Building Java Programs

Chapter 7
Arrays as Parameters

reading: 7.1-7.3
Why did the programmer quit his job?

Because he didn't get arrays.
Array parameter (declare)

public static type methodName(type[] name) {

• Example:

  // Returns the average of the given array of numbers.
  public static double average(int[] numbers) {
      int sum = 0;
      for (int i = 0; i < numbers.length; i++) {
          sum += numbers[i];
      }
      return (double) sum / numbers.length;
  }

• You don't specify the array's length (but you can examine it).
Array parameter (call)

methodName(arrayName);

- Example:

```java
class MyProgram {
    public static void main(String[] args) {
        // figure out the average TA IQ
        int[] iq = {126, 84, 149, 167, 95};
        double avg = average(iq);
        System.out.println("Average IQ = "+ avg);
    }
    ...
}
```

- Notice that you don't write the [] when passing the array.
Array return (declare)

public static type[] methodName(parameters) {

• Example:

// Returns a new array with two copies of each value.
// Example: [1, 4, 0, 7] -> [1, 1, 4, 4, 0, 0, 7, 7]
public static int[] double(int[] numbers) {
    int[] result = new int[2 * numbers.length];
    for (int i = 0; i < numbers.length; i++) {
        result[2 * i] = numbers[i];
        result[2 * i + 1] = numbers[i];
    }
    return result;
}
Array return (call)

```
type[] name = methodName(parameters);
```

- **Example:**
  ```java
  public class MyProgram {
      public static void main(String[] args) {
          int[] iq = {126, 84, 149, 167, 95};
          int[] doubled = double(iq);
          System.out.println(Arrays.toString(doubled));
      }
  }
  ...
  
  - **Output:**
  
  [126, 126, 84, 84, 149, 149, 167, 167, 95, 95]
Array reversal question

- Write code that reverses the elements of an array.

  - For example, if the array initially stores:
    
    \[11, 42, -5, 27, 0, 89\]

  - Then after your reversal code, it should store:
    
    \[89, 0, 27, -5, 42, 11\]

- The code should work for an array of any size.
- Don’t make an extra array. Reverse the original array
- Hint: think about swapping various elements...
Algorithm idea

- Swap pairs of elements from the edges; work inwards:

<table>
<thead>
<tr>
<th>index</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>value</td>
<td>89</td>
<td>0</td>
<td>27</td>
<td>-5</td>
<td>42</td>
<td>11</td>
</tr>
</tbody>
</table>

↑  ↑  ↑  ↑  ↑  ↑
public static void main(String[] args) {
    int a = 7;
    int b = 35;

    // swap a with b?
    a = b;
    b = a;

    System.out.println(a + " " + b);
}

• What is wrong with this code? What is its output?

• The red code should be replaced with:

    int temp = a;
    a = b;
    b = temp;
Flawed algorithm

- What's wrong with this code?

```java
int[] numbers = [11, 42, -5, 27, 0, 89];

// reverse the array
for (int i = 0; i < numbers.length; i++) {
    int temp = numbers[i];
    numbers[i] = numbers[numbers.length - 1 - i];
    numbers[numbers.length - 1 - i] = temp;
}
```

- The loop goes too far and un-reverses the array! Fixed version:

```java
for (int i = 0; i < numbers.length / 2; i++) {
    int temp = numbers[i];
    numbers[i] = numbers[numbers.length - 1 - i];
    numbers[numbers.length - 1 - i] = temp;
}
```
Array reverse question 2

- Turn your array reversal code into a reverse method.
  - Accept the array of integers to reverse as a parameter.

```java
int[] numbers = {11, 42, -5, 27, 0, 89};
reverse(numbers);
```

- How do we write methods that accept arrays as parameters?
- Will we need to return the new array contents after reversal?
...
Reference semantics

reading: 7.3
A swap method?

• Does the following swap method work? Why or why not?

```java
public static void main(String[] args) {
    int a = 7;
    int b = 35;

    // swap a with b?
    swap(a, b);
    System.out.println(a + " " + b);
}

public static void swap(int a, int b) {
    int temp = a;
    a = b;
    b = temp;
}
```
Value semantics

- **value semantics**: Behavior where values are copied when assigned, passed as parameters, or returned.
  - All primitive types in Java use value semantics.
  - When one variable is assigned to another, its value is copied.
  - Modifying the value of one variable does not affect others.

```java
int x = 5;
int y = x;   // x = 5, y = 5
y = 17;     // x = 5, y = 17
x = 8;      // x = 8, y = 17
```
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.

```java
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]
```

References and objects

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

```java
DrawingPanel panel1 = new DrawingPanel(80, 50);
DrawingPanel panel2 = panel1;  // same window  
panel2.setBackground(Color.CYAN);
```

![Diagram of panel1 and panel2]
cats1

