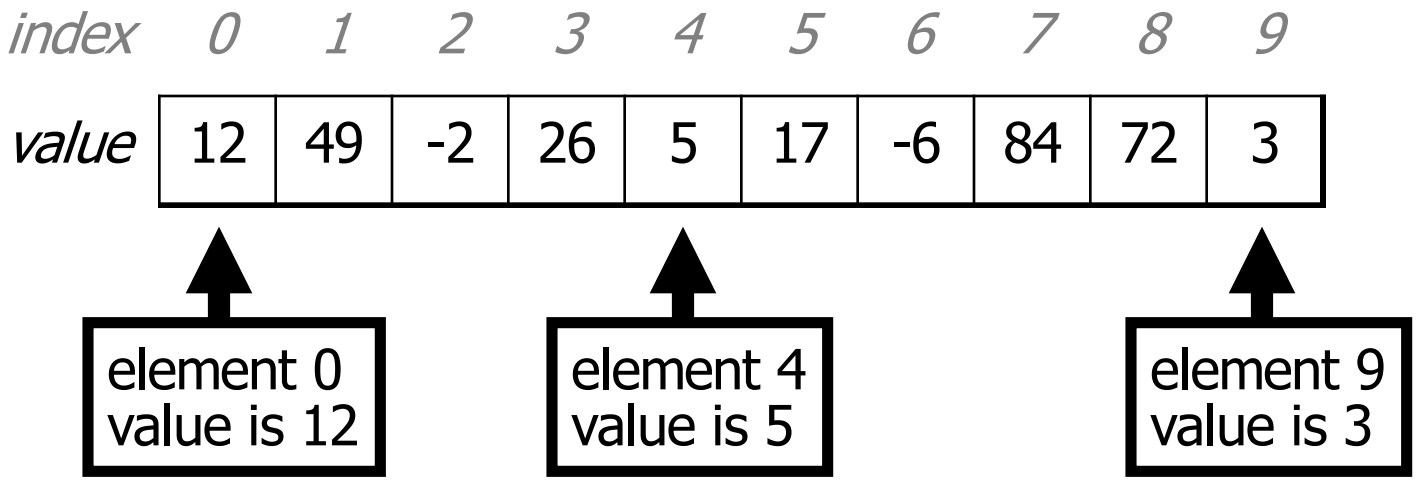
Lecture 10: Arrays

AP Computer Science Principles

Arrays

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

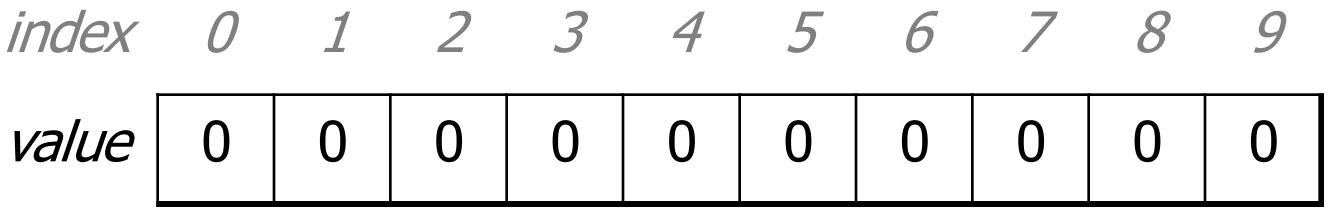


Array declaration

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

- Example:

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



Array declaration, cont.

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

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

Accessing elements

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

- Example:

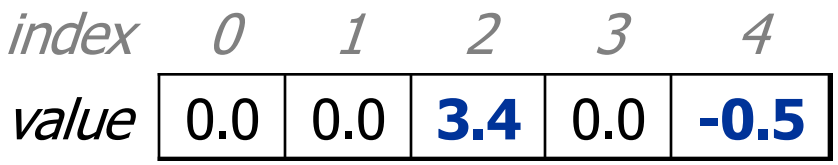
```
numbers[0] = 27;
numbers[3] = -6;

println(numbers[0]); // 27
if (numbers[3] < 0) {
    println("Element 3 is negative.");
}
```

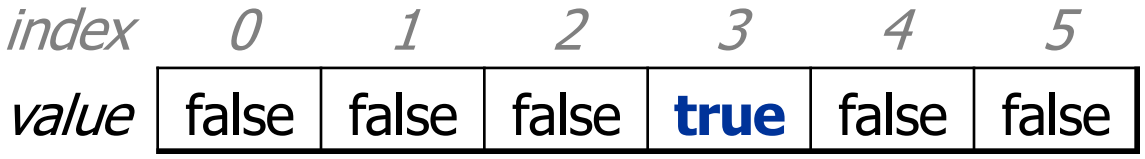
index	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
value	**27**	0	0	**-6**	0	0	0	0	0	0

