Arrays

Chapter 7 (Done right after 4… arrays and loops go together, especially for loops)

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Object Quick Primer

- A large subset of Java's features are for OOP – Object-Oriented Programming
- We'll get to that next and redo some of these examples with objects (where the comparison is helpful)
- Just remember the basic ideas of OOP: Instead of having all the information in primitive, largely unstructured form, we separate the parts that should be generally useful from the details (abstraction, with information hiding). We can group (encapsulate) data the belongs together along with the methods in separate classes (types, which we can define).

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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

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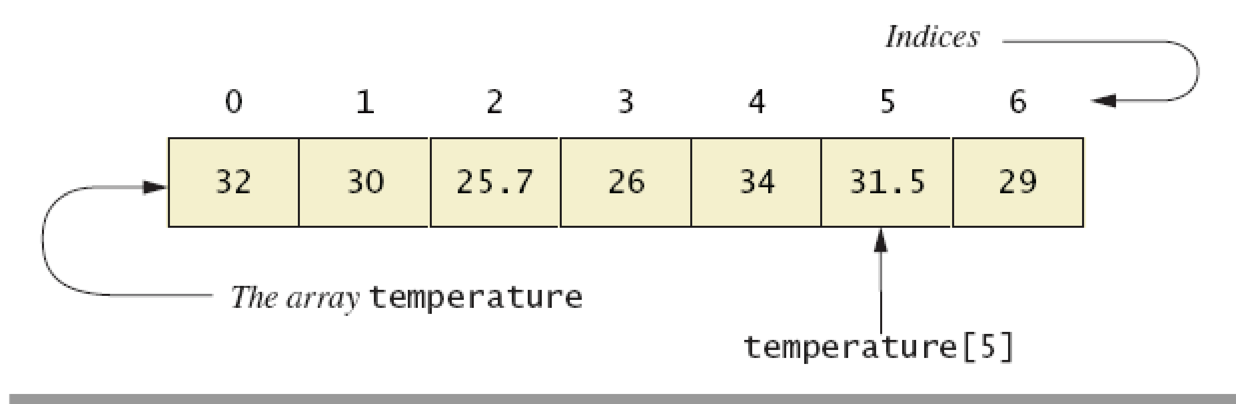
Creating and Accessing Arrays

- Figure 7.1 A common way to visualize an array



- Note sample program, listing 7.1
  class ArrayOfTemperatures

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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

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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. **This cannot be changed**.
- The type of the array elements is the array's base type
- The values will be initialized to 0, false, or null, as appropriate