```java
cat[] cats1 = {🐱, 🐱, 🐱, 🐱};
cat[] cats2 = cats1;
```

cats2
```cpp
/*
 * dogs1
 */

dog[] dogs1 = {🐶, 🐶, 🐶 };
dog[] dogs2 = dogs1;
```

---

![Image of dogs in boxes]
Value/Reference Semantics

- Variables of primitive types store values directly:
  
  \[
  \begin{array}{c}
  \text{age} \\
  \hline
  20
  \end{array}
  \quad
  \begin{array}{c}
  \text{cats} \\
  \hline
  3
  \end{array}
  \]

- Values are copied from one variable to another:
  
  \[
  \text{cats} = \text{age};
  \]
  
  \[
  \begin{array}{c}
  \text{age} \\
  \hline
  20
  \end{array}
  \quad
  \begin{array}{c}
  \text{cats} \\
  \hline
  20
  \end{array}
  \]

- Variables of object types store references to memory:

  \[
  \begin{array}{c}
  \text{grades} \\
  \hline
  \end{array}
  \quad
  \begin{array}{c}
  \text{index} \\
  \hline
  0 \quad 1 \quad 2
  \end{array}
  \quad
  \begin{array}{c}
  \text{value} \\
  \hline
  89 \quad 78 \quad 93
  \end{array}
  \]

- References are copied from one variable to another:
  
  \[
  \text{scores} = \text{grades};
  \]
  
  \[
  \text{scores}
  \]
Objects as parameters

- 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.

```java
public static void main(String[] args) {
    DrawingPanel window = new DrawingPanel(80, 50);
    window.setBackground(Color.YELLOW);
    example(window);
}

public static void example(DrawingPanel panel) {
    panel.setBackground(Color.CYAN);
    ...
}
```

- window
- panel
Arrays pass by reference

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

```java
public static void main(String[] args) {
    int[] iq = {126, 167, 95};
    increase(iq);
    System.out.println(Arrays.toString(iq));
}

public static void increase(int[] a) {
    for (int i = 0; i < a.length; i++) {
        a[i] = a[i] * 2;
    }
}
```

- Output:
  
<table>
<thead>
<tr>
<th>index</th>
<th>0</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>value</td>
<td>252</td>
<td>334</td>
<td>190</td>
</tr>
</tbody>
</table>

- *iq*
Array reverse question 2

- Turn your array reversal code into a `reverse` method.
  - Accept the array of integers to reverse as a parameter.

```java
int[] numbers = {11, 42, -5, 27, 0, 89};
reverse(numbers);
```

- Solution:
  ```java
  public static void reverse(int[] numbers) {
      for (int i = 0; i < numbers.length / 2; i++) {
          int temp = numbers[i];
          numbers[i] = numbers[numbers.length - 1 - i];
          numbers[numbers.length - 1 - i] = temp;
      }
  }
  ```
Array parameter questions

- Write a method `swap` that accepts an arrays of integers and two indexes and swaps the elements at those indexes.
  
  ```java
  int[] a1 = {12, 34, 56};
  swap(a1, 1, 2);
  System.out.println(Arrays.toString(a1)); // [12, 56, 34]
  ```

- Write a method `swapAll` that accepts two arrays of integers as parameters and swaps their entire contents.

  - Assume that the two arrays are the same length.

  ```java
  int[] a1 = {12, 34, 56};
  int[] a2 = {20, 50, 80};
  swapAll(a1, a2);
  System.out.println(Arrays.toString(a1)); // [20, 50, 80]
  System.out.println(Arrays.toString(a2)); // [12, 34, 56]
  ```
Array parameter answers

// Swaps the values at the given two indexes.
public static void swap(int[] a, int i, int j) {
    int temp = a[i];
    a[i] = a[j];
    a[j] = temp;
}

// Swaps the entire contents of a1 with those of a2.
public static void swapAll(int[] a1, int[] a2) {
    for (int i = 0; i < a1.length; i++) {
        int temp = a1[i];
        a1[i] = a2[i];
        a2[i] = temp;
    }
}
Array return question

- Write a method `merge` that accepts two arrays of integers and returns a new array containing all elements of the first array followed by all elements of the second.

  ```java
  int[] a1 = {12, 34, 56};
  int[] a2 = {7, 8, 9, 10};

  int[] a3 = merge(a1, a2);
  System.out.println(Arrays.toString(a3));
  // [12, 34, 56, 7, 8, 9, 10]
  ```

- Write a method `merge3` that merges 3 arrays similarly.

  ```java
  int[] a1 = {12, 34, 56};
  int[] a2 = {7, 8, 9, 10};
  int[] a3 = {444, 222, -1};

  int[] a4 = merge3(a1, a2, a3);
  System.out.println(Arrays.toString(a4));
  // [12, 34, 56, 7, 8, 9, 10, 444, 222, -1]
  ```
// Returns a new array containing all elements of a1
// followed by all elements of a2.
public static int[] merge(int[] a1, int[] a2) {
    int[] result = new int[a1.length + a2.length];
    for (int i = 0; i < a1.length; i++) {
        result[i] = a1[i];
    }
    for (int i = 0; i < a2.length; i++) {
        result[a1.length + i] = a2[i];
    }
    return result;
}
// Returns a new array containing all elements of a1, a2, a3.
public static int[] merge3(int[] a1, int[] a2, int[] a3) {
    int[] a4 = new int[a1.length + a2.length + a3.length];
    for (int i = 0; i < a1.length; i++) {
        a4[i] = a1[i];
    }
    for (int i = 0; i < a2.length; i++) {
        a4[a1.length + i] = a2[i];
    }
    for (int i = 0; i < a3.length; i++) {
        a4[a1.length + a2.length + i] = a3[i];
    }
    return a4;
}

// Shorter version that calls merge.
public static int[] merge3(int[] a1, int[] a2, int[] a3) {
    return merge(merge(a1, a2), a3);
}
"Array mystery" problem

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

- What element values are stored in the following array?

```java
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;
    }
}
```

<table>
<thead>
<tr>
<th>index</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>value</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>