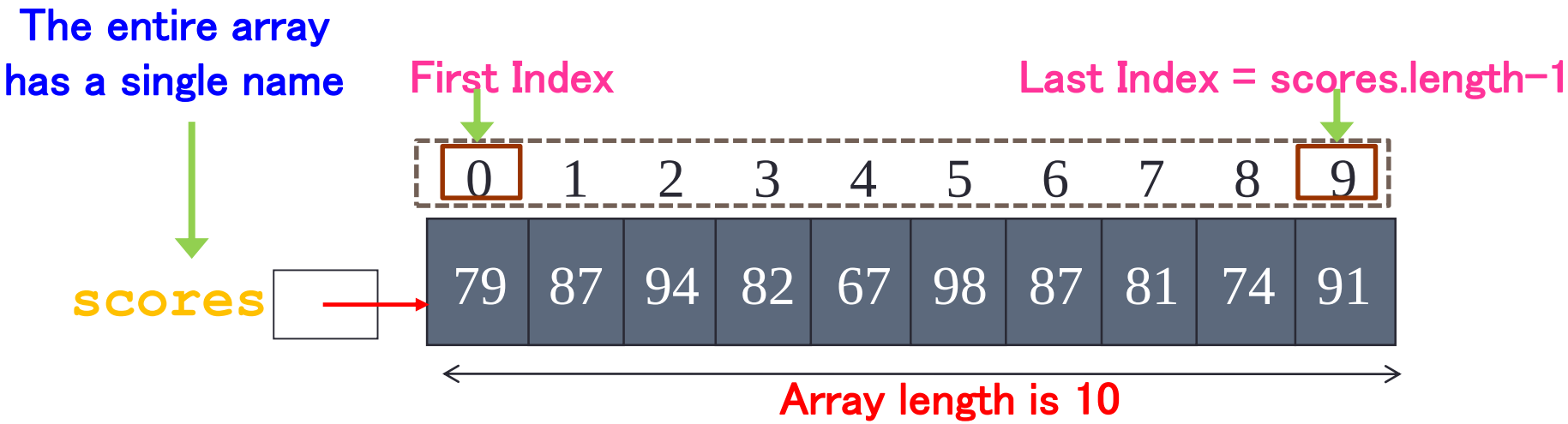
ARRAYS

Arrays

- An array is a container object that holds a fixed number of values of a single type.
- The length of an array is established when the array is created. After creation, its length is fixed.
- Each item in an array is called an element, and each element is accessed by its numerical index.
- As shown in the below illustration, numbering index begins with 0 and ends with its length-1.

Arrays

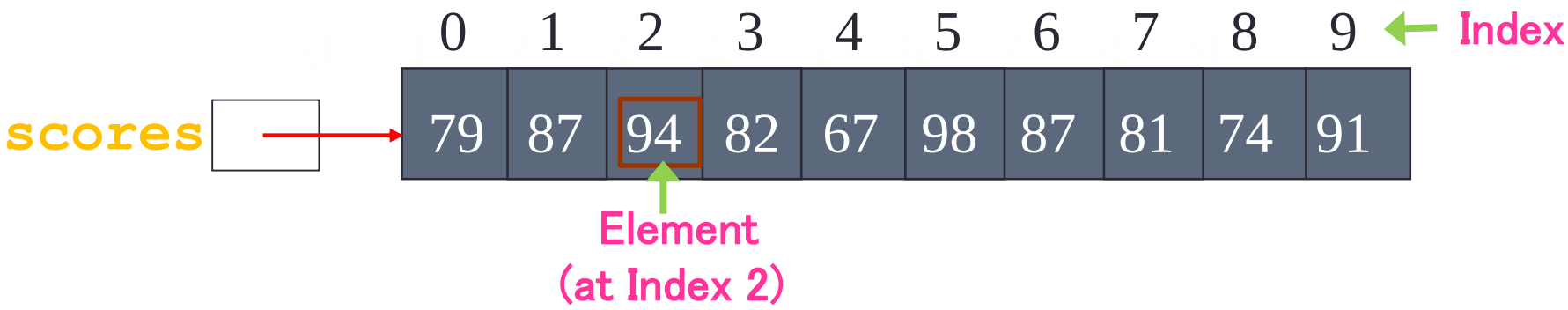
- An *array* is an ordered list of values



