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Arrays

Chapter 7

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
- Text fields, text areas in applets
- Drawing arbitrary polygons in applets

Array Basics: Outline

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

Creating and Accessing Arrays

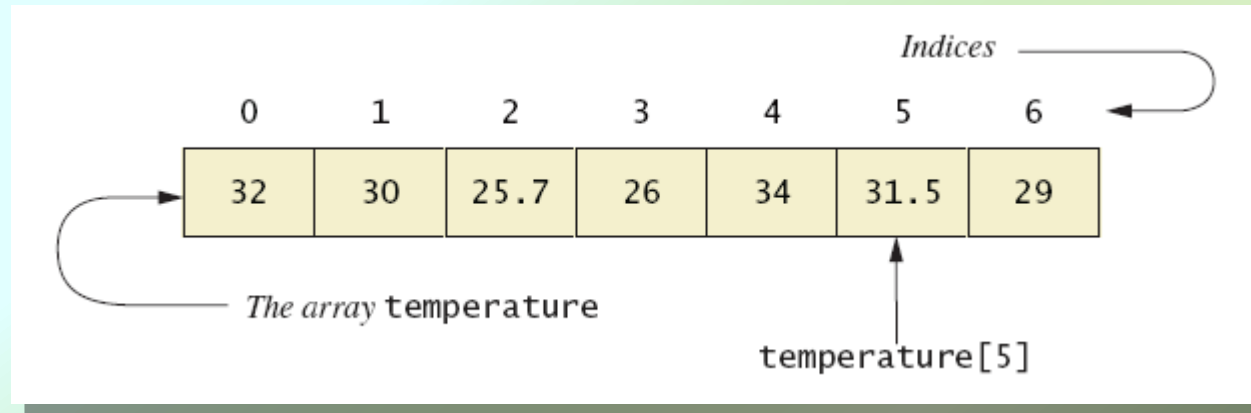
- An array is a special kind of object
- Think of as collection of variables of same type
- Creating an array with 7 variables of type double

```
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 7.1 A common way to visualize an array



- Note [sample program](#), listing 7.1
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

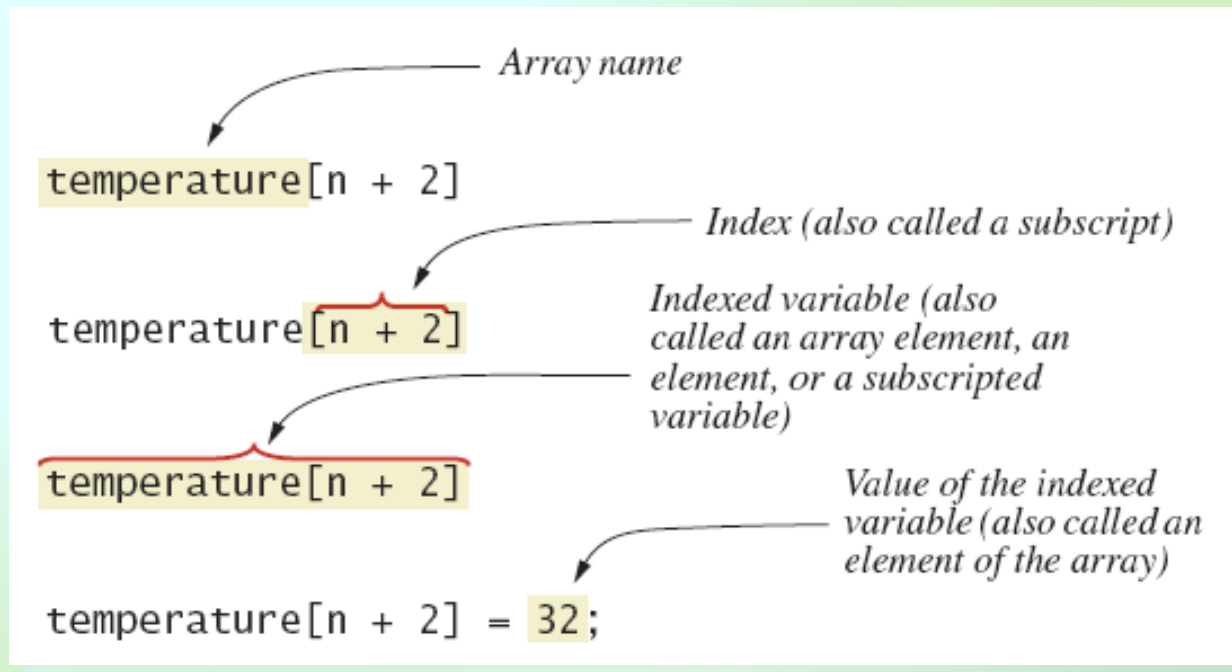
```
pressure = new int [100];
```

- To name an indexed value of the array

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

Array Details

- Figure 7.2 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 7.2
`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

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;
```