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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();
```


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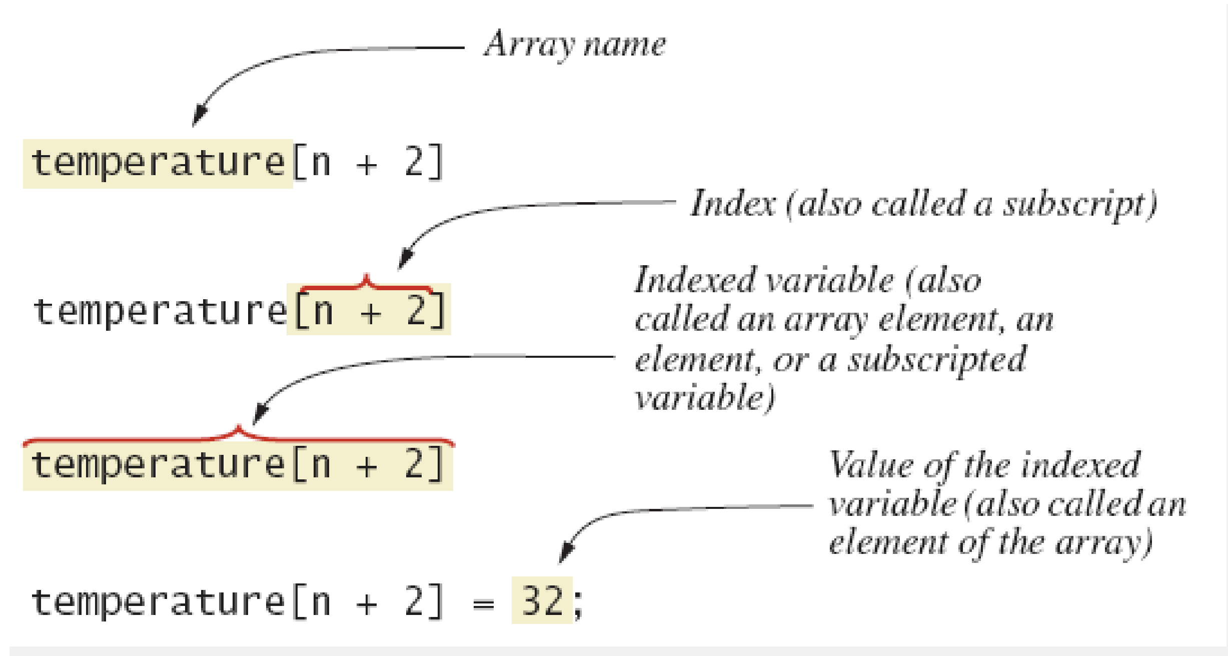
Array Details

- Figure 7.2 Array terminology



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The Instance Variable `length`

- As an object an array has only one public instance variable (no parentheses)
  - Variable **`length`**
  - Contains number of elements in the array
  - It is final, value cannot be changed
- Note revised code, listing 7.2 (once we do Objects, different way)
  `class ArrayOfTemperatures2`

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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

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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

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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;
```


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Case Study: Sales Report

- Program to generate a sales report
- Class will contain
  - Name
  - Sales figure
- View class declaration, listing 7.3

```
class SalesAssociate
```


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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

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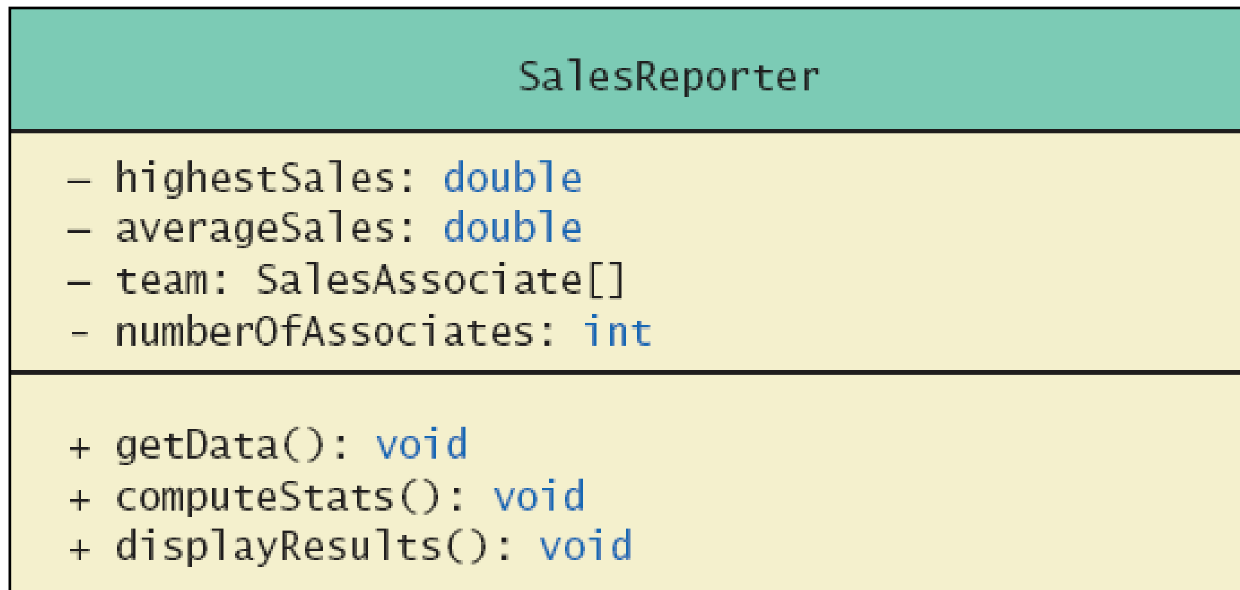
Case Study: Sales Report (later….)