An array of size N is indexed from zero to N−1

This array holds 10 values that are indexed from 0 to 9

Arrays



- A particular value in an array is referenced using the array name followed by the index in brackets, For example :

```
scores[2]
```

refers to the value `94` (the 3rd value in the array)

Arrays

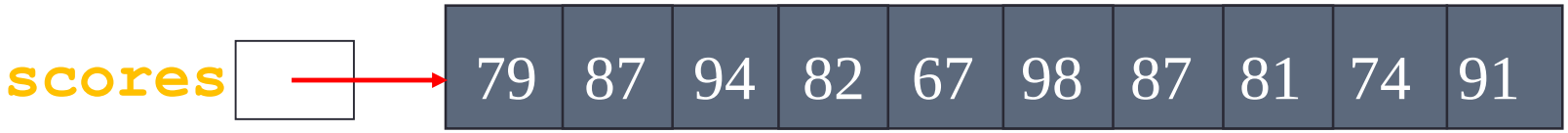
- For example, an array element can be assigned a value, printed, or used in a calculation:

```
scores[2] = 89;

scores[first] = scores[first] + 2;

mean = (scores[0] + scores[1])/2;

System.out.println ("Top = " + scores[5]);
```



Declaring and Creating Separately

- Declaring Array
  - *datatype[] arrayVar;*

    Example: `double[] myList;`

    `int[] scores, x, y;` ***//scores, x, and y are array***
  - *datatype arrayVar[];*

    Example: `double myList[];`

    `int scores[], x, y[];` ***//only scores and y are array***
- Creating Array

  arrayVar = new datatype[arraySize];

  Example:

```
myList = new double[20];
scores = new int[10];
y = new int[100];
```

Declaring and Creating in One Step

- *datatype*[] *arrayVar* = new *datatype*[*arraySize*];

Example:

```
double[] myList = new double[MAX];
float[] values = new float[35];
boolean status[] = new boolean[21];
```

Default Values

- When an array is created, its elements are assigned the default value of
  - `0` for the integer data types
  - 0.0 for the floating point data types
  - `'\u0000'` for char types, and
  - `false` for boolean types.

Bounds Checking

- Once an array is created, it has a fixed size
- An index used in an array reference must specify a valid element
- That is, the index value must be in range 0 to N-1
- The Java interpreter throws an *ArrayIndexOutOfBoundsException* if an array index is out of bounds
- This is called automatic bounds checking

Bounds Checking

- For example, if the array codes can hold 100 values, it can be indexed using only the numbers 0 to 99
- If the value of count is 100, then the following reference will cause an exception to be thrown:

  System.out.println (codes[index]);
- It's common to introduce off-by-one errors when using arrays

problem

```
for (int index=0; index <= 100; index++)
   codes[index] = index*50 + epsilon;
```

Bounds Checking

- Each array object has a public constant called length that stores the size of the array
- It is referenced using the array name,

```
arrayVar.length
```

- Note that length holds the number of elements, not the largest index

Array Example

```
public class Test {
  public static void main(String[] args) {
    int[] values = new int[5];
    for (int i = 1; i < values.length; i++) {
      values[i] = i + values[i-1];
    }
    values[0] = values[1] + values[4];
  }
}
```

After the array is created

0	11
1	1
2	3
3	6
4	10

Initializer Lists

- An initializer list can be used to instantiate and fill an array in one step
- The values are delimited by braces and separated by commas
- Examples:

```
int[] units = {147, 323, 89, 933, 540,
               269, 97, 114, 298, 476};

char letterGrades[] = {'A', 'B', 'C', 'D', 'F'};
```

Initializer Lists

- Note that when an initializer list is used:
  - the new operator is not used
  - no size value is specified
- The size of the array is determined by the number of items in the initializer list
- An initializer list can be used only in the array declaration

Arrays of Objects

- The elements of an array can be object references
- The following declaration reserves space to store 5 references to `String` objects

```
String[] words = new String[5];
```