Arrays in Classes and Methods: Outline

- Case Study: Sales Report
- 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

Case Study: Sales Report

- Program to generate a sales report
- Class will contain
 - Name
 - Sales figure
- View [class declaration](#), listing 7.3
class SalesAssociate

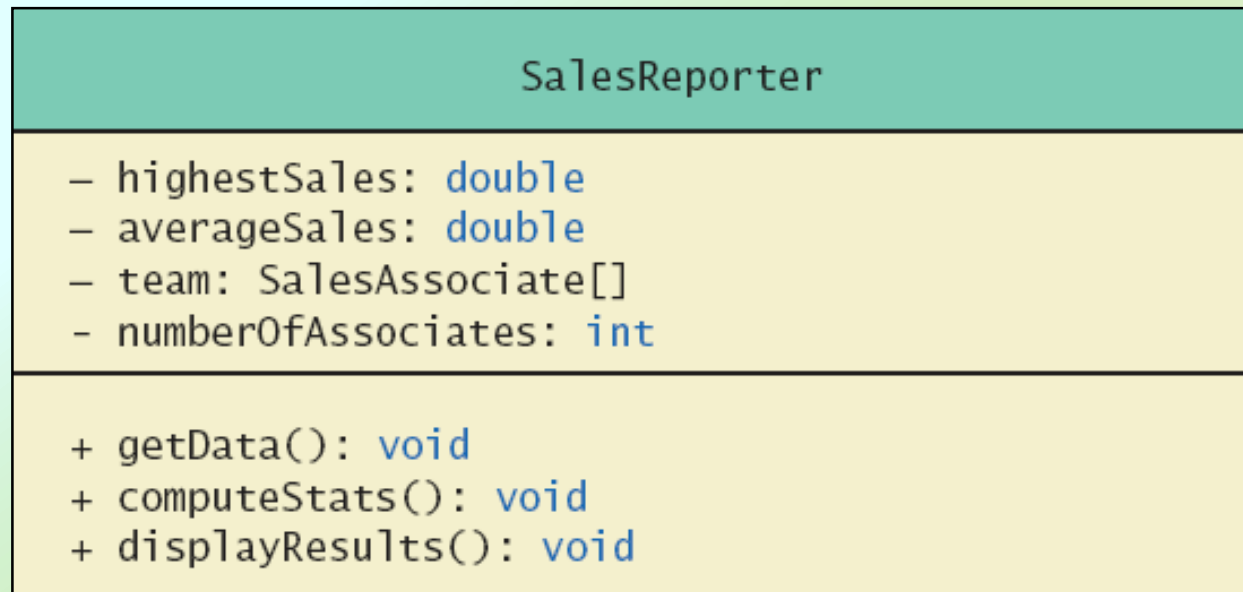
Case Study: Sales Report

Main subtasks for our program

1. Get ready
2. Obtain the data
3. Compute some statistics (update instance variables)
4. Display the results

Case Study: Sales Report

- Figure 7.3 Class diagram for class **SalesReporter**



Case Study: Sales Report

- View [sales report program](#), listing 7.4
class SalesReporter

```
Average sales per associate is $32000.0
The highest sales figure is $50000.0
The following had the highest sales:
Name: Natalie Dressed
Sales: $50000.0
$18000.0 above the average.

The rest performed as follows:
Name: Dusty Rhodes
Sales: $36000.0
$4000.0 above the average.

Name: Sandy Hair
Sales: $10000.0
$22000.0 below the average.
```