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



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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

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Entire Arrays as Arguments

- Declaration of array parameter similar to how an array is declared
- Passes a the address of the array – you work on original
- 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.>
}
```


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Indexed Variables and 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
- (Using an indexed value is just like a variable of that type,e.g. if **nums** is an array of **int**s then you can use num[0] or num[4] anywhere you could use an **int** variable – can assign to and get value from).

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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`**
  - **`SelectionSort args->A`**
  - **`SelectionSort printArr, swap`**
- Thus possible to pass to the run of a program multiple strings
  - These can then be used by the program

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Array Assignment and Equality

- 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 (similar to Strings – pitfall)
  - arr1.equals(arr2) works just like **==** (PITFALL)
  - To compare arrays element by element, use Arrays.equals(arr1,arr2)
    - You will need to **import java.util.Arrays;**
    - Uses Object.equals() (which works for Strings).
    - **null** will equal **null (“null” means “nothing”, but *not* “empty”)**

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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");
```


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Gotcha – Creating an Array of Objects/Strings

- When you create an array of objects Java does not create instances of any of the objects! For example, consider the code:

```
SalesAssociate[] team = new SalesAssociate[10];
```

- We can't access team[0] yet; it is **null**. First we must create references to an object:

```
team[0] = new SalesAssociate("Jane Doe", 5000);
team[1] = new SalesAssociate("John Doe", 5000);
```

- we can now access team[0].getName() or team[1].getSalary()

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Methods that Return Arrays

- A Java method may return an array
- ~~View example program, listing 7.7~~
  ~~`class ReturnArrayDemo`~~ **`(Doing NegateArray in SelectionSort)`**
- Note definition of return type as an array
- Useful to return multiple values, especially of the same type
- To return the array value
  - Declare a local array
  - Use that identifier in the **`return`** statement

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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
- (Careful: “List” often means something very particular in programming – like an array but accessed differently. Size is not fixed at initialization)

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Programming Example (TBD as Object later)

- View demo program, listing 7.8
  `class ListDemo`
- Note declaration of the list object
- Note method calls

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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

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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

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Partially Filled Arrays

- Array size specified when it is made (with **new** or initializer list)
- 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
- If the default initialization is not good, then initialize right after

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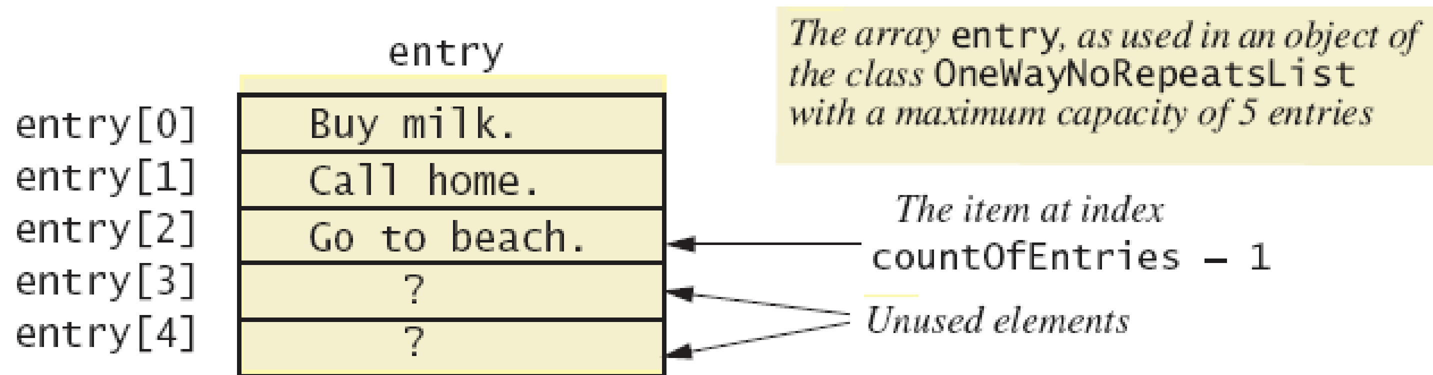
Partially Filled Arrays

