numbers[4] = 99;
numbers[6] = 2;
int x = numbers[1];
numbers[x] = 42;
numbers[numbers[6]] = 11;
// use numbers[6] as index
```



Arrays and `for` loops

- It is common to use `for` loops to access array elements. This is called **traversing the array.**

```
for (int i = 0; i < 8; i++) {
    System.out.print(numbers[i] + " ");
}
System.out.println();  // output: 0 3 11 42 99 0 2 0
```

- Sometimes we assign each element a value in a loop.

```
for (int i = 0; i < 8; i++) {
    numbers[i] = 2 * i;
}
```

index	0	1	2	3	4	5	6	7
value	0	2	4	6	8	10	12	14

The `length` field

- An array's `length` field stores its number of elements.

  name`.length`

  ```
  for (int i = 0; i < numbers.length; i++) {
      System.out.print(numbers[i] + " ");
  }
  // output: 0 2 4 6 8 10 12 14
  ```

  – It does not use parentheses like a String's `.length()`.

- What expressions refer to:
  – The last element of any array?
  – The middle element?

numbers.length - 1

numbers.length/2, if length is even, this element is the first element of the second half of the array.

Arrays and `while` loops

While loop can also be used to traverse the array. The following compute the sum of an array using a while loop and a for loop. Note the difference. In both cases, this requires the elements of the array to be accessed by the indices(i).

While Loop:

```
int sum = 0;
int i = 0;
while(i < numbers.length){
    sum += numbers[i];
    i++;
}
```

For Loop:

```
int sum = 0;
for(int i = 0; i < numbers.length; i++){
    sum += numbers[i];
}
```

Typically, traversing an array is best done with a for loop.

Quick array initialization

Arrays can be used created quickly using **initializer lists**.

type`[]` **name** `=` `{`**value**`,` **value**`,` … **value**`};`

– Example:

```
int[] numbers = {12, 49, -2, 26, 5, 17, -6};
```

index	0	1	2	3	4	5	6
value	12	49	-2	26	5	17	-6

– Useful when you know what the array's elements will be

– The compiler figures out the size by counting the values

"Array mystery" problem

What element values are stored in the following array?

```
int[] a = {1, 7, 5, 6, 4, 14, 11};
for (int i = 0; i < a.length - 1; i++) {
    if (a[i] > a[i + 1]) {
        a[i + 1] = a[i + 1] * 2;
    }
}
```

index	0	1	2	3	4	5	6
value	1	7	10	12	8	14	22

Limitations of arrays

- You cannot resize an existing array:

```
int[] a = new int[4];
a.length = 10;              // error
```

- You cannot compare arrays with `==` or `equals`:

```
int[] a1 = {42, -7, 1, 15};
int[] a2 = {42, -7, 1, 15};
if (a1 == a2) { ... }              // false!
if (a1.equals(a2)) { ... }         // false!
```

- An array does not know how to print itself:

```
int[] a1 = {42, -7, 1, 15};
System.out.println(a1);            // [I@98f8c4]
```

Arrays.toString

```
public static void main(String[] args) {
      int[] a = {0, 14, 4, 6, 8};
      System.out.println(a);
}
```

Output: `I@674f1c67` 6. (14 pts)

Prints out the address not the contents of a.

`Arrays.toString` accepts an array as a parameter and returns a `String` representation of its elements.

- Must `import java.util.*;`
- `Arrays` is one of the classes in the util's package.

Arrays.toString

```
import java.util.*;