Sample
screen
output

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 7.5
`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 7.6
class TestEquals

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

Sample
screen
output

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 7.7
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

Programming with Arrays and Classes: Outline

- Programming Example: A Specialized List Class
- Partially Filled Arrays

Programming Example

- A specialized List class
 - Objects can be used for keeping lists of items
- Methods include
 - Capability to add items to the list
 - Also delete entire list, start with blank list
 - But no method to modify or delete list item
- Maximum number of items can be specified

Programming Example

- View [demo program](#), listing 7.8
class ListDemo
- Note declaration of the list object
- Note method calls

Programming Example

```
Enter items for the list, when prompted.  
Enter an item:  
Buy milk  
More items for the list? yes  
Enter an item:  
Walk dog  
More items for the list? yes  
Enter an item:  
Buy milk  
More items for the list? yes  
Enter an item:  
Write program  
The list is now full.  
The list contains:  
Buy milk  
Walk dog  
Write program
```

Sample
screen
output

Programming Example

- Now view array wrapped in a class to represent a list, listing 7.9

```
class OneWayNoRepeatsList
```

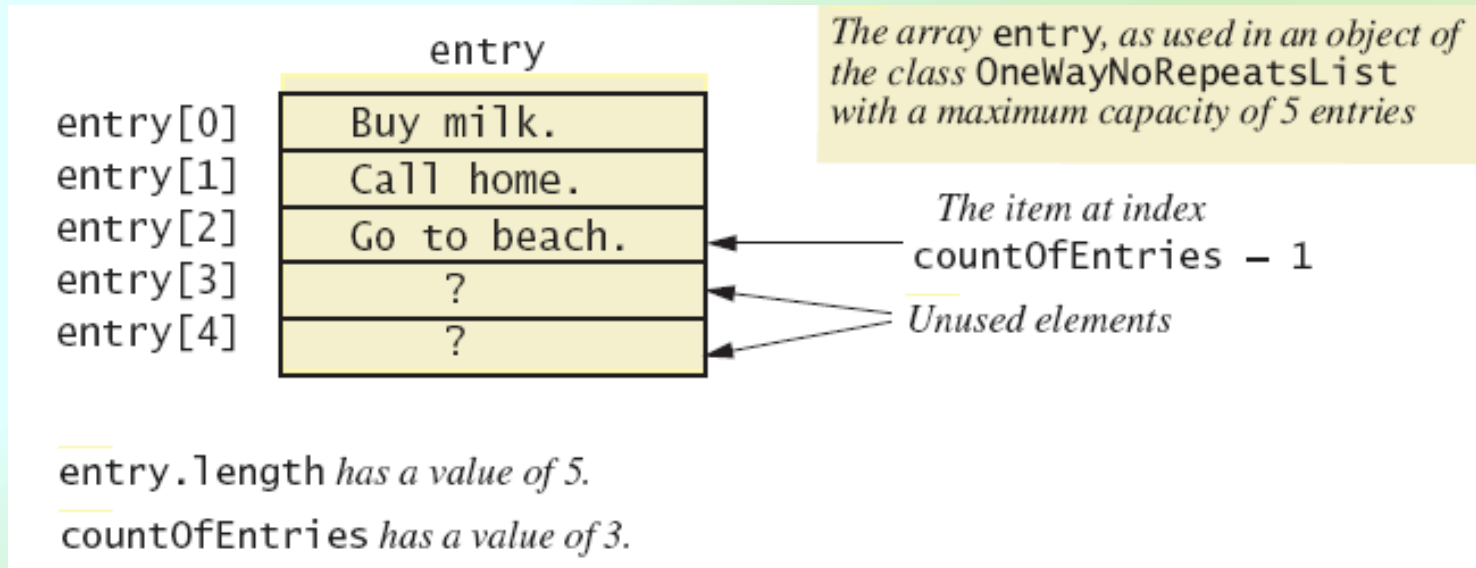
- Notable code elements
 - Declaration of private array
 - Method to find n^{th} list item
 - Method to check if item is on the list or not