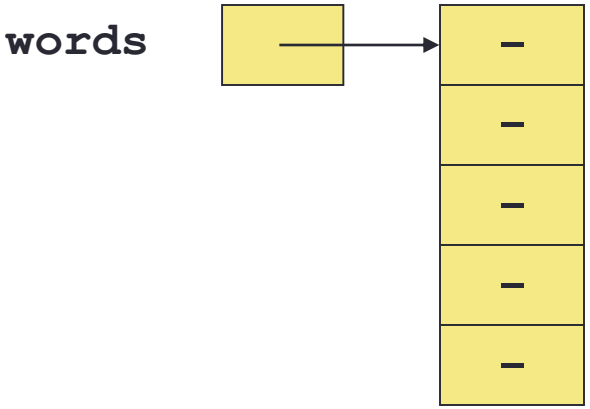
- It does NOT create the `String` objects themselves
- Initially an array of objects holds `null` references
- Each object stored in an array must be instantiated separately such as

```
words[0]=new String("friendship"); or

words[0]="friendship";
```

Arrays of Objects

- The `words` array when initially declared:

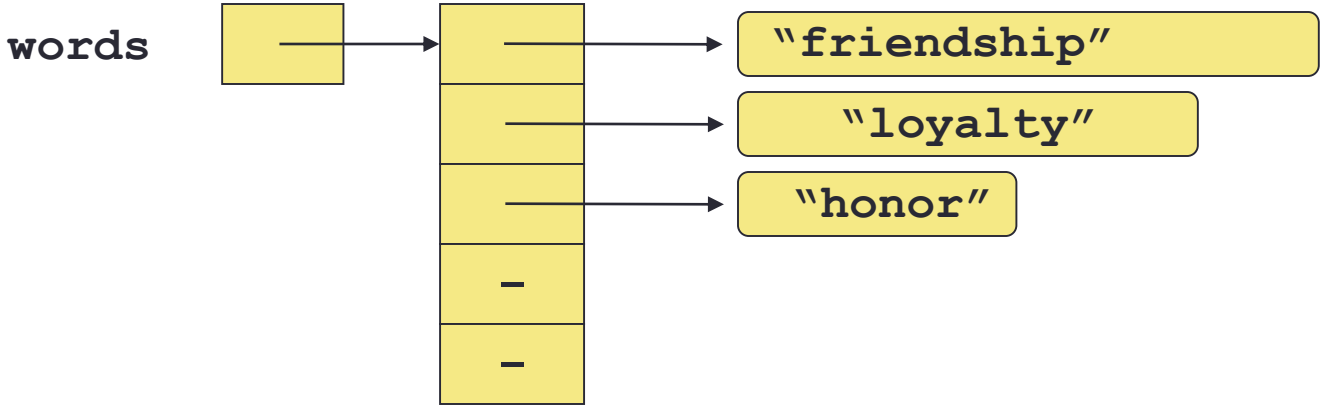


At this point, the following reference would throw a `NullPointerException`:

```
System.out.println (words[0].length());
```

Arrays of Objects

- After some `String` objects are created and stored in the array:




```
String[] words = new String[5];

words[0]="friendship";

words[1]=new String("loyalty");

words[2]="honor";
```

Initializer List of Object Arrays

- Keep in mind that `String` objects can be created using literals
- The following declaration creates an array object called `verbs` and fills it with four `String` objects