public class Example
public static void main(String[] args) {
     int[] a = {0, 14, 4, 6, 8};
     System.out.println("a is " +
                      Arrays.toString(a));
}
```

Output:

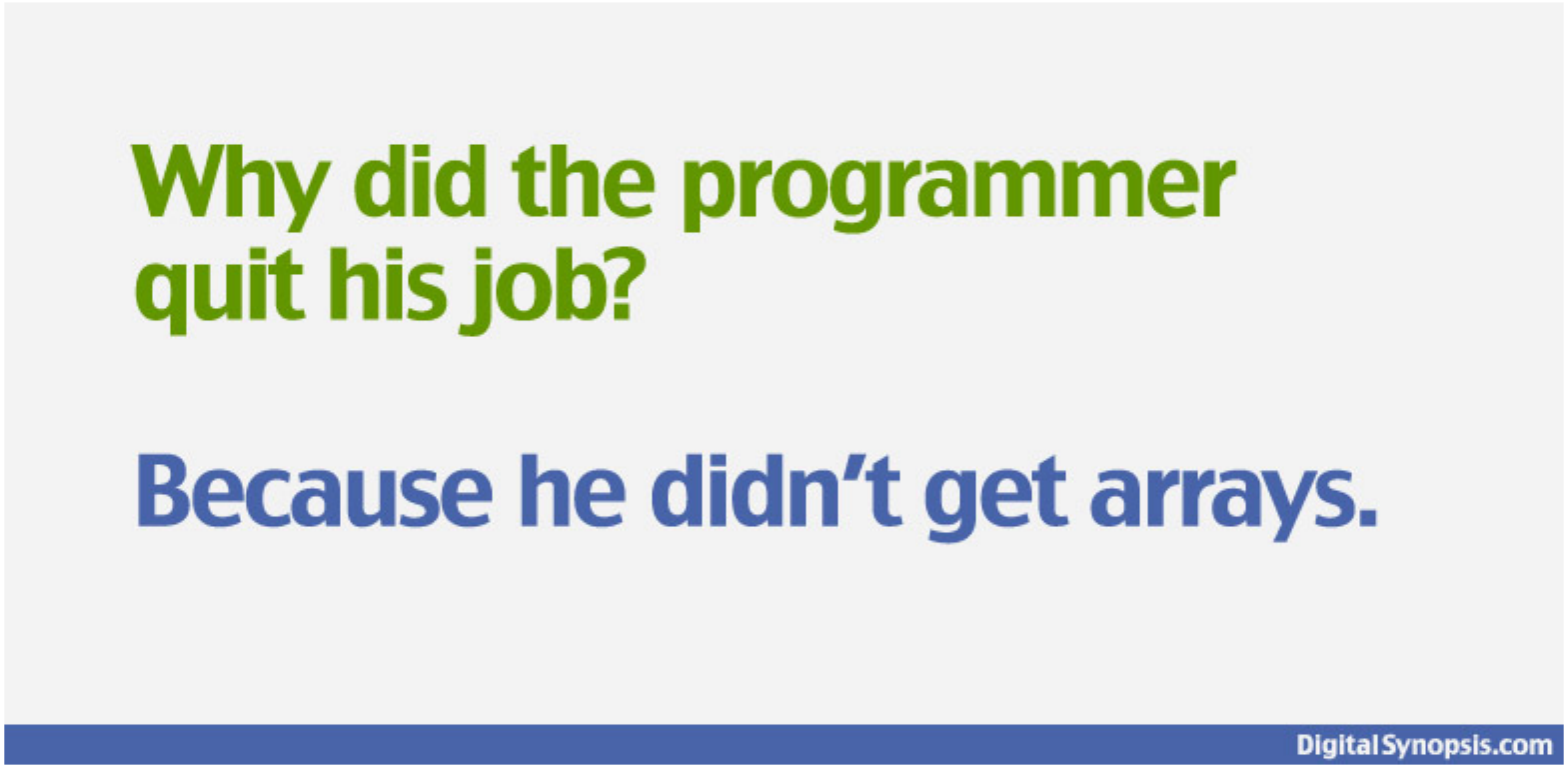
```
a is [0, 14, 4, 6, 8]
```

Arrays

```
String[] a={"hip", "hip"};

//hip hip arrays!
```

Arrays



Why did the programmer quit his job?

Because he didn't get arrays.

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He didn't get arrays and he didn't get a raise.

Array Lab 1

Write the method `average` which accepts an int array and returns the average of the values.

Write the method `countAboveAve` which accepts an int array and returns the number of values that are above the average. You must call `average`.

Write the method `largest` which accepts an int array and returns the largest value of the array.

Write the method `indexOfsmallest` which accepts an int array and returns the index of the smallest value. If there are multiple smallest values, return the index of the first one.

Array Lab 1

Also write the main method with an array and check to make sure your methods work!

```
public static double average(int[] array){}
public static int countAboveAve(int[] array){}
public static int largest(int[] array){}
public static int indexOfsmallest(int[] array){}
```

Array Lab 2

This lab is on Processing.

Write the Ball class with attributes center_x, center_y, change_x, change_y, radius(floats) and a color.

Methods:
update()
display()

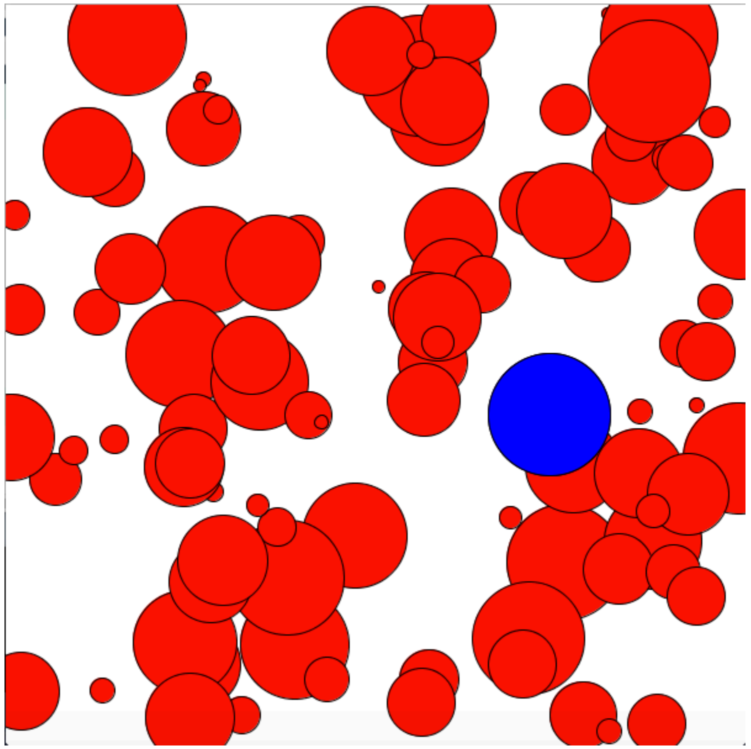
Make it bounce on the screen. We have done this before but the the ball was not an object.

Array Lab 2

Create an array of ball objects and make it move on the screen!

Write a method largestBall
that returns the largest Ball
and set it to a different color.

There's a .pde template file
on my github website if you need
some help.



References

1) CPJava Website
2) CPJava Google Classroom
3) CPJava trinket.io Classroom
4) Runestone CSAwesome BUSHSCHOOL_CPJAVA Course
5) Online Textbook Think Java - 2nd Edition by Allen Downey and Chris Mayfield
6) Building Java Programs: A Back to Basics Approach by Stuart Reges and Marty Stepp