Arrays

Chapter 6

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Objectives

- Nature and purpose of an array
- Using arrays in Java programs
- Methods with array parameter
- Methods that return an array
- Array as an instance variable
- Use an array not filled completely

Objectives

- Order (sort) the elements of an array
- Search an array for a particular item
- Define, use multidimensional array

Array Basics: Outline

- Creating and Accessing Arrays
- Array Details
- The Instance Variable **length**
- More About Array Indices
- Analyzing Arrays

Creating and Accessing Arrays

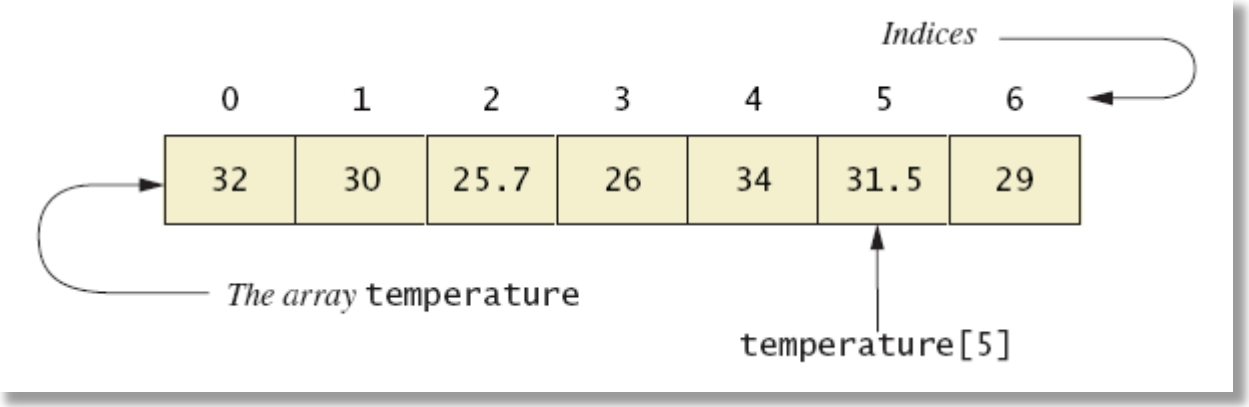
- An array is a special kind of object
- Think of as collection of variables of same type
- Creating an array with 7 variables of type double

```
double[] temperature = new double[7];
```

- To access an element use
  - The name of the array
  - An index number enclosed in braces
- Array indices begin at zero

Creating and Accessing Arrays

- Figure 6.1 A common way to visualize an array



- Note sample program, listing 6.1
  `class ArrayOfTemperatures`

Creating and Accessing Arrays

```
Enter 7 temperatures:
32
30
25.7
26
34
31.5
29
The average temperature is 29.7428
The temperatures are
32.0 above average
30.0 above average
25.7 below average
26.0 below average
34.0 above average
31.5 above average
29.0 below average
Have a nice week.
```

Sample screen output

Array Details

- Syntax for declaring an array with **new**

```
Base_Type[] Array_Name = new Base_Type[Length];
```

- The number of elements in an array is its length
- The type of the array elements is the array's base type