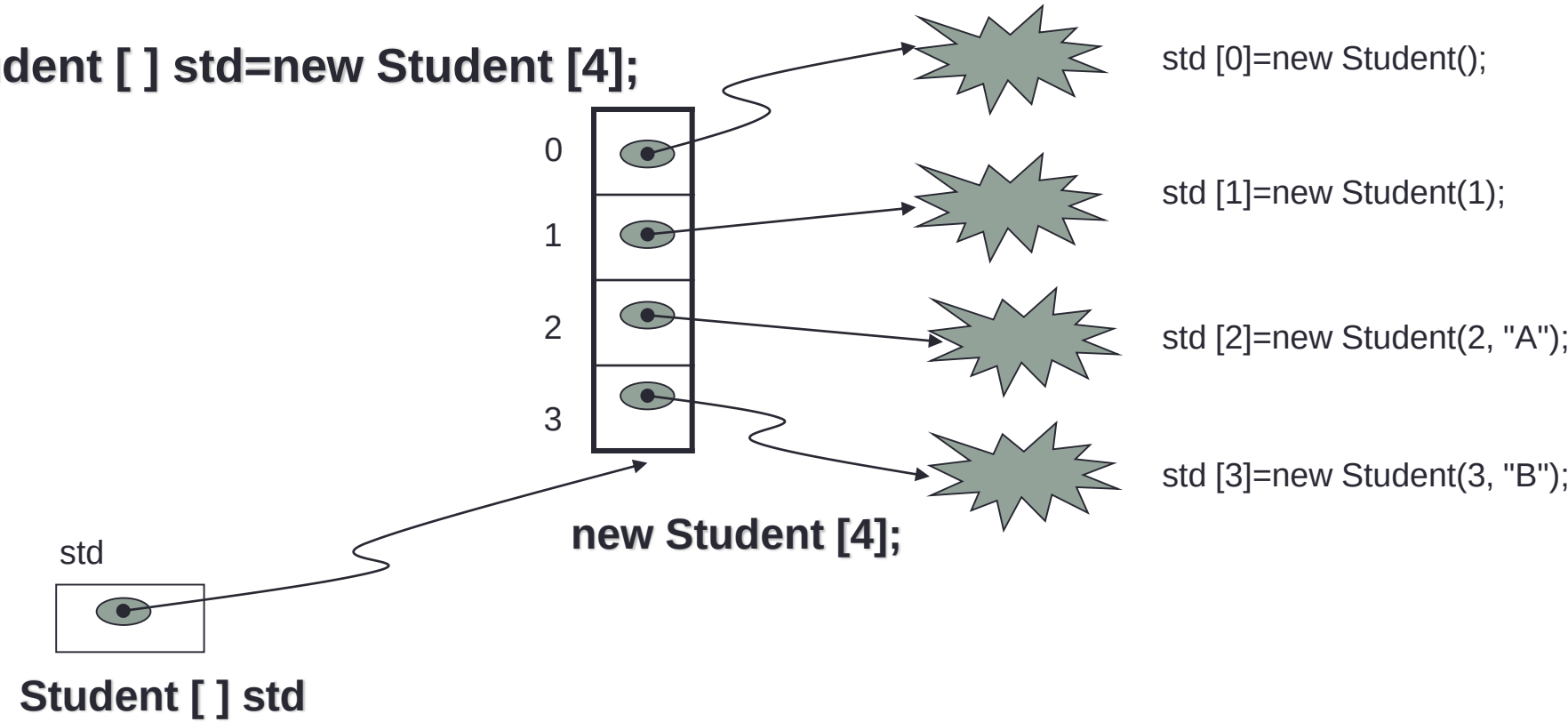
```
String[] verbs = {"play", "work", "eat", "sleep"};
```

OR

```
String[] verbs = {new String("play"), new String("work"),
new string("eat"), new String("sleep")};
```

Initializer List of Object Arrays

Student [ ] std=new Student [4];



