Array 1

Programming Fundamentals Teaching Team 2023

Objectives

After studying this material, students should be able to:

- Understand the concept of 1-dimensional arrays
- Provide examples of the use of 1-dimensional arrays
- Solve simple searching and sorting case studies

Outlines

- Preface
- Declaration and Instantiation
- Accessing and filling array data
- Array Element Length
- Searching
- Sorting
- Exercise

Preface

- How do we store large amounts of data that have similar data types and values?
- Example: Storing the grades of all Polinema students
  - We need to declare thousands of variables
  - Each variable name must be unique
  - The operations performed for each variable have the same value. Example:
    - The operation prints the value
    - Convert numeric to letter grades

Preface

- In mathematics, in a matrix that has matrix elements, the matrix elements are written using indexed variables.
- Suppose a matrix A [5,5] with dimension 5x5 will have matrix elements, namely a_{00} to a_{44}
- In computer programming, the implementation of indexed variables uses arrays. So that the array can be one or more dimensions.

Definition

- An array is a complex variable with the **same data type**, using the **same name**, and having a **certain index**.
- In other words, an array is a set of values (elements) with the same data type, where each array element can be accessed using a unique index.

Array Properties

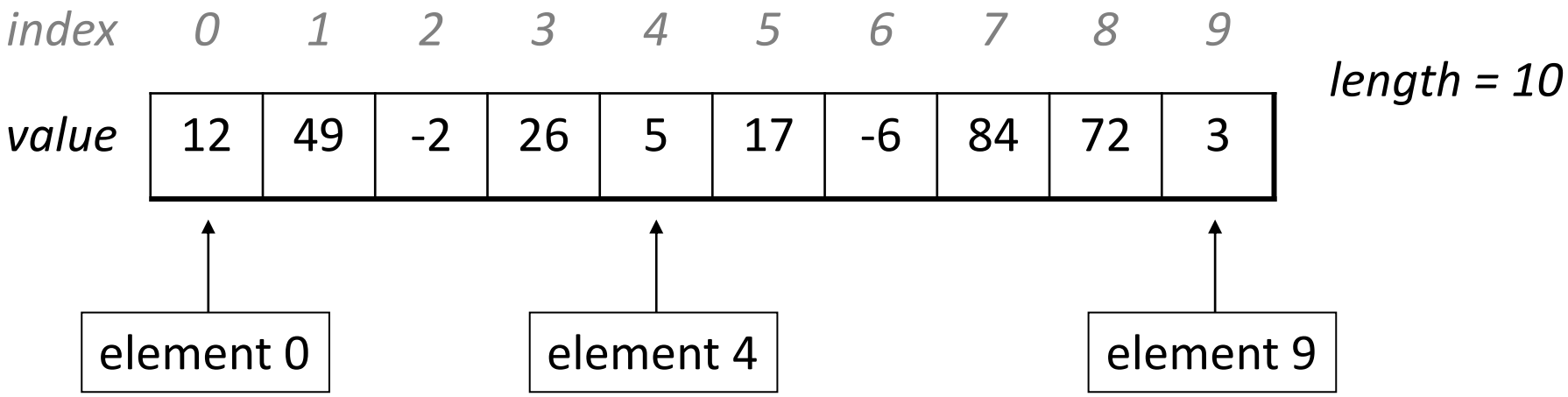
- Homogeneous
  - All elements in the array structure have the same data type.
- Random Access
  - Each element in the array structure can be accessed individually, directly to the desired element location, not necessarily through the first element.
- Is a reference variable

Array Visualization

- Suppose there is an array named **a** with 10 elements (N = 10), the array elements can be described as follows:

- The empty box shows the elements of the Array
- Each element has a numbering 0-9 (index)
- Array index **starts at 0** and ends with **N-1**

Array Visualization



One Dimensional Array Declaration

- Declaration

```
dataType arrayName[];
```

or

```
dataType[] arrayName;
```

Example:
```
int a[];
int[] a;
```

- **dataType** is the data type of the array to be created
- **arrayName** is the name of the array to be created

One Dimensional Array Instantiation

Array object instantiation:

- When an array is declared, only references from the array are created. Meanwhile, memory allocation is done using the **new** keyword
- How to instantiate array variables:

```
arrayName = new dataType[numberOfElements];
```

Example: `a = new int[10];`

One Dimensional Array

- The declaration and instantiation of an array object can be combined in an instruction as follows:

```
dataType[] arrayName = new dataType[numberOfElements];
```

or

```
dataType arrayName[] = new dataType[numberOfElements];
```

- Example:

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

or

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

Accessing Array Elements

- Refers to the index number

```
arrayName[index]
```

- Example:
  - Accessing an array variable **a** with index **i** can be written:

```
a[i]
```

  - Index **i** can only be **0 or positive** with the maximum value is **numberOfElements - 1**

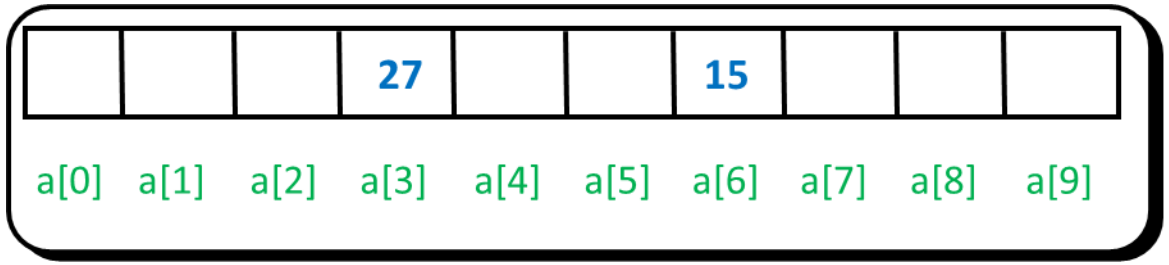
Accessing Array Elements

- Example:

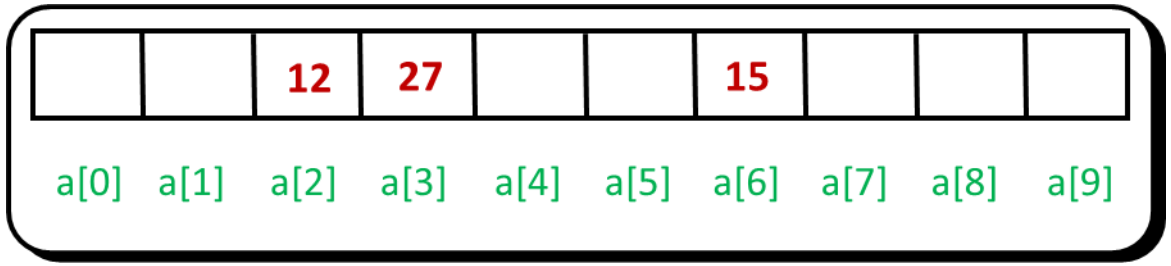
```
String[] cars = {"Volvo", "BMW", "Ford”};
System.out.println(cars[0]); //displays Volvo
System.out.println(cars[2]); //displays Ford
```