- Figure 7.4 A partially filled array



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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

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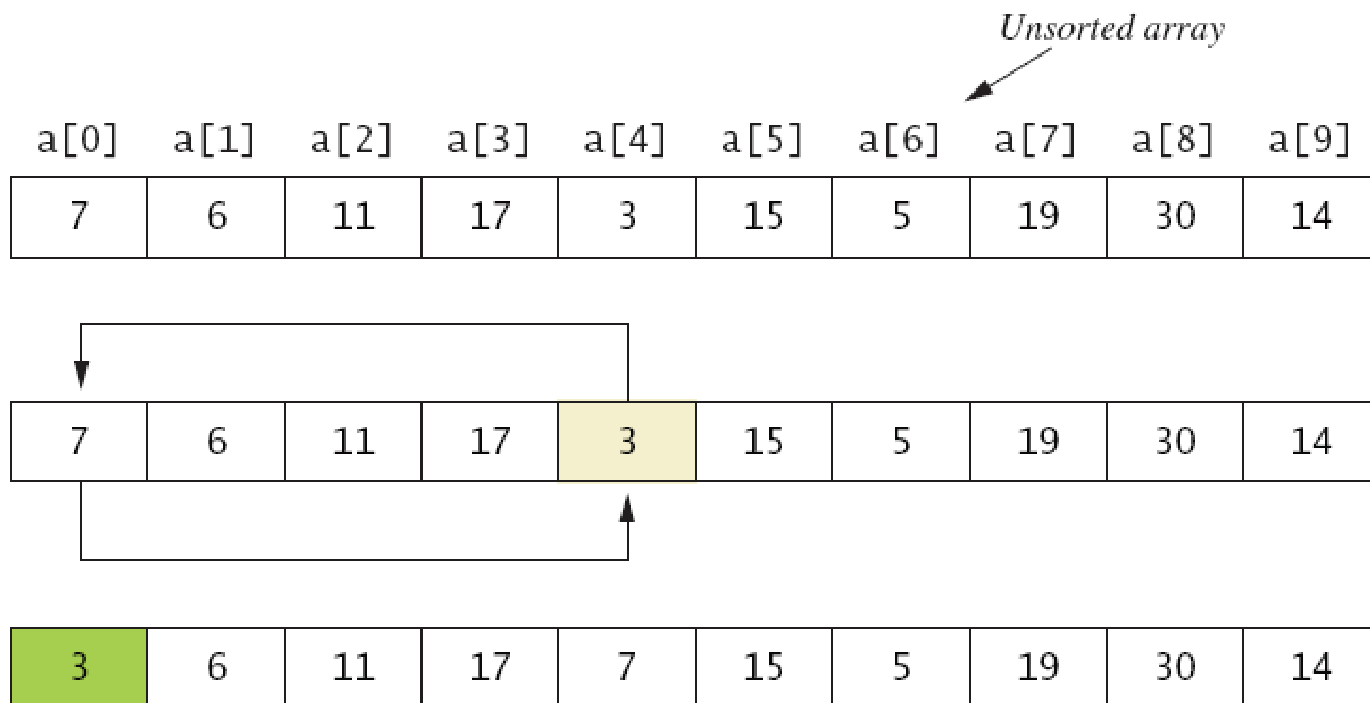
Selection Sort