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 7.4 A partially filled array



Sorting, Searching Arrays: Outline

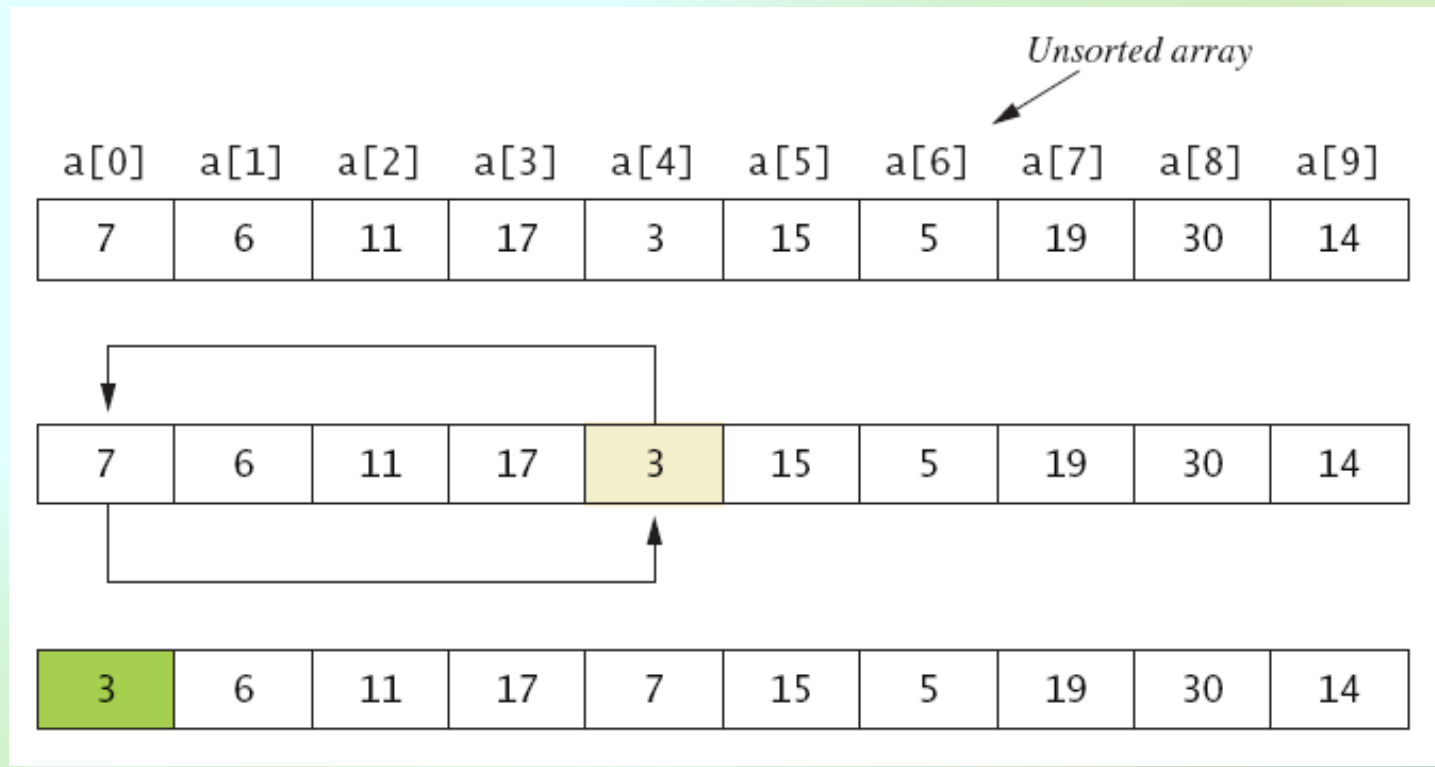
- Selection Sort
- Other Sorting Algorithms
- Searching an Array