Square Brackets with Arrays

- With a data type when declaring an array

```
int [ ] pressure;
```

- To enclose an integer expression to declare the length of the array

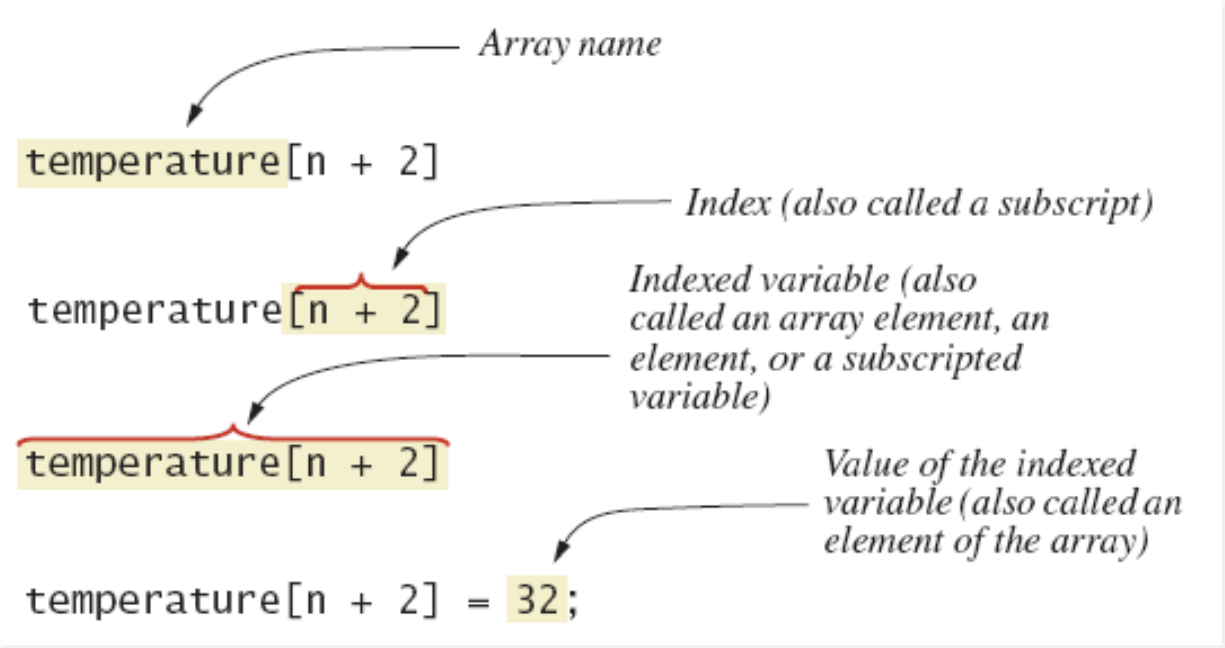
```
pressure = new int [100];
```

- To name an indexed value of the array

```
pressure[3] =
keyboard.nextInt();
```

Array Details

- Figure 6.2 Array terminology



The Instance Variable `length`

- As an object an array has only one public instance variable
  - Variable `length`
  - Contains number of elements in the array
  - It is final, value cannot be changed
- Note revised code, listing 6.2
  `class ArrayOfTemperatures2`

The Instance Variable `length`

```
How many temperatures do you have?
3
Enter 3 temperatures:
32
26.5
27
The average temperature is 28.5
The temperatures are
32.0 above average
26.5 below average
27.0 below average
Have a nice week.
```

Sample screen output

More About Array Indices

- Index of first array element is 0
- Last valid Index is `arrayName.length - 1`
- Array indices must be within bounds to be valid
  - When program tries to access outside bounds, run time error occurs
- OK to "waste" element 0
  - Program easier to manage and understand
  - Yet, get used to using index 0

Gotcha – Don't Exceed Array Bounds

- The code below fails if the user enters a number like 4. Use input validation.

```
Scanner kbd = new Scanner(System.in);
int[] count = {0,0,0,0};

System.out.println("Enter ten numbers between 0 and 3.");
for (int i = 0; i < 10; i++)
{
 int num = kbd.nextInt();
 count[num]++;
}
for (int i = 0; i < count.length; i++)
   System.out.println("You entered " + count[i] + " " + i + "'s");
```

Initializing Arrays

- Possible to initialize at declaration time

```
double[] reading = {3.3, 15.8, 9.7};
```