Fill in Data on Array

- Filling data to array elements is done using assignment operators
- Example: `a[6] = 15;  a[3] = 27;`

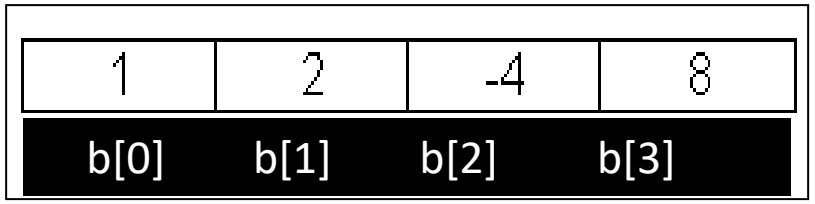


- Statement `a[2] = a[3] - a[6];` resulting:



Array Initialization

- Arrays can be explicitly initialized when defined and may not be assigned a dimension value.
- Example: `int b[ ]={1, 2, -4, 8};`



- Example: `int b[]={1, 2, -4, 8,0,0,0,0};`

Example of Array Initialization

- `boolean results[] = { true, false, true, false };`
- `String[] cars = {"Volvo", "BMW", "Ford”};`
- `int[] myNum = {10, 20, 30, 40};`
- `double []grades = {100, 90, 80, 75};`
- `String days[] = { “Monday”, “Tuesday”, “Wednesday”, “Thursday”, “Friday”, “Saturday”, “Sunday”};`

Replacing Array Elements

- `String[] cars = {"Volvo", "BMW", "Ford”};`

  Result:

Volvo	BMW	Ford
cars[0]	cars[1]	cars[2]

- `cars[0] = "Opel";`

  Result:

Opel	BMW	Ford
cars[0]	cars[1]	cars[2]

Get the Length of an Array

- You can get the length of an array using

  ***arrayName*.length**

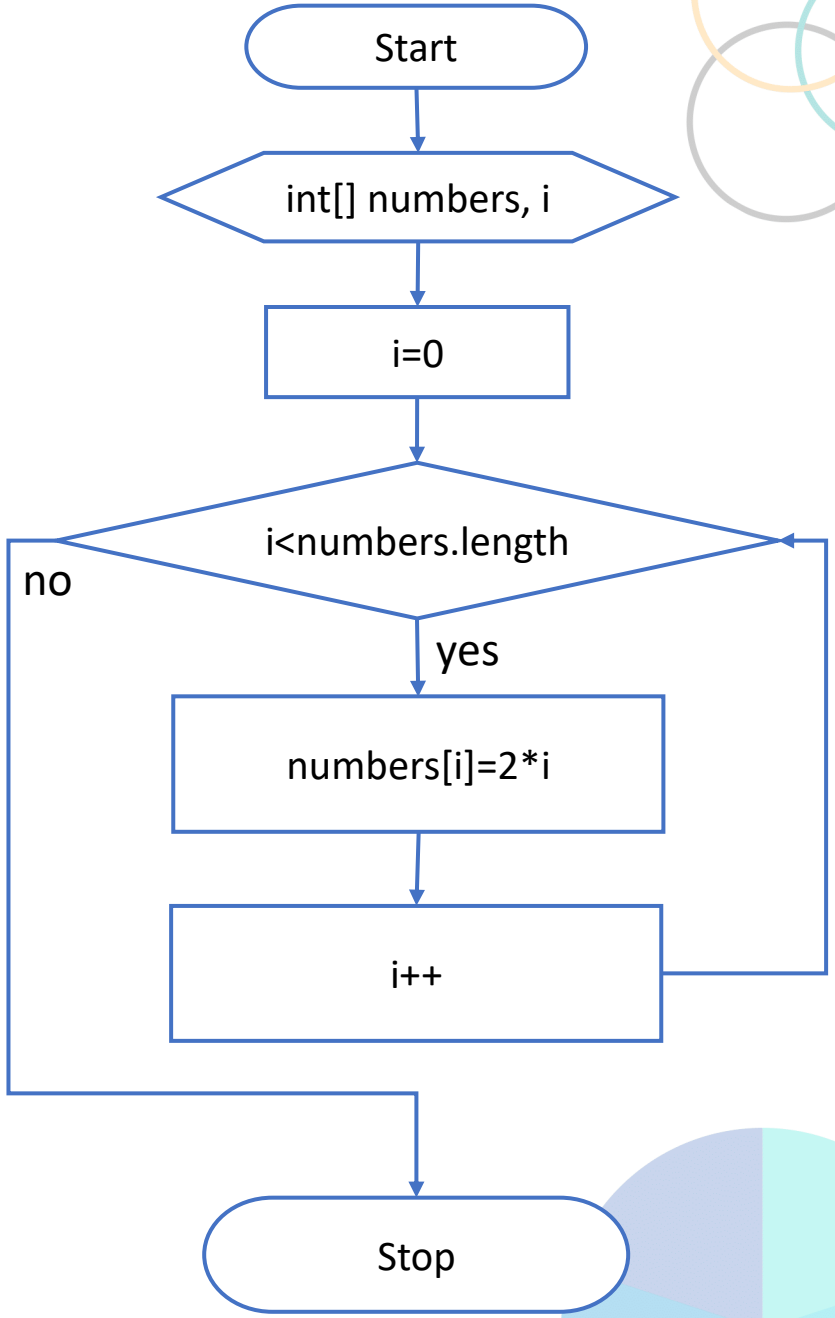
- Examples of using the length of an array:
  - What is the index of the last element of an array?
  - What is the index of the middle element of an array?

Array Loop

- We can use the length of the array, together with its index, to perform some operations using loops.
- For example, we can efficiently initialize an array.