Two Methods for Creating Object Arrays

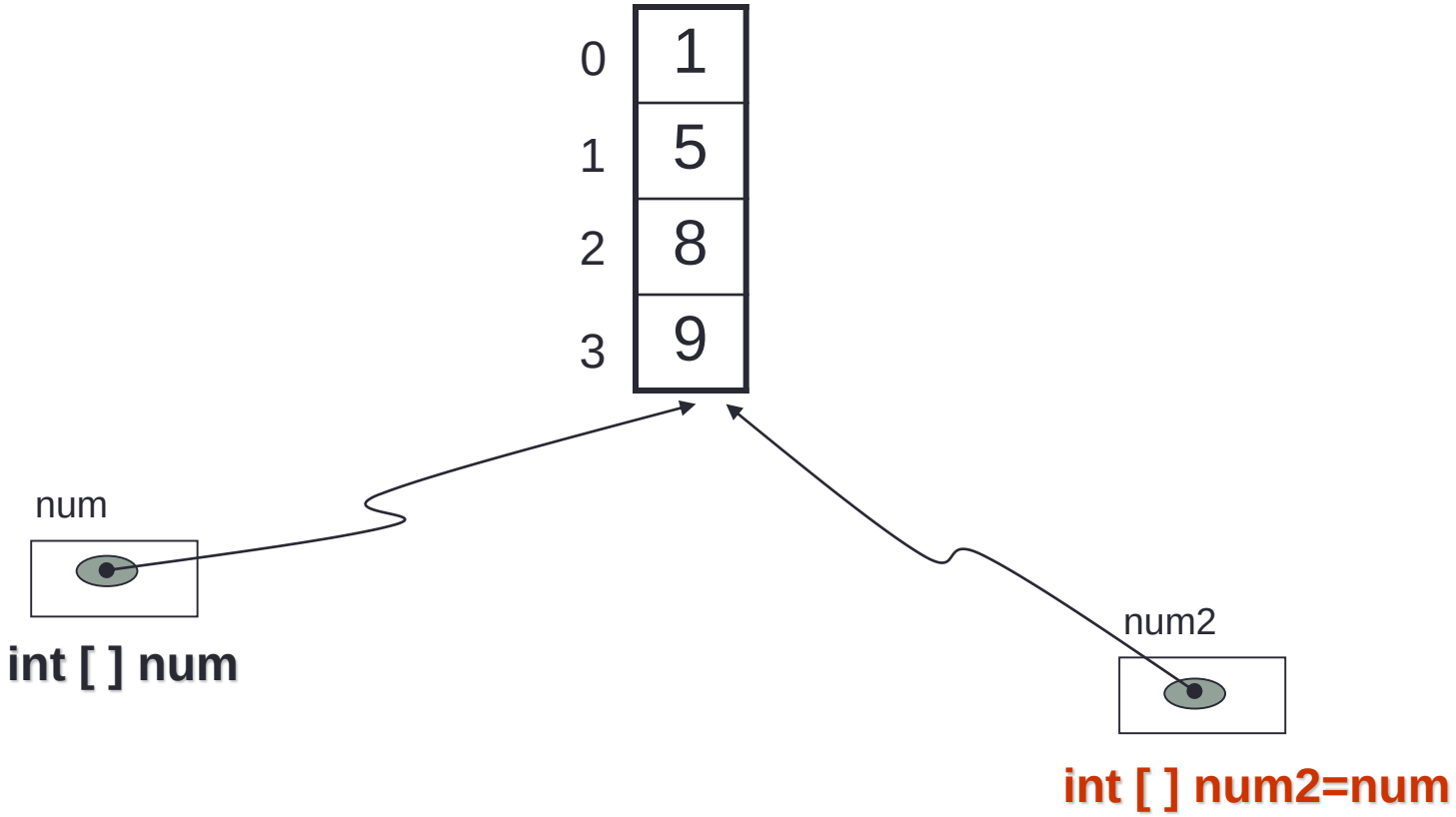
1. Student [ ] std=new Student [4];

```
std [0]=new Student();
std [1]=new Student(1);
std [2]=new Student(2, "A");
std [3]=new Student(3, "B");
```

2. Student std[ ] ={new Student(), new Student(1),new Student(2, "A"), new Student(3, "B")};

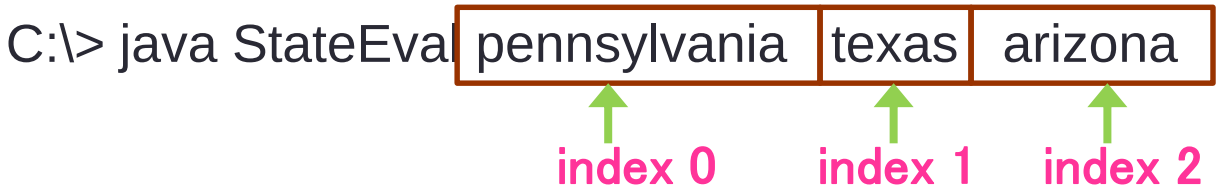
Array Assignment

int [ ] num =new int[4];



Command-Line Arguments

- The signature of the main method indicates that it takes an array of String objects as a parameter
- These values come from command-line arguments that are provided when the interpreter is invoked
- For example, the following invocation of the interpreter passes three String objects into main:



- These strings are stored at indexes 0-2 of the array parameter of the main method