- Also may use normal assignment statements
  - One at a time
  - In a loop

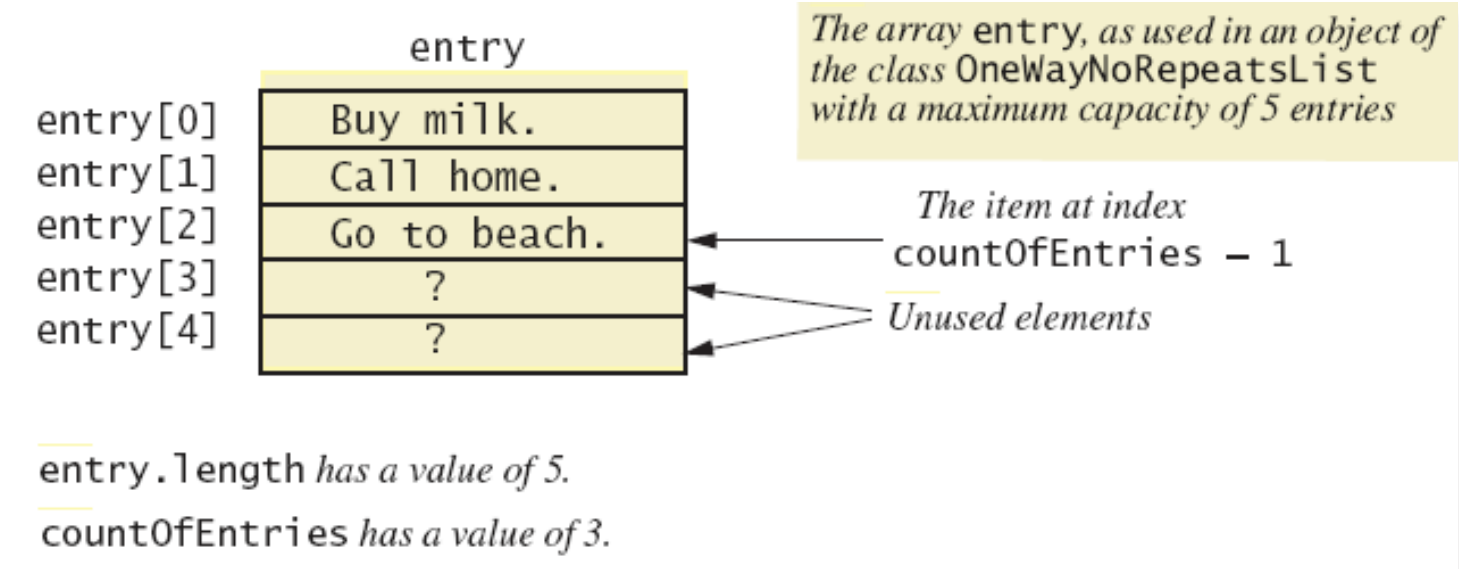
```
int[] count = new int[100];
for (int i = 0; i < 100; i++)
    count[i] = 0;
```

Partially Filled Arrays

- Array size specified at definition
- Not all elements of the array might receive values
  - This is termed a *partially filled array*
- Programmer must keep track of how much of array is used

Partially Filled Arrays

- Figure 6.3 A partially filled array



Arrays in Classes and Methods: Outline

- Indexed Variables as Method Arguments
- Entire Arrays as Arguments to a Method
- Arguments for the Method main
- Array Assignment and Equality
- Methods that Return Arrays

Indexed Variables as Method Arguments

- Indexed variable of an array
  - Example … `a[i]`
  - Can be used anywhere variable of array base type can be used
- View program using indexed variable as an argument, listing 6.3
  `class ArgumentDemo`

Entire Arrays as Arguments

- Declaration of array parameter similar to how an array is declared
- Example:

```
public class SampleClass
{
    public static void incrementArrayBy2(double[] anArray)
    {
        for (int i = 0; i < anArray.length; i++)
            anArray[i] = anArray[i] + 2;
    }
    <The rest of the class definition goes here.>
}
```

Entire Arrays as Arguments

- Note – array parameter in a method heading does not specify the length
  - An array of any length can be passed to the method
  - Inside the method, elements of the array can be changed
- When you pass the entire array, do not use square brackets in the actual parameter

Arguments for Method main

- Recall heading of method **`main`**

```
public static void main (String[] args)
```

- This declares an array
  - Formal parameter named **`args`**
  - Its base type is **`String`**
- Thus possible to pass to the run of a program multiple strings
  - These can then be used by the program

Array Assignment and Equality

- Arrays are objects
  - Assignment and equality operators behave (misbehave) as specified in previous chapter
- Variable for the array object contains memory address of the object
  - Assignment operator = copies this address
  - Equality operator == tests whether two arrays are stored in same place in memory

Array Assignment and Equality

- Two kinds of equality
- View example program, listing 6.4
  `class TestEquals`

Sample screen output

```
Not equal by ==.
Equal by the equals method.
```

Array Assignment and Equality

- Note results of **`==`**
- Note definition and use of method **`equals`**
  - Receives two array parameters
  - Checks length and each individual pair of array elements
- Remember array types are reference types

Methods that Return Arrays

- A Java method may return an array
- View example program, listing 6.5
  `class ReturnArrayDemo`
- Note definition of return type as an array
- To return the array value
  - Declare a local array
  - Use that identifier in the `return` statement