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

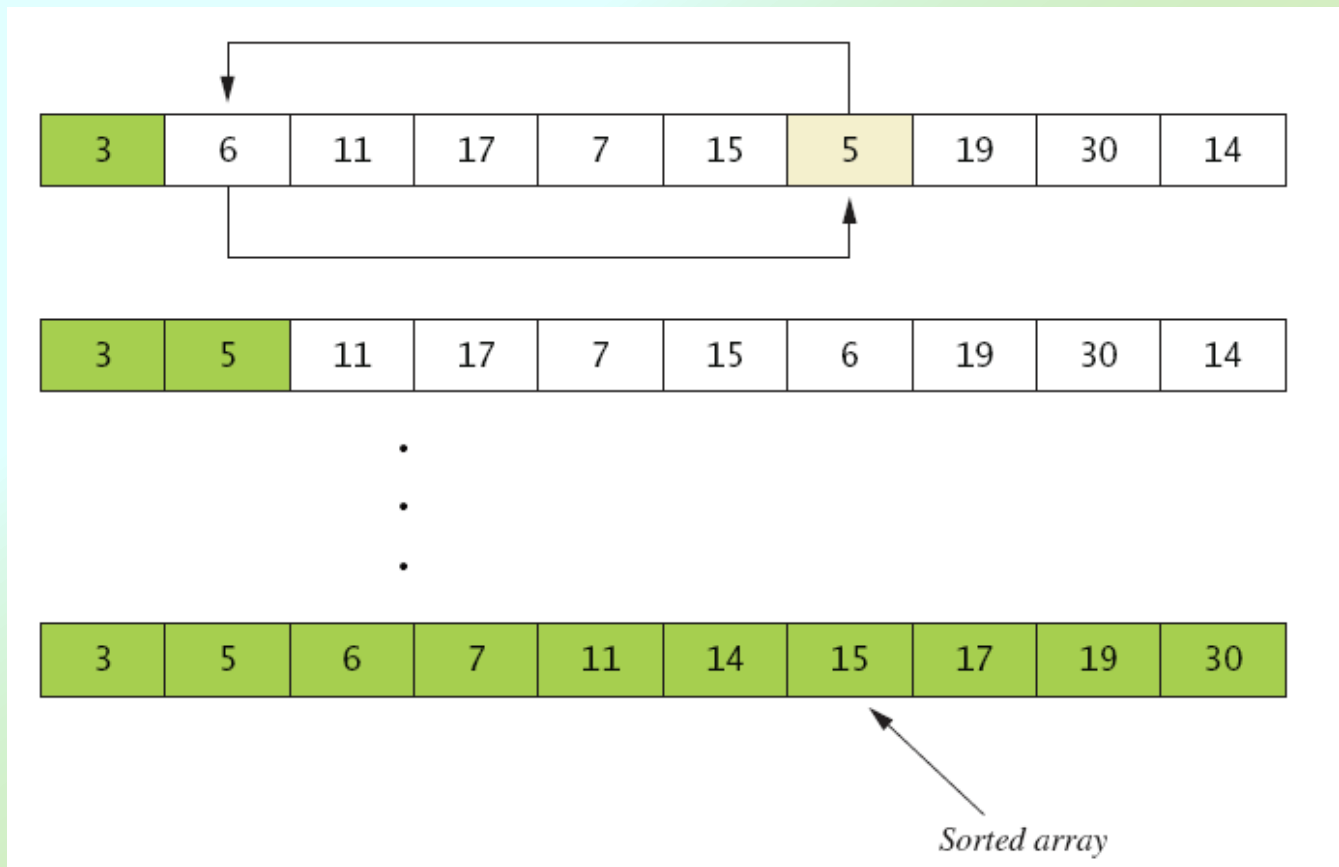
Selection Sort

- Figure 7.5a



Selection Sort

- Figure 7.5b



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 7.10

```
class ArraySorter
```

- View [demo program](#), listing 7.11

```
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 7.6, 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 7.7 Row and column indices for an array named `table`

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

<i>Indices</i>	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 7.12
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 7.13
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
```

Programming Example

- Employee Time Records
 - Two-dimensional array stores hours worked
 - For each employee
 - For each of 5 days of work week
 - Array is private instance variable of class
- View [sample program](#), listing 7.14
class TimeBook