Arrays of other types

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




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

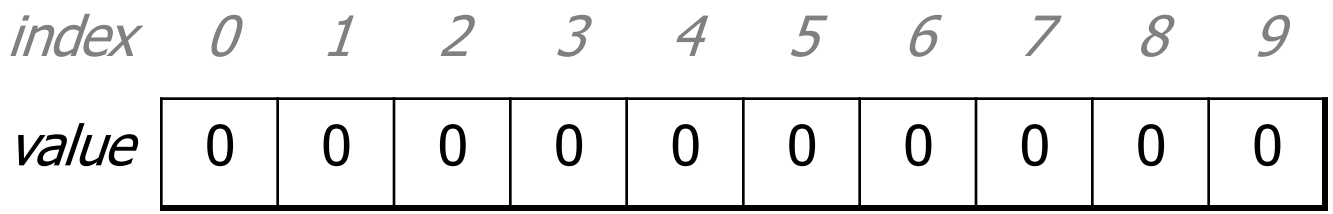


Out-of-bounds

- 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];
println(data[0]);          // okay
println(data[9]);          // okay
println(data[-1]);         // exception
println(data[10]);         // exception
```



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
```

x

3

	index	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*
numbers	*value*	0	3	11	42	99	0	2	0

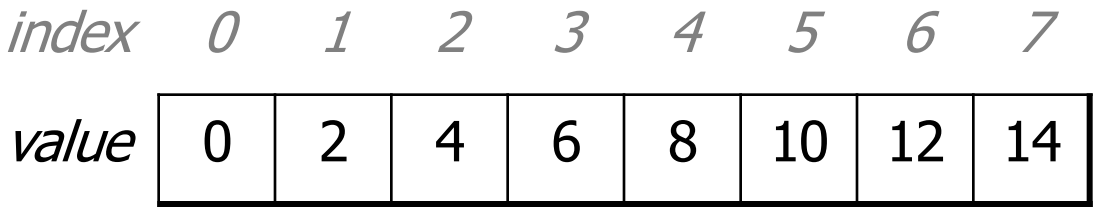
Arrays and `for` loops

- It is common to use `for` loops to access array elements.

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



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
```

- What expressions refer to:
  - The last element of any array? `numbers[numbers.length-1]`
  - The middle element? `numbers[numbers.length/2]`

Quick array initialization

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

- **traversal**: An examination of each element of an array.
- 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;
    }
}
```

"Array mystery" problem

- **traversal**: An examination of each element of an array.
- 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!
// the above compare whether a1 and a2 are the same objects.
```

- An array does not know how to print itself:

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

printArray(array)

```
int[] e = {1, -2, 4};
printArray(e);
```

Output:

[0] 1
[1] -2
[2] 4

Finding the largest Value

Given an array, return the the largest value in the array.

```
void setup(){
int[] a = {1,-5,5,7,56,23};
int large = largest(a); // large = 56
}
int largest(int[] array){
      int largest = array[0];
      for(int i = 1; i < array.length; i++){
            if(array[i] > largest)
                  largest = array[i];
      }
      return largest;
}
```

Reference semantics

Value semantics

- **value semantics**: When primitive variables (`int`, `float`, `boolean`) and String are passed as parameters, their values are copied. Modifying the parameter will not affect the variable passed in.

```
void setup() {
    int x = 23;
    strange(x);
    println("2. x = " + x);
}
void strange(int x) {
   x = x + 1;
   println("1. x = " + x);
}
```

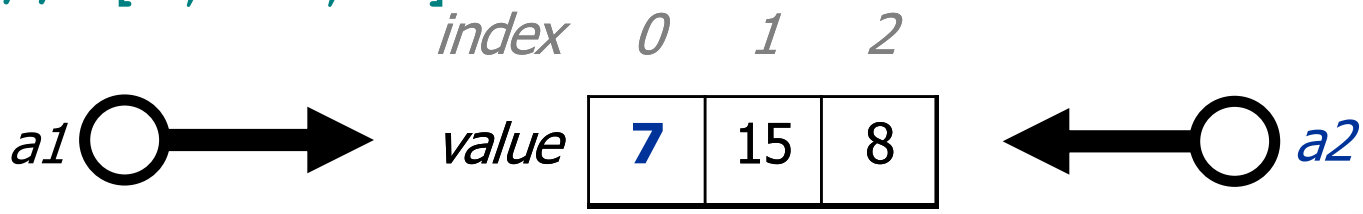
Output:

```
1. x = 24
2. x = 23
```

Reference semantics (objects)

- **reference semantics**: Behavior where variables actually store the address of an object in memory.
  - When one variable is assigned to another, the object is *not* copied; both variables refer to the *same object*.
  - Modifying the value of one variable *will* affect others.