- Figure 7.5a



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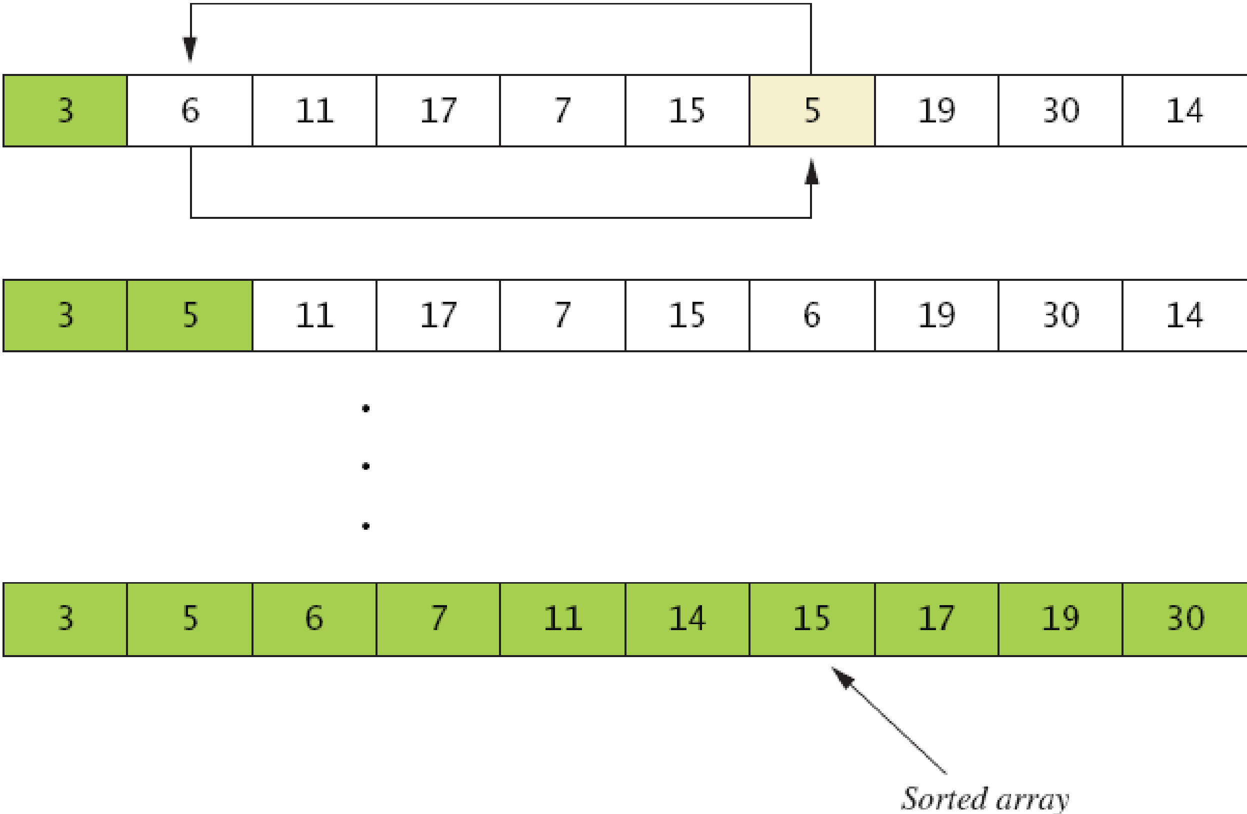
Selection Sort

- Figure 7.5b



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Selection Sort(poorly specified algorithm)

- 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.
}
```

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Selection Sort(better)

```
public static void swap(int[] A,int i,int j){
   int temp = A[i];
   A[i]=A[j];
   A[j]=temp;
  }

for( int i=0; i<A.length-1; ++i){
     int minIndex=i;
     for(int j = i;j<A.length;++j){
      if(A[j]<A[minIndex]) minIndex = j;
     }
     swap(A,minIndex,i);
}
```

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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

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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

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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

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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

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Multidimensional-Array Basics

- Figure 7.7 Row and column indices for an array named **`table`**
- `Careful: not always [row][column]`

`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

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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`

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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

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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

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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
```


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The `for-each` Statement

- Possible to step through values of an enumeration type
- Example

```
enum Suit {CLUBS, DIAMONDS, HEARTS, SPADES}
for (Suit nextSuit : Suit.values())
    System.out.print(nextSuit + " ");
```

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