Sorting, Searching Arrays: Outline

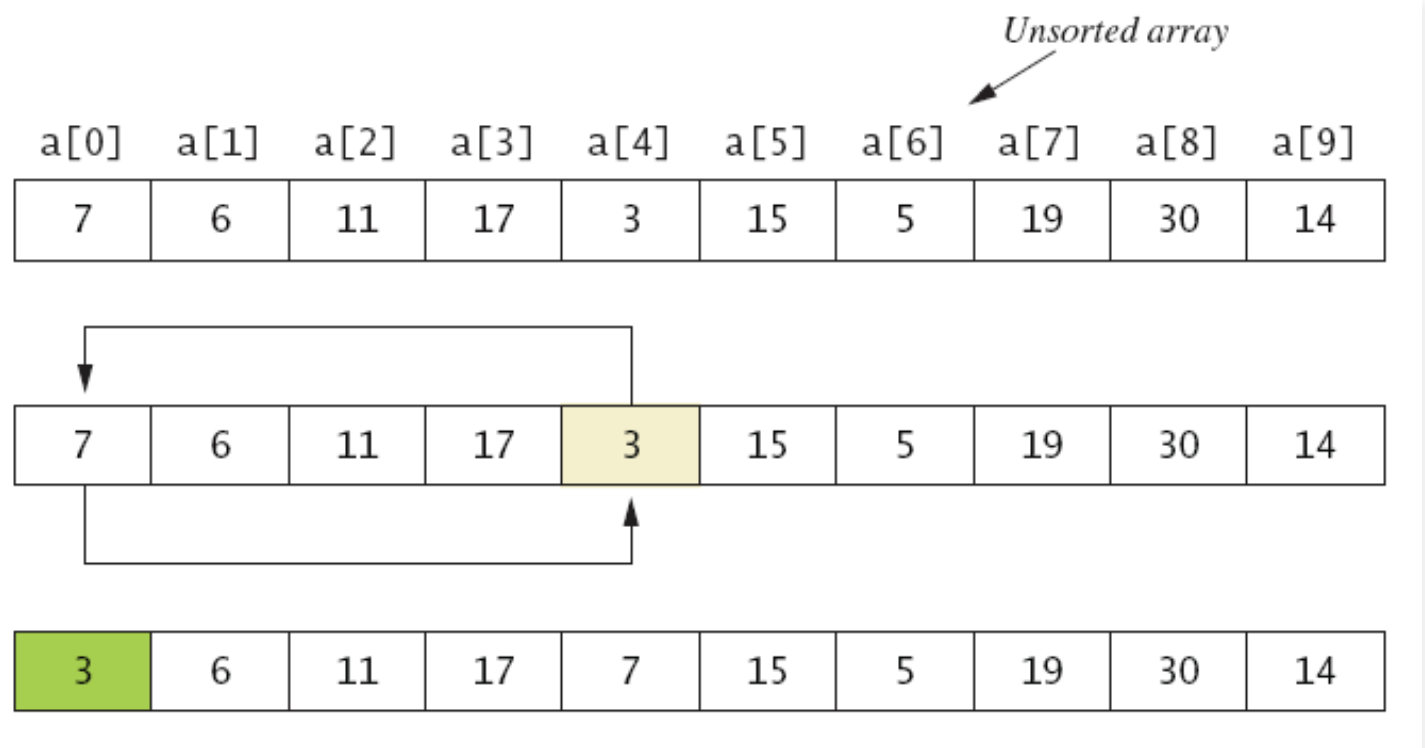
- Selection Sort
- Other Sorting Algorithms
- Searching an Array

Selection Sort

- Consider arranging all elements of an array so they are ascending order
- Algorithm is to step through the array
  - Place smallest element in index 0
  - Swap elements as needed to accomplish this
- Called an interchange sorting algorithm

