Arrays

Unit 5

Gaddis: 7.1-4,6

CS 1428
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Array Data Type

- Array: a variable that contains multiple values of the same type.

- Values are stored consecutively in memory.

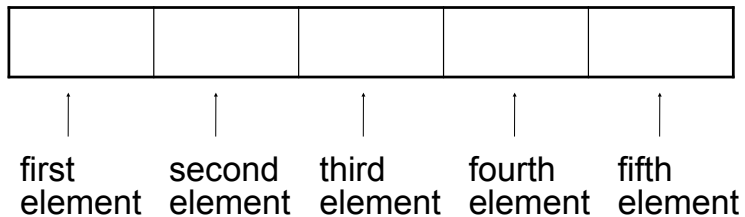- An array variable definition statement in C++:

  ```
  int numbers[5];
  ```

- This creates an array called `numbers` which contains 5 integer values (ints).

Array - Memory Layout

- The definition: `int numbers[5];`

  allocates the following memory:
  (values are stored consecutively in memory)

first   second   third   fourth   fifth
element   element   element   element   element

Array Terminology

- Given the following array definition:
  ```
  int numbers[5];
  ```

- `numbers` is the name of the array

- `int` is the data type of the array elements

- `5` is the size declarator:
  the number of elements (values) in the array.

Size Declarator

- The size declarator must be an *integer* and a *constant*.
  - ‣ it must be greater than 0
  - ‣ IT CANNOT BE A VARIABLE!*

- It can be a literal or a named constant.

```
const int SIZE = 40;
double grades[SIZE];
```

- Named constants ease program maintenance when the size of the array must be changed.

*Unless you are using a special compiler (mine is not special).

7.2 Accessing Array Elements

- Each element of the array has a unique subscript (or index) that indicates its position in the array.

- The subscripts are 0-based
  - ‣ the first element has subscript 0
  - ‣ the second element has subscript 1
  - ‣ . . .
  - ‣ the last element has subscript (size -1)

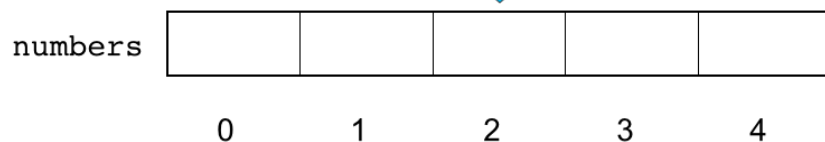the last element's subscript is n-1 where n is the number of elements in the array

Accessing Array Elements

- Syntax to access one element:

```
numbers[2]  //the third element of numbers array
```

- Called "numbers at 2" or "numbers sub 2"

numbers

0	1	2	3	4

Array subscripts

- The subscript is ALWAYS an integer
  - ‣ regardless of the type of the array elements.

- the subscript can be ANY integer expression

  - ‣ literal: 2   `numbers[2]`
  - ‣ variable: i   `numbers[i]`
  - ‣ expression: (i+2)/2   `numbers[(i+2)/2]`

Array subscripts

- Given the following array definition:

```
double tests[10];
```

the expression `tests[i]` may be used exactly like **any** variable of type double.

```
tests[0] = 79;
cout << tests[0];
cin >> tests[1];
tests[4] = tests[0] + tests[1];
```

Using array elements:

```
double values[3];   //array definition

values[0] = 22.3;   //assignment to array element
values[1] = 11.1;

cout << "Enter a number: ";
cin >> values[2];

double sum = values[0] + values[1] + values[2];
double avg = sum/3.0;

cout << "Values at zero: " << values[0] << endl;

int i=2;
if (values[i] > 32.0)
    cout << "Above freezing" << endl;
```

7.4 Array initialization

- You can initialize arrays when they are defined.

```
const int NUM_SCORES = 3;
float scores[NUM_SCORES] = {86.5, 92.1, 77.5};
```

- Values are assigned in order:

scores[0] = 86.5

scores[1] = 92.1

scores[2] = 77.5

86.5	92.1	77.5

- NOTE: **un**initialized arrays have GARBAGE values stored in them (not necessarily 0).

Partial Array Initialization

- When you initialize, you don't need to specify a value for every position.

```
float scores[7] = {86.5, 92.1, 77.5};
```

- In this case, the first 3 elements are initialized to the specified values.