Command-Line Arguments: Example

```
public class Adder {
  public static void main(String[] args) {
   if (args.length == 2) {
       int x = Integer.parseInt(args[0]) ;
       int y = Integer.parseInt(args[1]) ;
       System.out.println("Result = "+ (x+y));
   }
   else
       System.out.println("Using: java Adder value1 value2");
  }
}
```

For each

- The another version of the for loop can be used when processing array elements

```
for (int score : scores)
    System.out.println (score);
```

This is only appropriate when processing all array elements from top (lowest index) to bottom (highest index)

For each Example

```
int[] scores = {2, 5, 9, 11, 25};
for (int score : scores)
   System.out.println (score);
```

```
Student stdArr[] ={new Student(), new Student(1),new
  Student(2, "A"), new Student(3, "B")};
for(Student s: stdArr)
  System.out.println(s);
```

```
double[] values = {2, 5, 9, 11, 25};
double sum = 0;
for (double v : values)
   sum = sum + v;
System.out.println("Average: "+ (sum/values.length));
```

The pointer technique

- Use Arrays to specify the value of an element in one array as the element number in another array.
- A frequency distribution is a tally of one type of value in an array, such as how many students in a school are in each class or how many of company's customers live in each zip code area.

Example of a Frequency Distribution

	Grade
1	10
2	8
3	5
4	10
5	9
6	10
7	6
8	1
9	3
10	8
11	7
12	7
13	10
14	9
15	8
16	9
17	9
18	6
19	7
20	4
21	3
22	2
23	7
24	6
25	8
26	9
27	10
28	9
29	8
30	10

	F
1	1
2	1
3	2
4	1
5	1
6	3
7	4
8	5
9	6
10	6

F[Grade[i]]++

The *element* number of the frequency distribution array is the number of points correct and the *value* of the element is the number of students that received that grade. Therefore, the frequency distribution array *F* shows that there is 1 student who received 1 point, 1 that received 2 points, 2 that received 3 points, 1 that received 4 points, 1 that received 5 points, 3 that received 6 points, 4 that received 7 points, 5 that received 8 points, 6 that received 9 points and 6 that received 10 points.

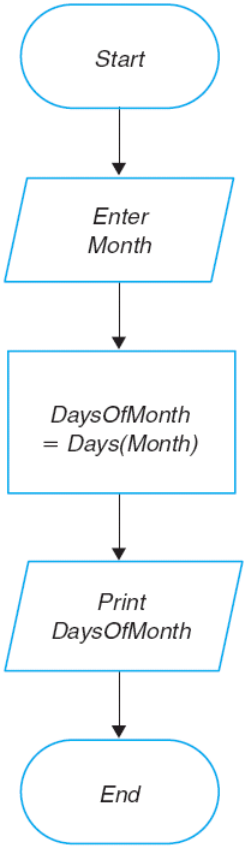
Table Look-Up Technique

Element	Days
1	31
2	28
3	31
4	30
5	31
6	30
7	31
8	31
9	30
10	31
11	30
12	31

Algorithm

1. *Enter Month*
2. *DaysOfMonth = Days(Month)*
3. Print *DaysOfMonth*
4. *End*

Flowchart



Arrays as Parameters

- An entire array can be passed as a parameter to a method
- Like any other object, the reference to the array is passed, making the formal and actual parameters aliases of each other
- Therefore, changing an array element within the method changes the original
- An individual array element can be passed to a method as well, in which case the type of the formal parameter is the same as the element type

Example: ArrayAsParameter.java

```
public class ArrayAsParameter {
        public static void printArray(int a[]){
        /*for(int i=0;i<a.length;i++)
                System.out.println("a["+i+"] = "+a[i]);*/
                for(int i: a){
                        System.out.println(i);
                }
        }
        public static int[]  sumArray(int a[], int b[]){
                int[] result=new int[a.length];
                for(int i=0;i<a.length;i++)
                        result[i]=a[i]+b[i];
                return result;
        }
        public static void main(String[] args) {
                int num1[]={5, 4, 3};
                int num2[]={1, 2, 4};
                int result[]=sumArray(num1, num2);
                printArray(result);
        }
}
```