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

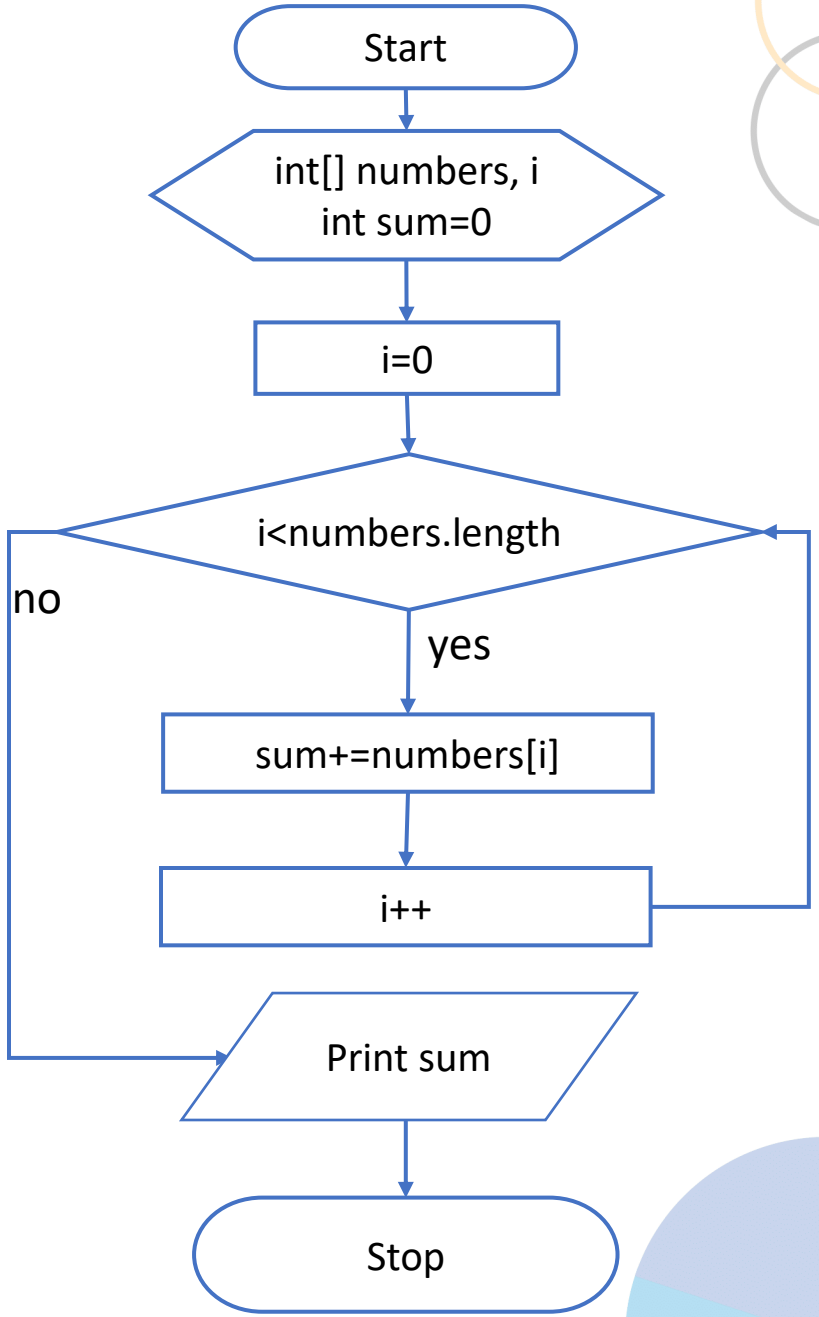
index	0	1	2	3	4	5	6	7
value	0	2	4	6	8	10	12	14



Example of Array Loop

- Sum all the elements of the array

```
// assume that the user has created int[] numbers
int sum = 0;
for (int i = 0; i < numbers.length; i++)
{
      sum += numbers[i];
}
println(sum);
```



Array Loop

for-each loop

- This is another form of a for loop that is used to traverse arrays
- for-each loop reduces code significantly and there is no indexes or counters inside the loop
- Syntax:

```
for(dataType tempVar : arrayName){
    //statement
}
```

tempVar: temporary variable for looping process

Example of Array Loop

- Access all array elements using the "**for-each**" loop

```
int array[] = {33, 4, 5, 23, 1, 5, 6};
//initialization array -> specifies the number of arrays
//and fill in the value of each array element

for (int i : array) { //displays each element of the array
    System.out.println(i);
}
```

Output:

```
33
4
5
23
1
5
6
```

Example of Array Loop

```java
import java.util.Scanner;

public class Motorcycle {
    public static void main(String[] args) {

        // create an array with the name motorcycle
        String[] motorcycle = new String[5];

        // create a scanner
        Scanner scan = new Scanner(System.in);

        // fill the data into an array
        for (int i = 0; i < motorcycle.length; i++) {
            System.out.print("Motorcycle " + i + ": ");
            motorcycle[i] = scan.nextLine();
        }

        System.out.println("----------------------------");

        // displays all the contents of the array
        for (String b : motorcycle) {
            System.out.println(b);
        }
    }
}
```

Output:

```
Motorcycle 0: Mio
Motorcycle 1: Vario
Motorcycle 2: Beat
Motorcycle 3: Nmax
Motorcycle 4: Nex
----------------------------
Mio
Vario
Beat
Nmax
Nex
```

Difference with or without Array

```
int number1 = 1;
int number2 = 2;
int number3 = 3;
```

<< without array

```
int number[] = {1, 2, 3};
```

<< with array

Array Usage Steps

1. Declare an array reference variable
2. Array element instantiation
3. Initialize array (if needed)
4. Manipulate array elements

Example of Incorrect Array Initialization

- Example: `int b[4] = { 1, 2, -4, 8, 9 };`
  - **ERROR** because the dimension value is smaller than the number of elements

- Example:
  - Initialize array after being defined incorrectly

```
int b[5];
b[5]={0,0,0,0,0};
```