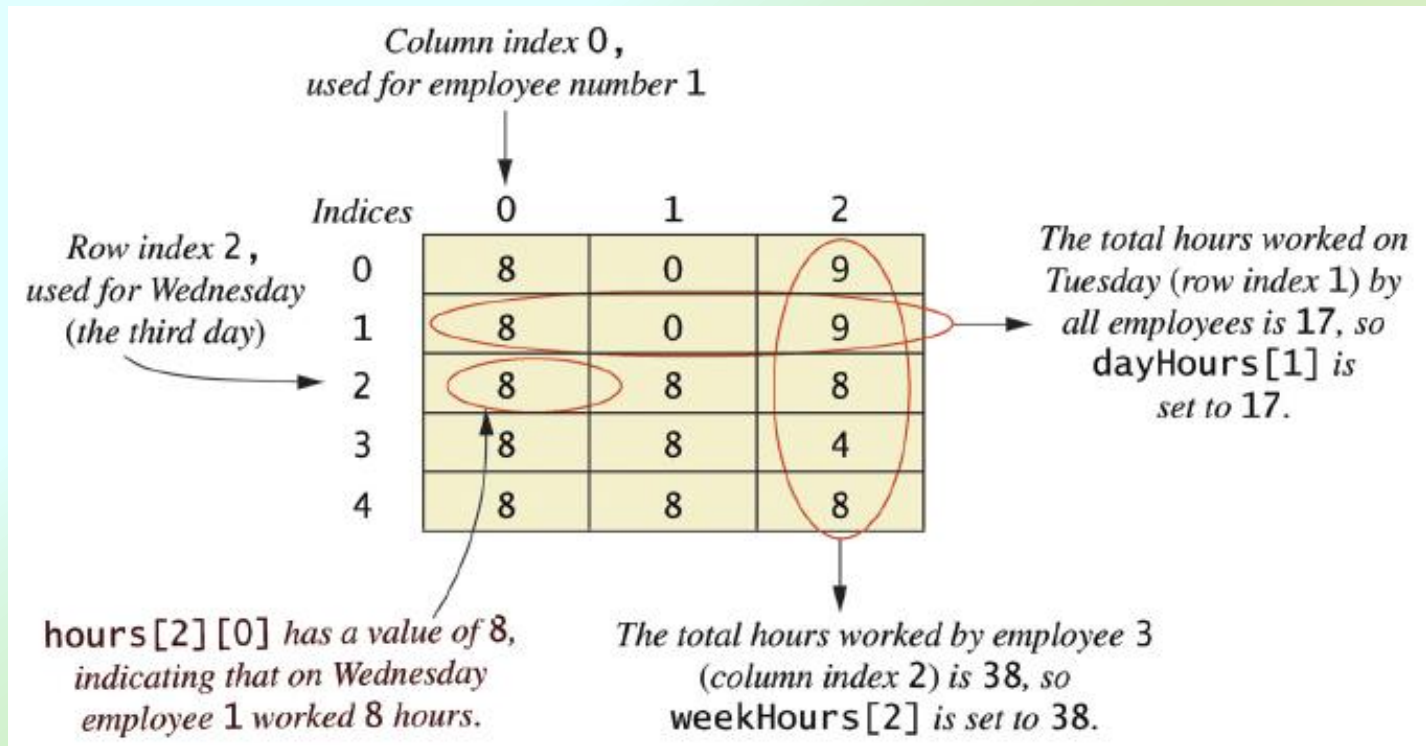
Programming Example

Employee	1	2	3	Totals
Monday	8	0	9	17
Tuesday	8	0	9	17
Wednesday	8	8	8	24
Thursday	8	8	4	20
Friday	8	8	8	24
Total	= 40	24	38	

Sample
screen
output

Programming Example

- Figure 7.8 Arrays for the class **TimeBook**



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

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
- Privacy leak caused by returning array corresponding to private instance variable

Summary

- Selection sort orders an array into ascending or descending order
- Multidimensional arrays are implemented as an array of arrays
- Treat two-dimensional array as a table with rows and columns