Multidimensional Arrays

- Thus far, you have used one-dimensional arrays to model linear collections of elements
- You can use a two-dimensional array to represent a matrix or a table

Distance Table (in miles)

	Chicago	Boston	New York	Atlanta	Miami	Dallas	Houston
Chicago	0	983	787	714	1375	967	1087
Boston	983	0	214	1102	1763	1723	1842
New York	787	214	0	888	1549	1548	1627
Atlanta	714	1102	888	0	661	781	810
Miami	1375	1763	1549	661	0	1426	1187
Dallas	967	1723	1548	781	1426	0	239
Houston	1087	1842	1627	810	1187	239	0

Two-Dimensional Arrays

```
// Declare array ref var
dataType[][] refVar;

// Create array and assign its reference to variable
refVar = new dataType[10][10];

// Combine declaration and creation in one statement
dataType[][] refVar = new dataType[10][10];

// Alternative syntax
dataType refVar[][] = new dataType[10][10];
```

Declare and Create Two-Dimensional Arrays

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

// or

int matrix[][] = new int[10][10];
matrix[0][0] = 3;

for (int i = 0; i < matrix.length; i++)
  for (int j = 0; j < matrix[i].length; j++)
    matrix[i][j] = (int)(Math.random() * 1000);

double[][] x;
```

Two-Dimensional Array Illustration

	0	1	2	3	4
0					
1					
2					
3					
4					

```
matrix = new int[5][5];
```

	0	1	2	3	4
0					
1					
2		7			
3					
4					

```
matrix[2][1] = 7;
```

	0	1	2
0	1	2	3
1	4	5	6
2	7	8	9
3	10	11	12

```
int[][] array = {
   {1, 2, 3},
   {4, 5, 6},
   {7, 8, 9},
   {10, 11, 12}
};
```

matrix.length? 5

matrix[0].length? 5

array.length? 4

array[0].length? 3

Declare, Create, and Initialize Using Shorthand Notations

- You can also use an array initializer to declare, create and initialize a two-dimensional array. For example,

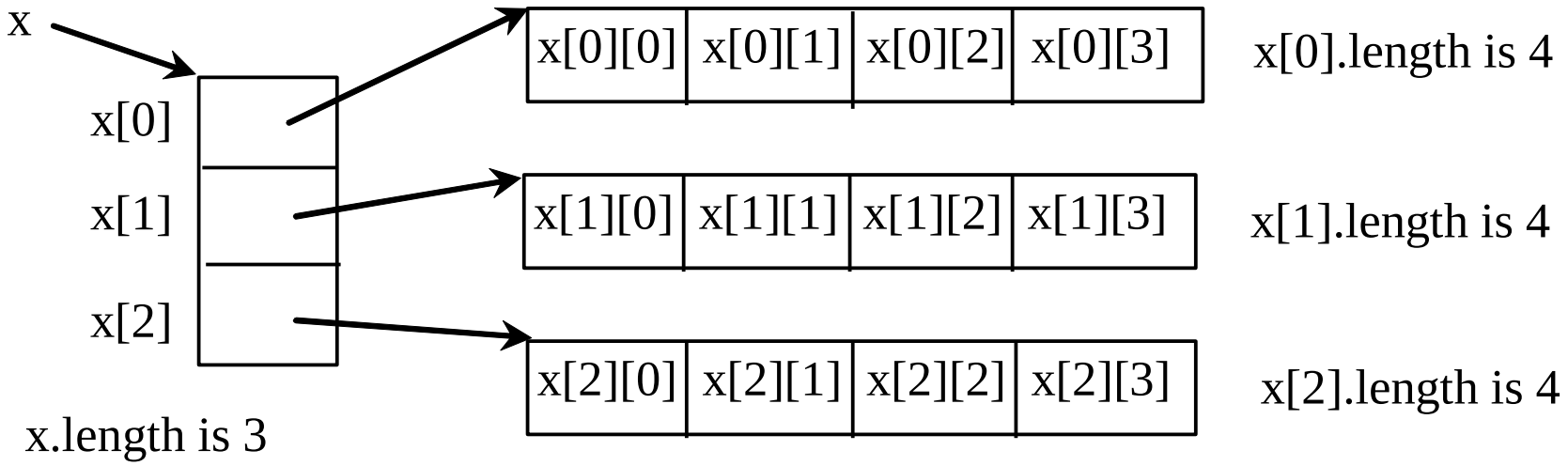
```
int[][] array
   = {
  {1, 2, 3},
  {4, 5, 6},
  {7, 8, 9},
  {10, 11,
   12}
};
```

Same as