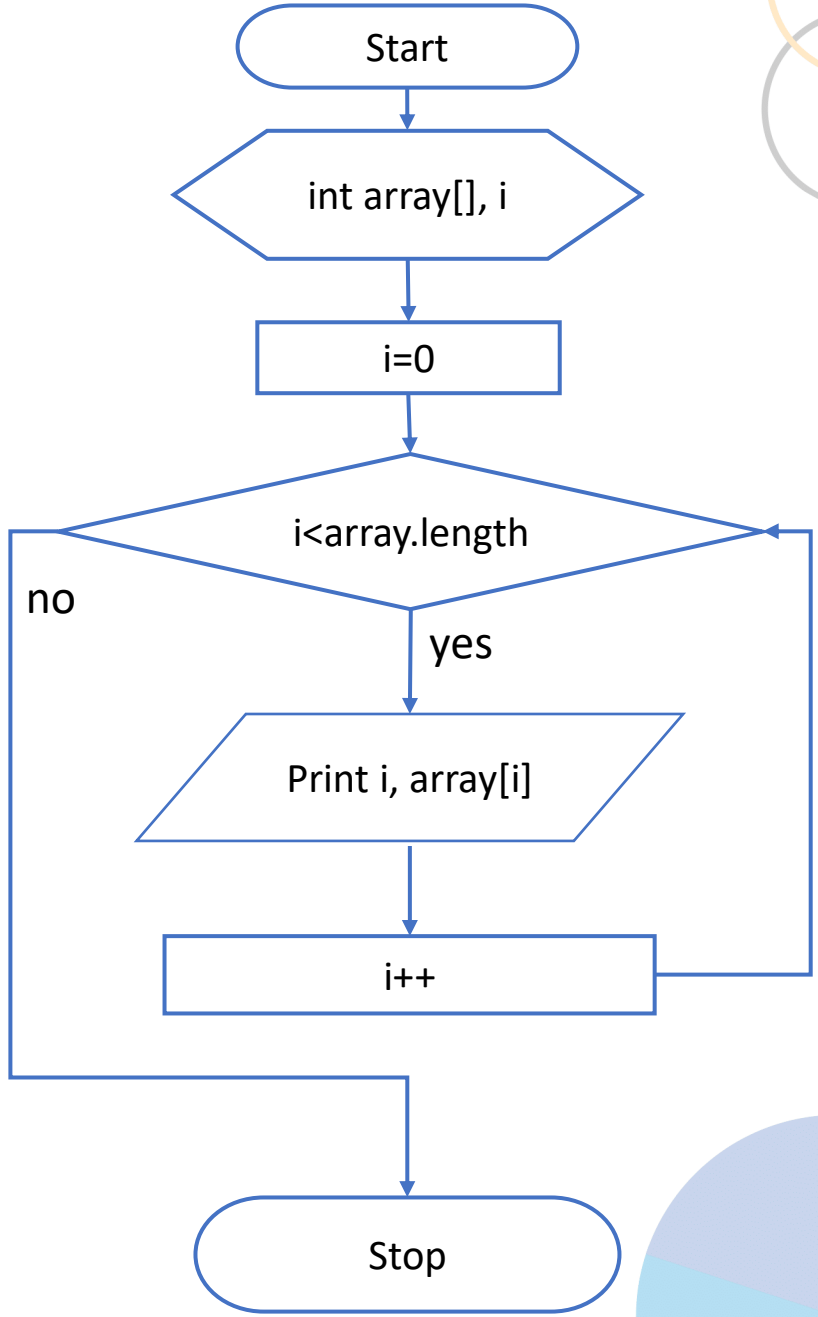
Examples of Using Arrays

Example 1

```
int array[]; //array declaration
array = new int[10]; //array instantiation
System.out.printf("%s%5s\n", "Index ", "Value");
//adds each element to the array and displays it
for (int i = 0; i < array.length; i++) {
    System.out.printf("%2d%5d\n", i, array[i]);
}
```

Output:

```
Index Value
 0     0
 1     0
 2     0
 3     0
 4     0
 5     0
 6     0
 7     0
 8     0
 9     0
```

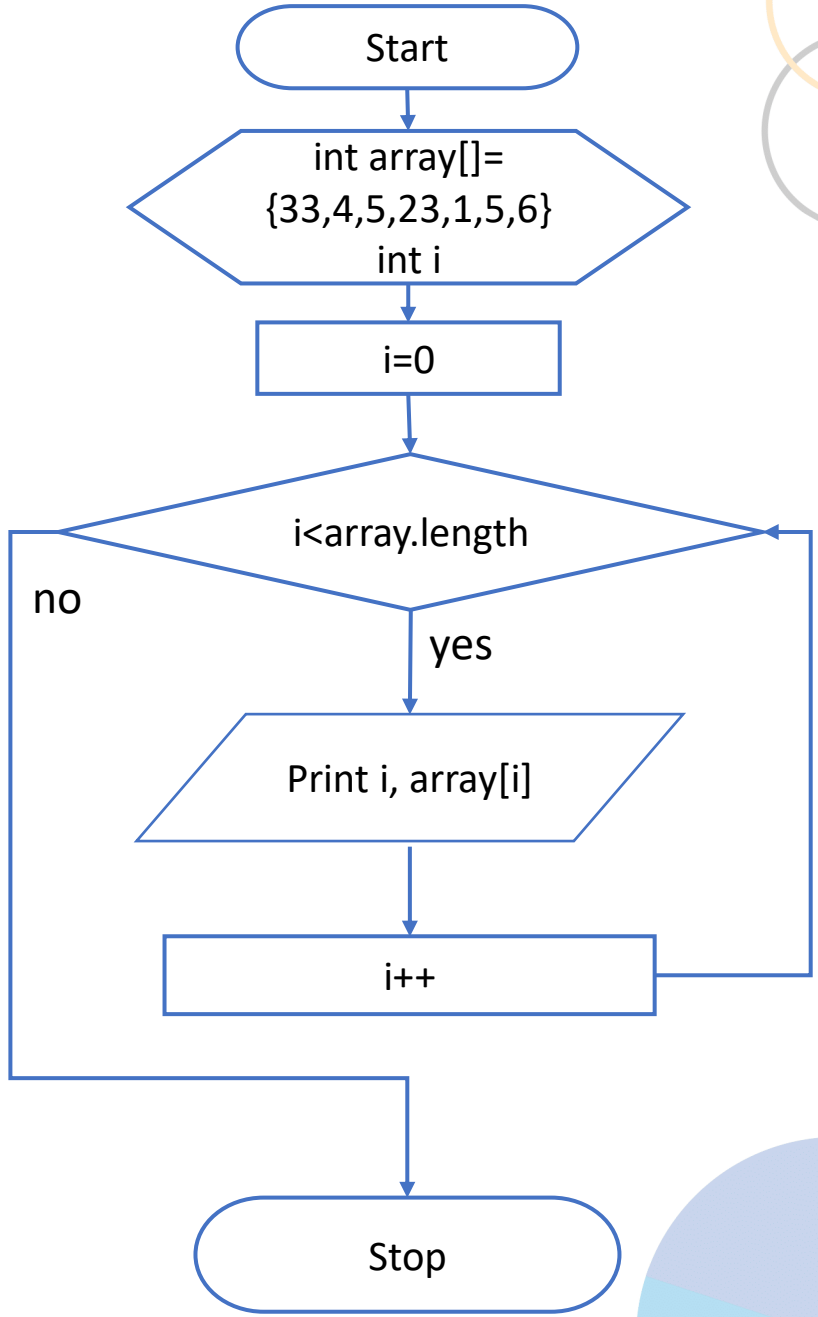


Example 2

```
int array[] = {33, 4, 5, 23, 1, 5, 6};
//initialization array -> specifies the number of arrays
//and fill in the value of each array element
System.out.printf("%s\t%s\n", "Index ", "Value");
for (int i = 0; i < array.length; i++) {
    System.out.printf("%d\t%d\n", i, array[i]);
} //displays each element of the array
```

Output:

Index	Value
0	33
1	4
2	5
3	23
4	1
5	5
6	6



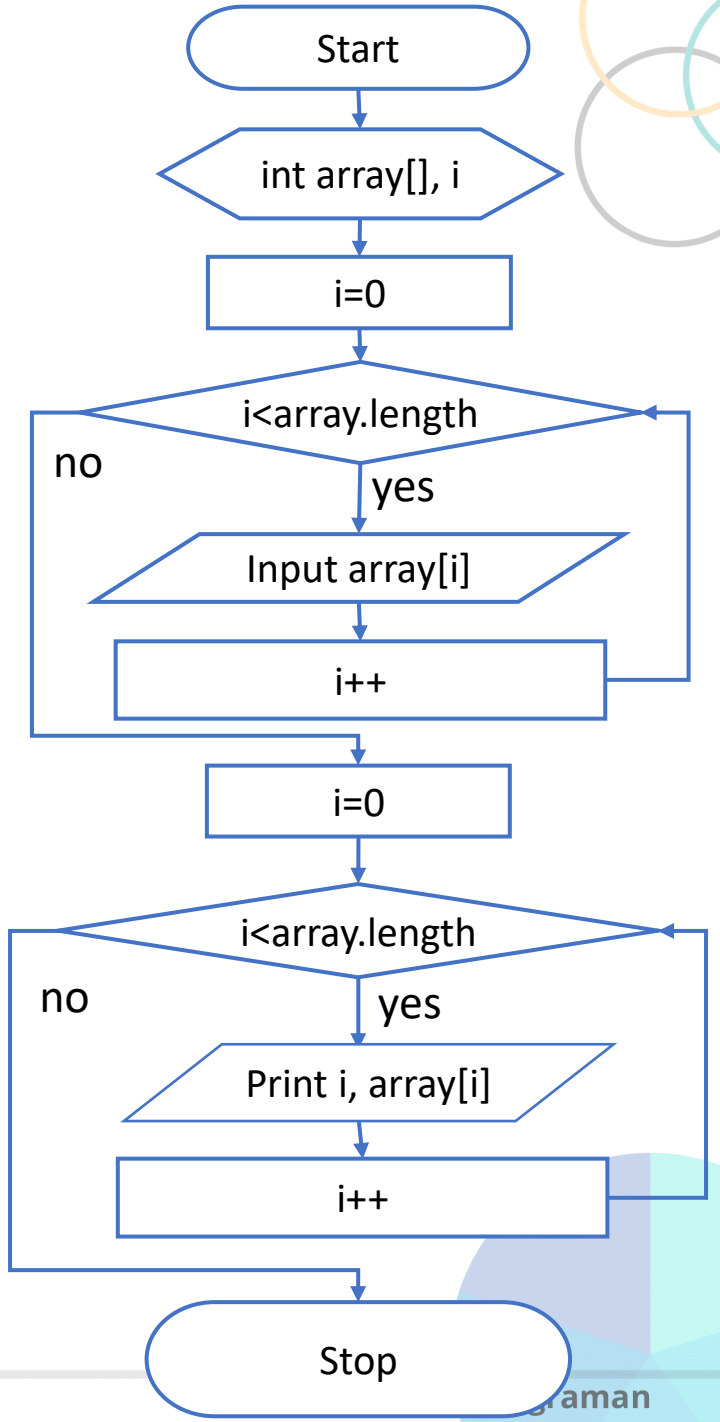
Example 3

- The program asks for input of 5 numbers then displays the 5 numbers

```
Scanner input = new Scanner(System.in);
int array[]; //array declaration
array = new int[5]; //array instantiation
//enter numbers and stores them as array elements
for (int i = 0; i < array.length; i++) {
    System.out.print("Enter a number: ");
    array[i] = input.nextInt();
}
//displays each element of the array
for (int i = 0; i < array.length; i++) {
    System.out.printf("Array of elements %d is valued %d\n", i, array[i]);
}
```

Output:

```
Enter a number: 74
Enter a number: 12
Enter a number: 9
Enter a number: 45
Enter a number: 88
Array of elements 0 is valued 74
Array of elements 1 is valued 12
Array of elements 2 is valued 9
Array of elements 3 is valued 45
Array of elements 4 is valued 88
```