```
int[] a1 = {4, 15, 8};
int[] a2 = a1;// refer to same array as a1
a2[0] = 7;
System.out.println(Arrays.toString(a1));
// [7, 15, 8]
```



Objects as parameters

- Arrays and objects(except String) use reference semantics. Why?
  - *efficiency.* Copying large objects slows down a program.
  - *sharing.* It's useful to share an object's data among methods.

- When an object is passed as a parameter, the object is *not* copied. The parameter refers to the same object.
  - If the parameter is modified, it *will* affect the original object.

- Arrays are passed as parameters by *reference.*
  - Changes made in the method are also seen by the caller.

Value Semantics

Example:

```
void setup(){
    int x = 2;
    triple(x);
    println(x); // 2

}
void triple(int number) {
    number = number * 3;
}
```

Value Semantics

String uses value semantics like primitive types.

Example:

```
void setup(){
      String str = “hi”;
      twice(str);
      println(str); // “hi”
}
void twice(String str) {
      str = str + str;
}
```

Reference Semantics

Example:

```
void setup() {
  int[] arr = {0,1,2,3};
  triple(arr);
  printArray(arr);  //{0,3,6,9}
}
void triple(int[] numbers) {
  for (int i = 0; i < numbers.length; i++) {
      numbers[i] = numbers[i] * 3;
  }
}
```

Arrays

```
String[] a = [“hip”, “hip”];

//hip hip arrays!
```

Arrays

Why did the programmer quit his job?

Because he didn’t get arrays.

(He didn’t get arrays and 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 `indexOfLargest` which accepts an int array and returns the index of the largest value. If there are multiple largest values, return the index of the first one.

Write the method `equals` which accept two integer arrays and determine if they have the same value.

Lab 1 Outline

Write the setup() method to test your methods.

```
void setup(){
        int[] a = {1, 3, 2, 5, -4, -7};
        println(indexOfLargest(a)); // should be 3
}
float average(int[] array){
}
int countAboveAve(int[] array){
}
int indexOfLargest(int[] array){
}
boolean equals(int[] a, int[] b){
}
```

Lab 2

Due: Tues, Oct 6.

In Array-1, do:
makeMiddle, commonEnd, midThree and swapEnds

In Array-2, do:
countEvens, lucky13, no14 and sum28

Array Lab 3

Write a program generate a large number of balls with random starting position that moves left and right at random speeds.

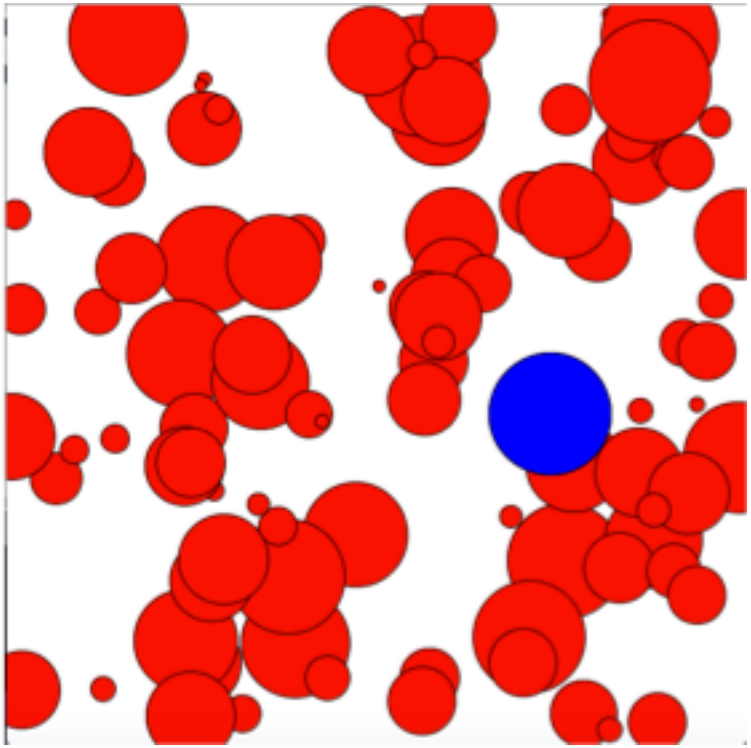
You'll need 4 arrays: an array for x positions, an array for y positions, an array for its xspeed and one more for its diameter(or radius).

The setup() method randomizes position, speed and diameters with a for loop.

The draw() method draw and moves and bounces the balls.

Array Lab 3

Add the method `indexLargest` which returns the index of the largest ball. Draw this largest ball in blue. The .pde template file can be found on Classroom.



References

Part of this lecture is taken from the following book.

1) Stuart Reges and Marty Stepp. Building Java Programs: A Back to Basics Approach. Pearson Education. 2008.