```
int[][] array = new int[4][3];
array[0][0] = 1; array[0][1] = 2; array[0][2] = 3;
array[1][0] = 4; array[1][1] = 5; array[1][2] = 6;
array[2][0] = 7; array[2][1] = 8; array[2][2] = 9;
array[3][0] = 10; array[3][1] = 11; array[3][2] = 12;
```

Lengths of Two-Dimensional Arrays

- int[][] x = new int[3][4];



Lengths of Two-Dimensional Arrays

```
int[][] array = {
   {1, 2, 3},
   {4, 5, 6},
   {7, 8, 9},
   {10, 11, 12}
};
```

```
array.length
array[0].length
array[1].length
array[2].length
array[3].length
```

array[4].length ArrayIndexOutOfBoundsException

Ragged Arrays

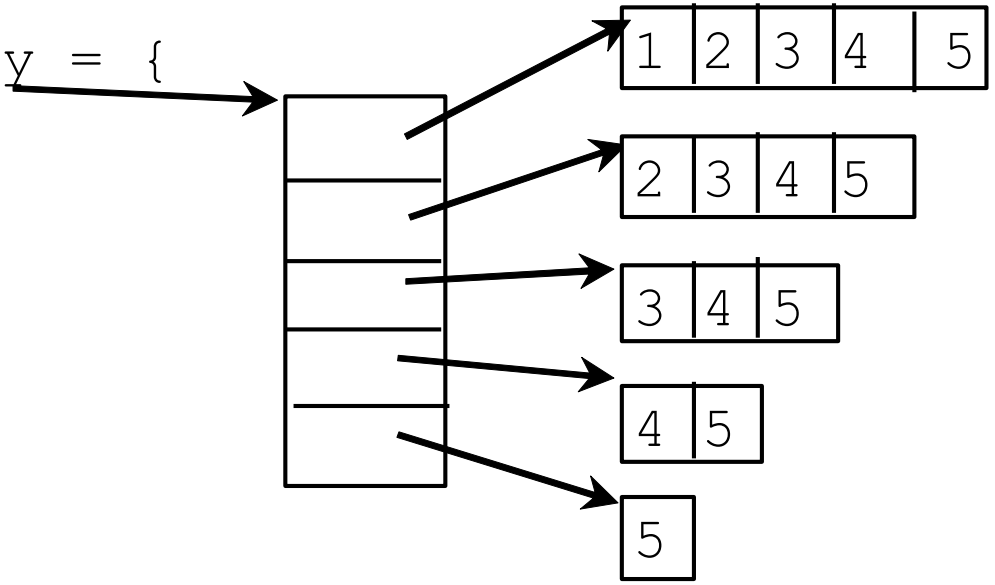
- Each row in a two-dimensional array is itself an array. So, the rows can have different lengths. Such an array is known as *a ragged array*. For example,

```
int[][] matrix = {
   {1, 2, 3, 4, 5},
   {2, 3, 4, 5},
   {3, 4, 5},
   {4, 5},
   {5}
};
```

```
 matrix.length is 5
matrix[0].length is 5
matrix[1].length is 4
matrix[2].length is 3
matrix[3].length is 2
matrix[4].length is 1
```

Ragged Arrays

```
int[][] triangleArray = {
   {1, 2, 3, 4, 5},
   {2, 3, 4, 5},
   {3, 4, 5},
   {4, 5},
   {5}
};
```



Multidimensional Arrays

- Occasionally, you will need to represent n-dimensional data structures. In Java, you can create n-dimensional arrays for any integer n.

- The way to declare two-dimensional array variables and create two-dimensional arrays can be generalized to declare n-dimensional array variables and create n-dimensional arrays for n >= 3. For example, the following syntax declares a three-dimensional array variable scores, creates an array, and assigns its reference to scores

```
double[][][] scores = new double[10][5][2];
```