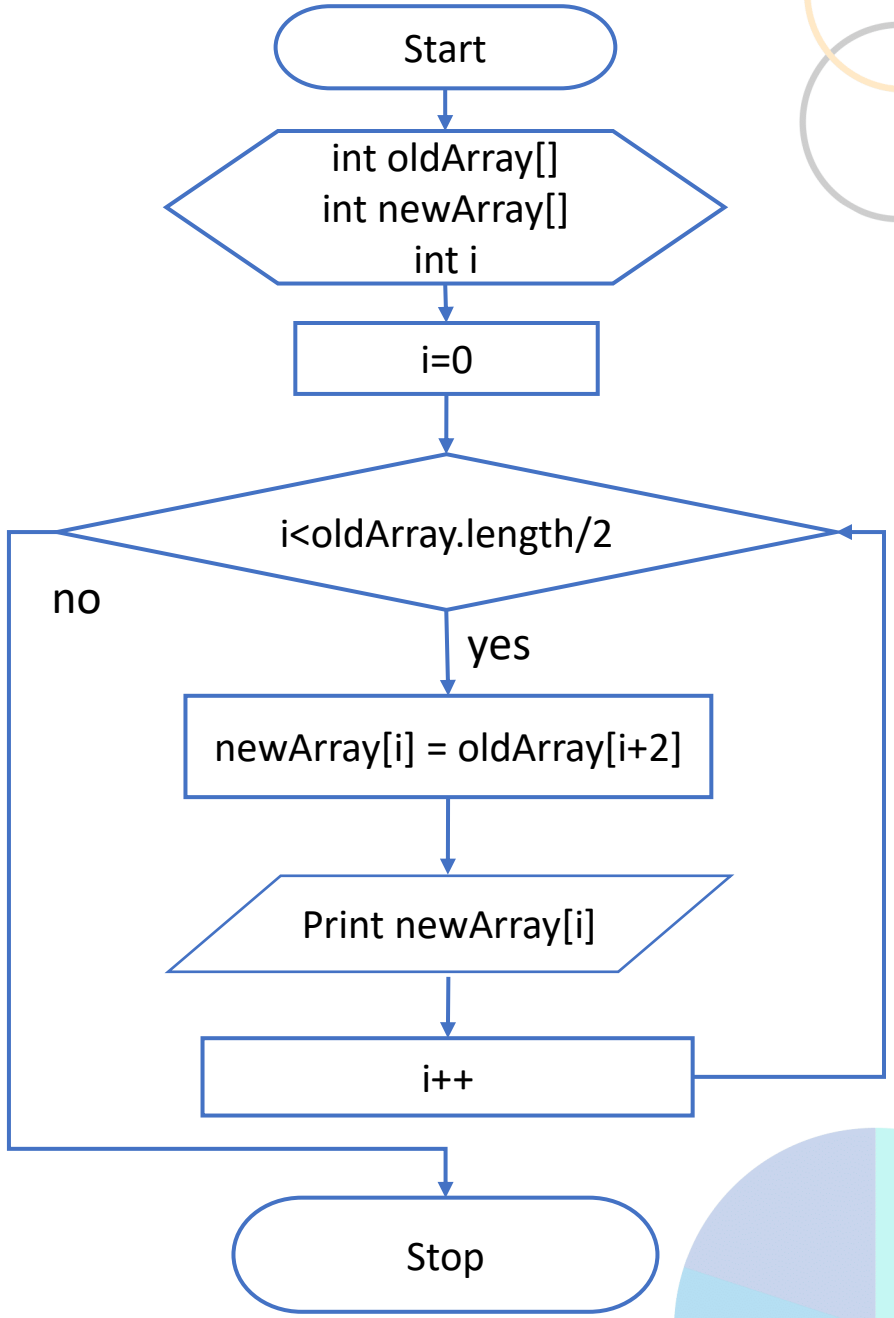
Example 4

- Make a copy of the array contents

```
int[] oldArray = {1, 3, 6, 7, 9};
int[] newArray = new int[5];
//the loop is only performed half the length of oldArray
for (int i = 0; i < oldArray.length / 2; i++) {
    newArray[i] = oldArray[i + 2];
    System.out.print(newArray[i] + " ");
}
```

Output:

```
6 7
```

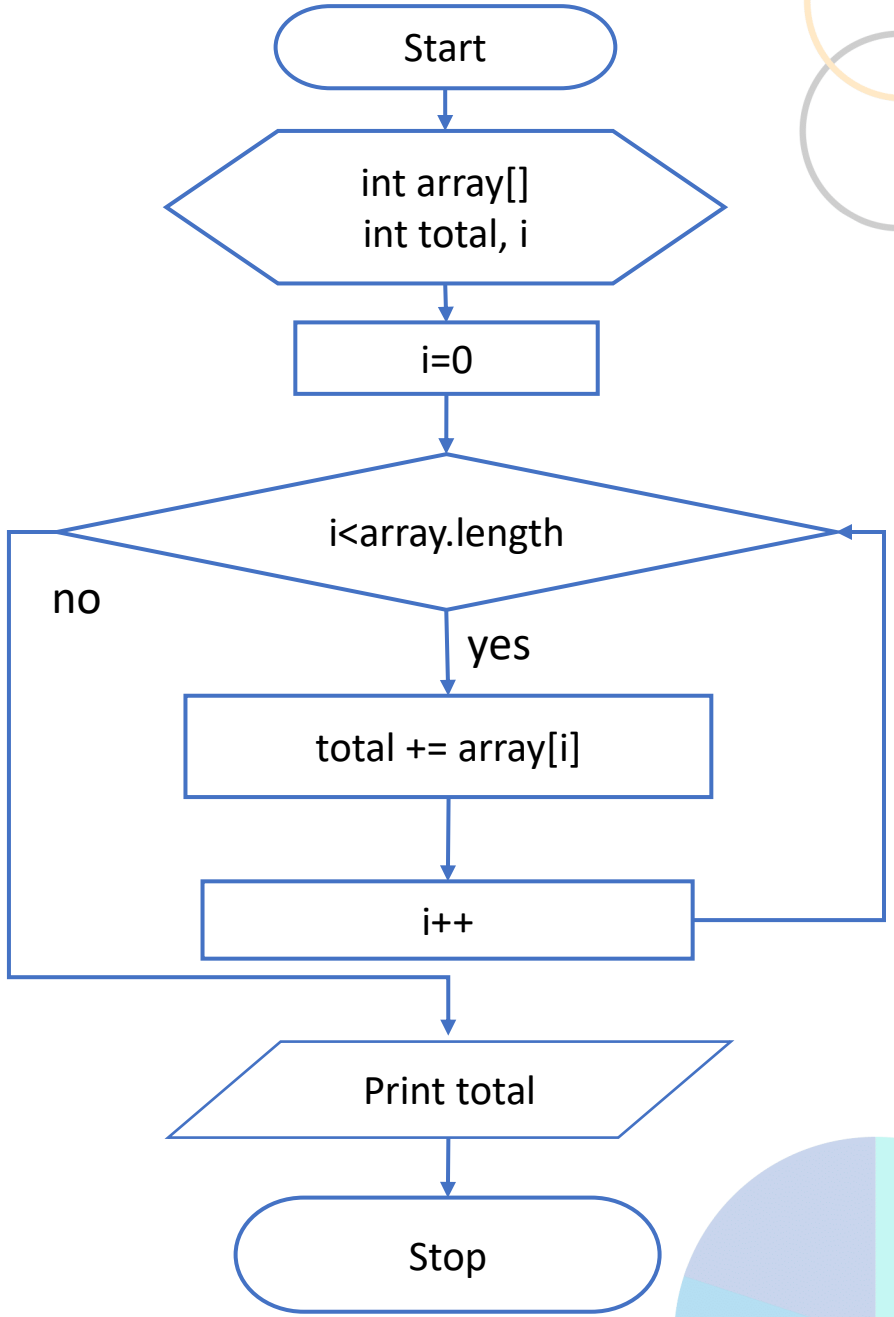


Example 5

- Array Summation

```
int array[] = {33, 4, 5, 23, 1, 5, 6};
int total = 0;
//adds the value of each element to total
for (int i = 0; i < array.length; i++) {
    total += array[i];
}
System.out.println(total);
```

Output: 77



Searching & Sorting

Enrichment Material

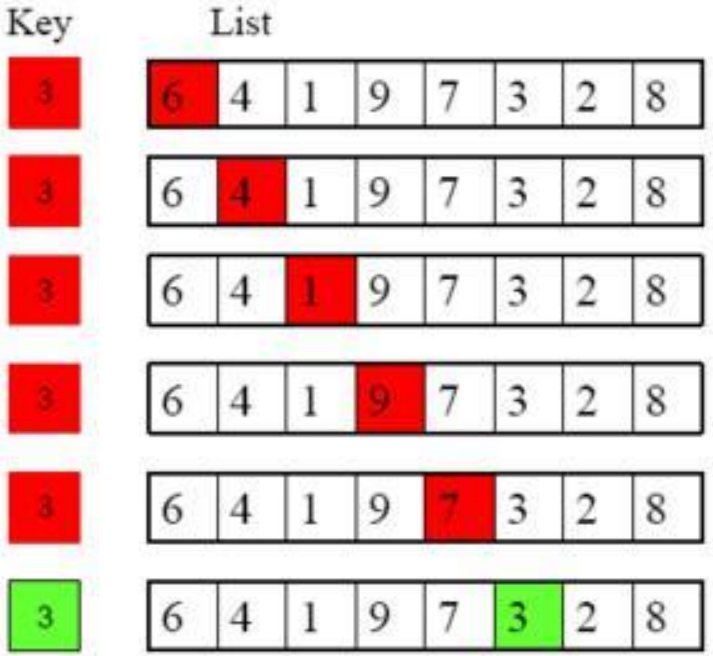
Searching

- One of the most common ways to perform array operations is searching
- Searching is performed to **find a specific value** for an element in array
- One of the easiest searching algorithms is **Linear Search**

Searching

- Suppose that in an array, you want to find the index position of an array element.
- In Linear Search, compare the "key" or number you want to find, with each element in the array.