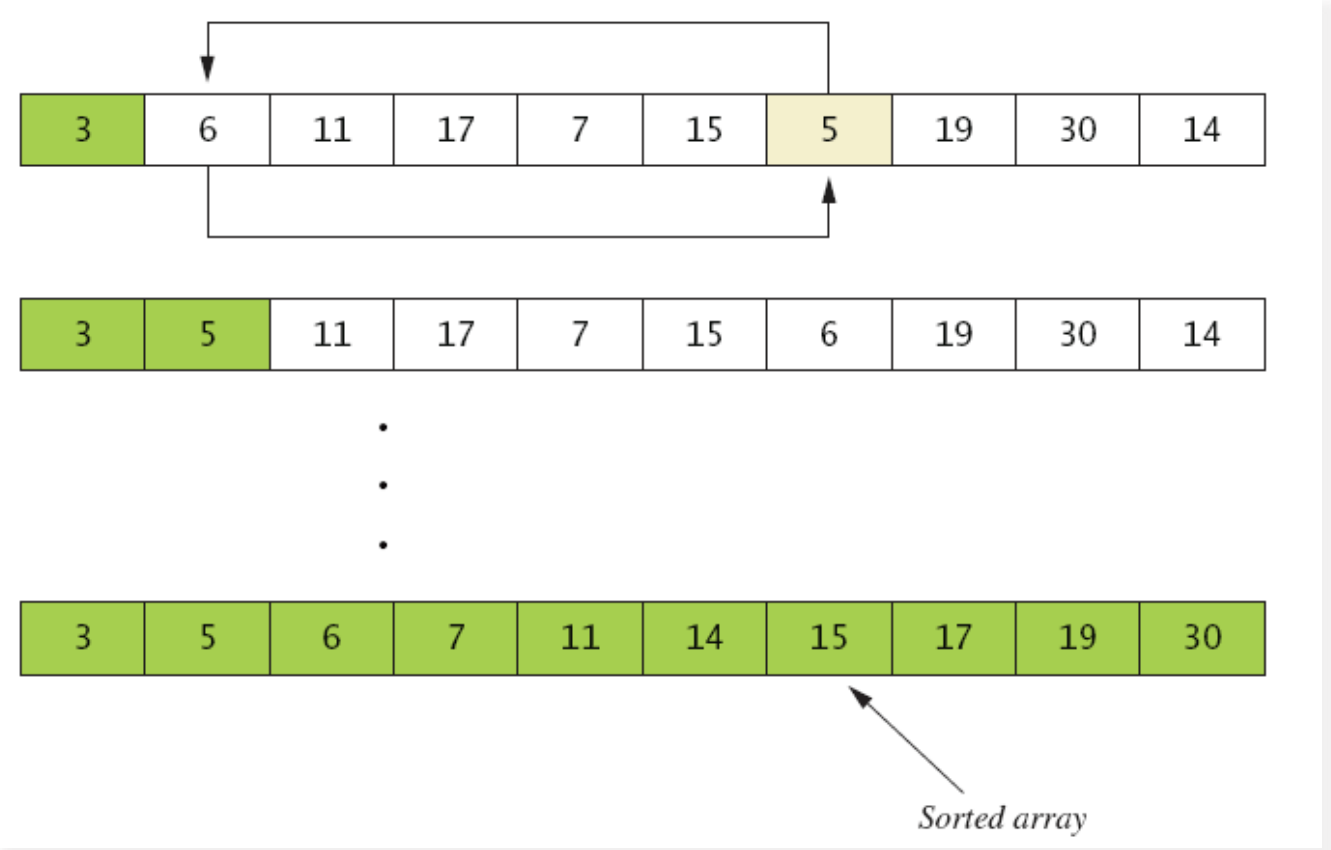
Selection Sort

- Figure 6.4a



Selection Sort

- Figure 6.4b



Selection Sort

- Algorithm for selection sort of an array

```
for (index = 0; index < a.length - 1; index++)
{// Place the correct value in a[index]:
    indexOfNextSmallest = the index of the smallest value among
                          a[index], a[index+1], ..., a[a.length - 1]
    Interchange the values of a[index] and a[indexOfNextSmallest].
    // Assertion: a[0] <= a[1] <=...<= a[index] and these
    // are the smallest of the original array elements.
    // The remaining positions contain the rest of the
    // original array elements.
}
```

Selection Sort

- View implementation of selection sort, listing 6.8
  `class ArraySorter`
- View demo program, listing 6.9
  `class SelectionSortDemo`

```
Array values before sorting:
7 5 11 2 16 4 18 14 12 30
Array values after sorting:
2 4 5 7 11 12 14 16 18 30
```

Sample screen output

Other Sorting Algorithms

- Selection sort is simplest
  - But it is very inefficient for large arrays
- Java Class Library provides for efficient sorting
  - Has a class called Arrays
  - Class has multiple versions of a sort method

Searching an Array

- Method used in **`OneWayNoRepeatsList`** is sequential search
  - Looks in order from first to last
  - Good for unsorted arrays
- Search ends when
  - Item is found … or …
  - End of list is reached
- If list is sorted, use more efficient searches