- The key you want to find is 3
- A loop is used to compare each array element
- The number 3 is in the 5th index.
- So once found, looping will stop

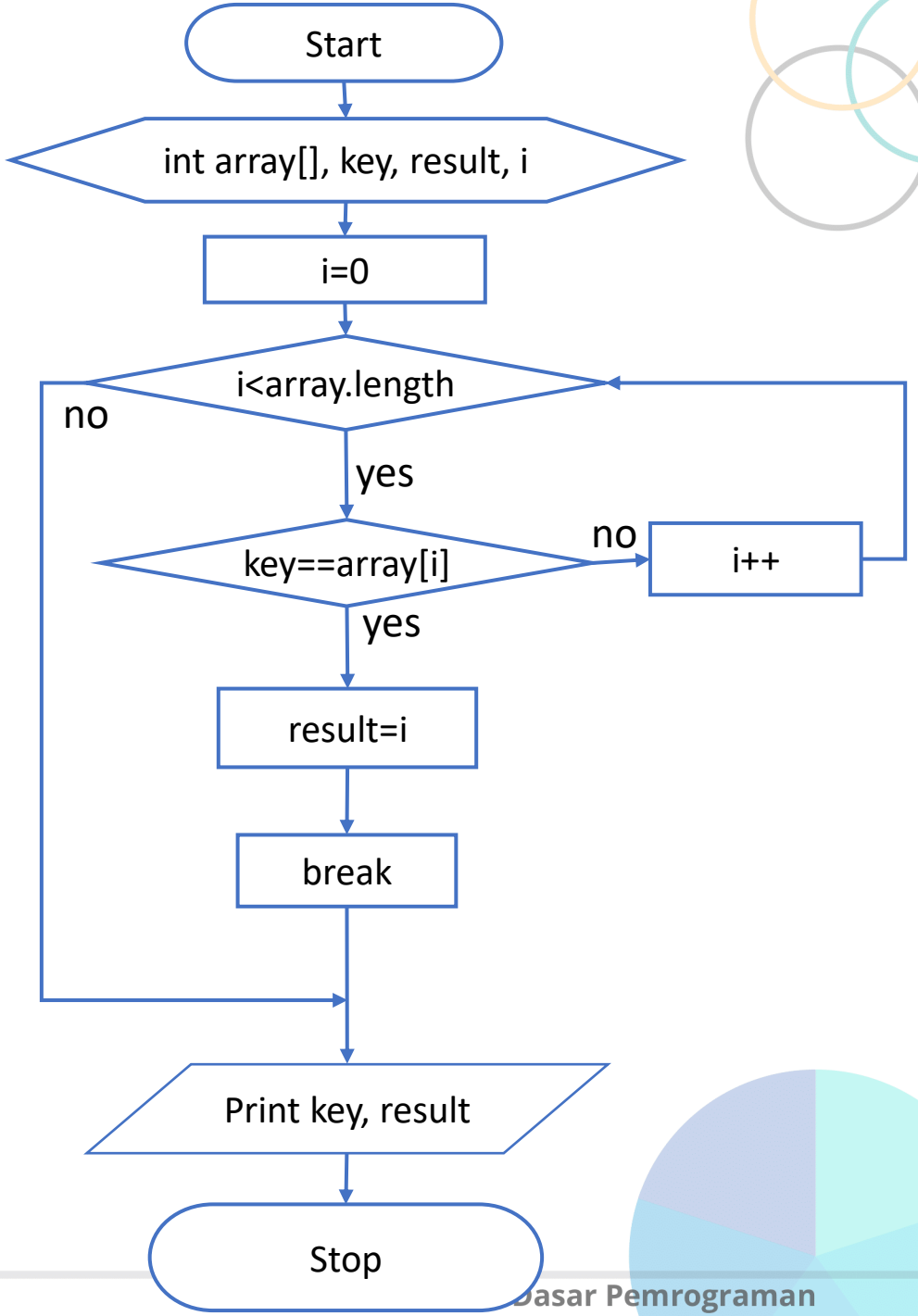


Searching

```
int array[] = {6, 4, 1, 9, 7, 3, 2, 8};
int key = 3;
int result = 0;
for (int i = 0; i < array.length; i++) {
    if (key == array[i]) {
        result = i;
        break;
    }
}
System.out.println("Key " + key + " is in index " + result);
```

Output:

```
Key 3 is in index 5
```

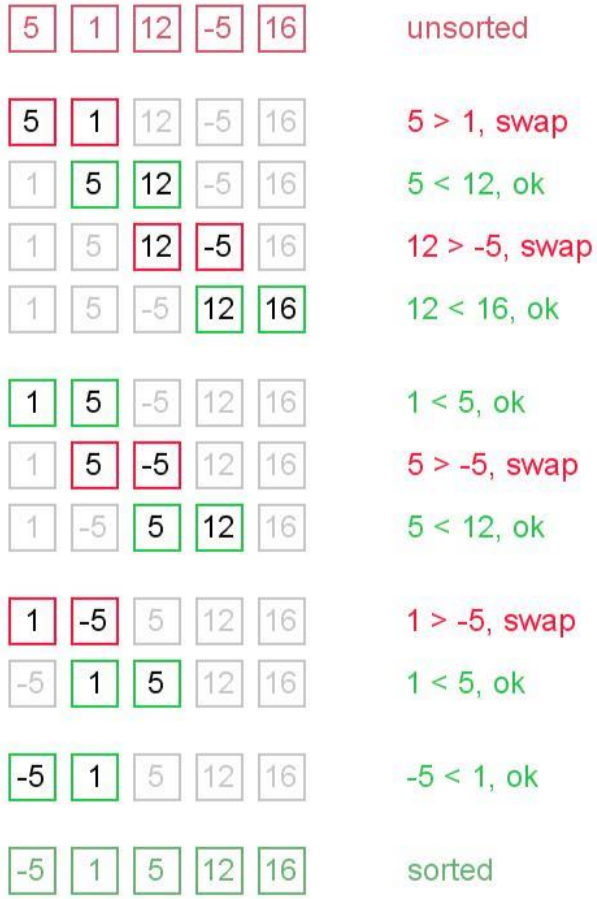


Sorting

- Sorting is the process of **sorting array elements** from smallest to largest (ascending) or vice versa (descending)
- One of the easiest sorting algorithms is **Bubble Sort**