Multidimensional Arrays: Outline

- Multidimensional-Array Basics
- Multidimensional-Array Parameters and Returned Values
- Java's Representation of Multidimensional
- Ragged Arrays
- Programming Example: Employee Time Records

Multidimensional-Array Basics

- Consider Figure 6.5, a table of values

Savings Account Balances for Various Interest Rates Compounded Annually (Rounded to Whole Dollar Amounts)						
Year	5.00%	5.50%	6.00%	6.50%	7.00%	7.50%
1	$1050	$1055	$1060	$1065	$1070	$1075
2	$1103	$1113	$1124	$1134	$1145	$1156
3	$1158	$1174	$1191	$1208	$1225	$1242
4	$1216	$1239	$1262	$1286	$1311	$1335
5	$1276	$1307	$1338	$1370	$1403	$1436
6	$1340	$1379	$1419	$1459	$1501	$1543
7	$1407	$1455	$1504	$1554	$1606	$1659
8	$1477	$1535	$1594	$1655	$1718	$1783
9	$1551	$1619	$1689	$1763	$1838	$1917
10	$1629	$1708	$1791	$1877	$1967	$2061

Multidimensional-Array Basics

- Figure 6.6 Row and column indices for an array named **`table`**

`table[3][2]` has a value of 1262

Row index 3

Column index 2

Indices	0	1	2	3	4	5
0	$1050	$1055	$1060	$1065	$1070	$1075
1	$1103	$1113	$1124	$1134	$1145	$1156
2	$1158	$1174	$1191	$1208	$1225	$1242
3	$1216	$1239	$1262	$1286	$1311	$1335
4	$1276	$1307	$1338	$1370	$1403	$1436
5	$1340	$1379	$1419	$1459	$1501	$1543
6	$1407	$1455	$1504	$1554	$1606	$1659
7	$1477	$1535	$1594	$1655	$1718	$1783
8	$1551	$1619	$1689	$1763	$1838	$1917
9	$1629	$1708	$1791	$1877	$1967	$2061

Multidimensional-Array Basics

- We can access elements of the table with a nested for loop
- Example:

```
for (int row = 0; row < 10; row++)
   for (int column = 0; column < 6; column++)
      table[row][column] =
          balance(1000.00, row + 1, (5 + 0.5 * column));
```

- View sample program, listing 6.10
  `class InterestTable`

Multidimensional-Array Basics

```
Balances for Various Interest Rates Compounded Annually
(Rounded to Whole Dollar Amounts)

Years   5.00%   5.50%   6.00%   6.50%   7.00%   7.50%
1       $1050   $1055   $1060   $1065   $1070   $1075
2       $1103   $1113   $1124   $1134   $1145   $1156
3       $1158   $1174   $1191   $1208   $1225   $1242
4       $1216   $1239   $1262   $1286   $1311   $1335
5       $1276   $1307   $1338   $1370   $1403   $1436
6       $1340   $1379   $1419   $1459   $1501   $1543
7       $1407   $1455   $1504   $1554   $1606   $1659
8       $1477   $1535   $1594   $1655   $1718   $1783
9       $1551   $1619   $1689   $1763   $1838   $1917
10       $1629   $1708   $1791   $1877   $1967   $2061
```

Sample screen output

Multidimensional-Array Parameters and Returned Values

- Methods can have
  - Parameters that are multidimensional-arrays
  - Return values that are multidimensional-arrays
- View sample code, listing 6.11
  `class InterestTable2`

Java's Representation of Multidimensional Arrays

- Multidimensional array represented as several one-dimensional arrays
- Given
```
int [][] table = new int [10][6];
```
- Array table is actually 1 dimensional of type `int[]`
  - It is an array of arrays
- Important when sequencing through multidimensional array

Ragged Arrays

- Not necessary for all rows to be of the same length
- Example:

```
int[][] b;
b = new int[3][];
b[0] = new int[5]; //First row,  5 elements
b[1] = new int[7]; //Second row, 7 elements
b[2] = new int[4]; //Third row,  4 elements
```

Summary

- An array is a collection of variables all of the same type
- Arrays are objects, created with operator new
- Elements numbered starting with 0, ending with 1 less than length
- Indexed variable can be used as a parameter – treated like variable of base type

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Summary

- Entire array can be passed as parameter to a method
- Method return value can be an array
- Partially filled array usually stores values in initial segment, use an `int` to track how many are used
- Selection sort orders an array into ascending or descending order
- Multidimensional arrays are implemented as an array of arrays