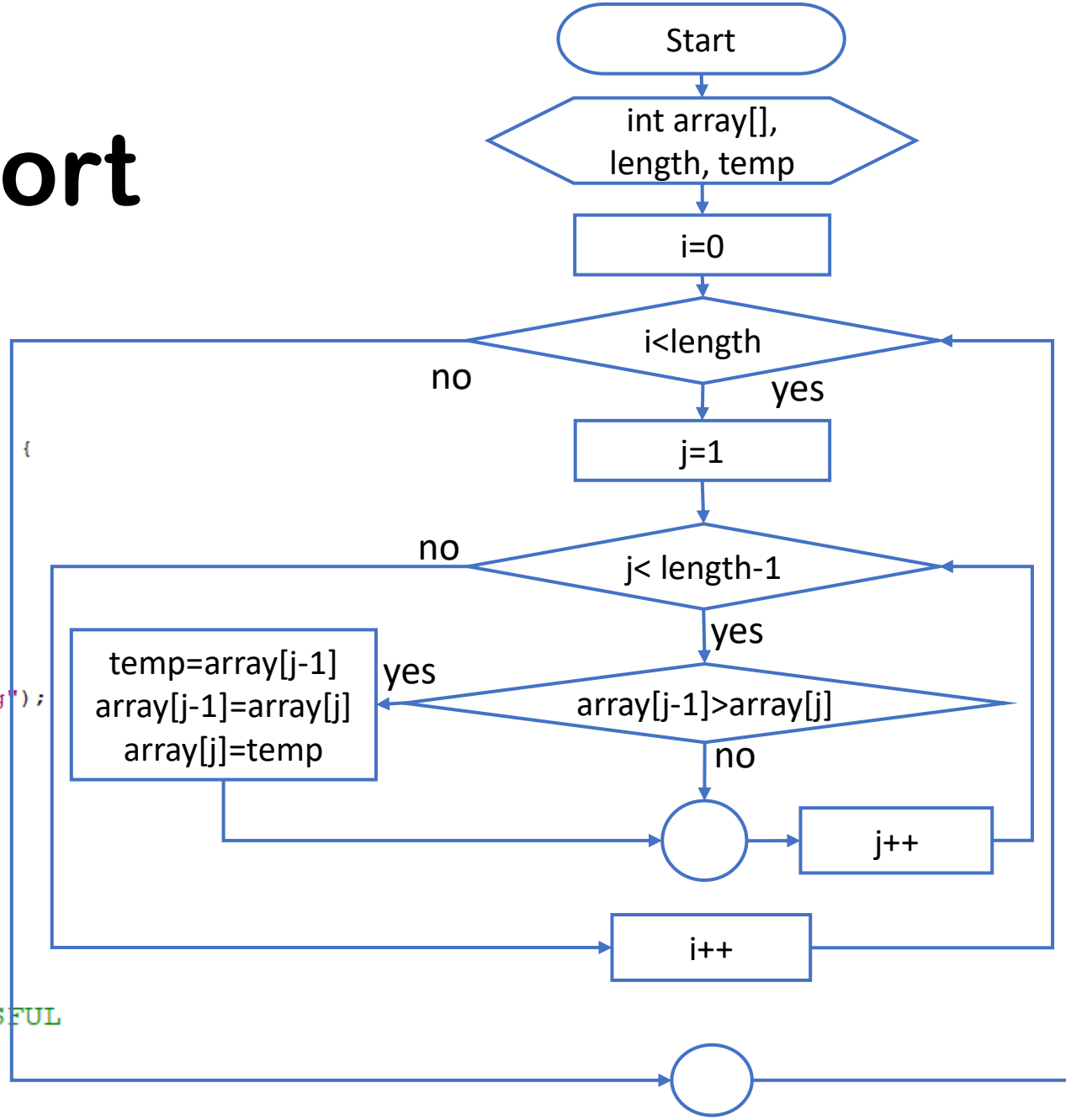
Sorting

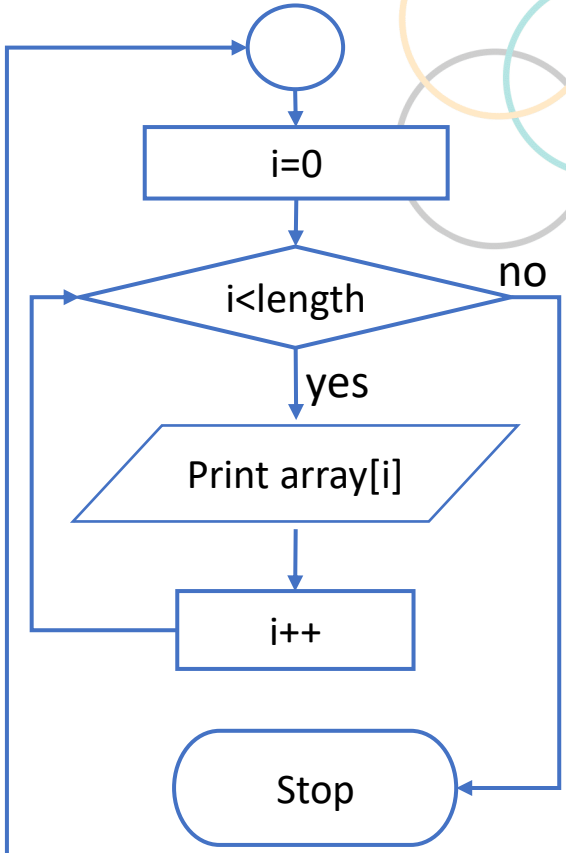
- In Bubble Sort, looping is performed from the first element to the last element of the array.
- Then each element is compared with the next element.
- If that element is bigger than the next element, it will be swapped.



Bubble Sort

```
int array[] = {6, 4, 1, 9, 7, 3, 2, 8};
int length = array.length;
int temp;
for (int i = 0; i < length; i++) {
    for (int j = 1; j < length - 1; j++) {
        if (array[j - 1] > array[j]) {
            temp = array[j - 1];
            array[j - 1] = array[j];
            array[j] = temp;
        }
    }
}
System.out.println("Result after sorting");
for (int i = 0; i < length; i++) {
    System.out.print(array[i] + " ");
}
```





Output:

```
Result after sorting
1 2 3 4 6 7 9 8 BUILD SUCCESSFUL
```

Individual Exercises

1. Create a flowchart of variable array filling with 60 elements length using looping!
2. Create a flowchart to fill array elements with 10 elements, then display the contents of array in reverse order!
3. Create a flowchart that asks for user input in the form of numbers 1-12. Display the name of the month according to the user input. The month names are stored in an array sequentially!
4. Create a flowchart to fill an array of integers with 8 elements, then calculate the average of all the elements of the array!

Group Assignments

1. Identify according to each group's project, what features require the use of a 1-dimensional array.
2. Identify according to the project, what features require 1-dimensional array operations in the form of searching and sorting.
3. Create an algorithm in the form of a flowchart according to the needs you have identified based on tasks in numbers 1 and 2