- The uninitialized values WILL be set to 0!!!!

86.5	92.1	77.5	0	0	0	0

Implicit array sizing

- When you initialize, you don't need to specify the size declarator.

```
float scores[] = {86.5, 92.1, 77.5};
```

- In this case, the compiler determines the size of the array from the number of elements listed.

86.5	92.1	77.5

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7.6 Processing Array Contents

- Generally there are NO operations that you can perform over an **entire** array.
- Some operations may appear to work (no errors) but you don't get the desired results.

```
int numbers1[] = {1, 2, 3};
int numbers2[] = {4, 5, 6};

cin >> numbers1;             //input, won't work
cout << numbers1 << endl;    //output, won't work
numbers1 = numbers2;         //assignment, won't work
if (numbers1==numbers2)      //comparison, won't work
 ...
numbers3 = numbers1 + numbers2; //addition, won't work
```

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Operations over arrays

- Most array operations must be done <u>one element at a time</u>.
- Input the 7 programming assignment grades for a student in CS1428:

```
const int NUM_SCORES = 7;
int scores[NUM_SCORES];
cout << "Enter the " << NUM_SCORES
     << " programming assignment scores: " << endl;
cin >> scores[0];
cin >> scores[1];
cin >> scores[2];
cin >> scores[3];
cin >> scores[4];
cin >> scores[5];
cin >> scores[6];
```

- Is there a better way?

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Array input using a loop

- We can use a for loop to **input** into the array
- The subscript/index can be a variable

```
const int NUM_SCORES = 7;
int scores[NUM_SCORES];
cout << "Enter the " << NUM_SCORES
     << " programming assignment scores: " << endl;

for (int i=0; i < NUM_SCORES; i++) {
   cin >> scores[i];
}
```

- This code is equivalent to the code on the previous slide.

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Array output using a loop

- We can use a for loop to **output** the elements of the array

```
const int NUM_SCORES = 7;
int scores[NUM_SCORES];
cout << "Enter the " << NUM_SCORES
     << " programming assignment scores: " << endl;

for (int i=0; i < NUM_SCORES; i++) {
   cin >> scores[i];
}

cout << "You entered these values: ";
for (int i=0; i < NUM_SCORES; i++) {
   cout << scores[i] << " ";
}
cout << endl;
```

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Summing values in an array

- We can use a for loop to **sum** the elements of the array (the *running total*)

```
const int NUM_SCORES = 7;
int scores[NUM_SCORES];
cout << "Enter the " << NUM_SCORES
     << " programming assignment scores: " << endl;

for (int i=0; i < NUM_SCORES; i++) {
   cin >> scores[i];
}

int total = 0;  //initialize accumulator
for (int i=0; i < NUM_SCORES; i++) {
   total = total + scores[i];
}
```

How do you get the average programming assignment score?

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Finding the maximum value in an array

- We can use a for loop to **find the max** value:
- Note: keep track of the maximum value encountered so far (the *running maximum*)

```
const int NUM_SCORES = 7;
int scores[NUM_SCORES];
cout << "Enter the " << NUM_SCORES
     << " programming assignment scores: " << endl;

for (int i=0; i < NUM_SCORES; i++) {
   cin >> scores[i];
}

int maximum = scores[0]; //init max to first elem
for (int i=1; i < NUM_SCORES; i++) { //start i at 1
   if (scores[i] > maximum)
      maximum = scores[i];    //save the new maximum
}  // no else needed
```

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Array assignment

- To **copy/assign** one array to another, you must assign element by element.

```
const int SIZE = 4;
int values1[SIZE] = {100, 200, 300, 400};
int values2[SIZE];

// values2 = values1;  WRONG, won't work correctly

for (int i = 0; i < SIZE; i++) {
   values2[i] = values1[i];
}
```

- Note: this also does not work:

```
values2 = {3,6,9,27};
            //only works for initialization
```

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7.3 C++: No bounds checking

- C++ does not check it to make sure an array subscript is valid (between 0 and size-1)
- If you use a subscript that is outside the bounds of the array you **may not** get a warning or error.
- You may unintentionally change memory allocated to other variables.

```
const int SIZE = 3;
int values[SIZE];

for (int i=0; i < 5; i++) {
    values[i] = 100;
}
```

This code defines a three-element array and then writes five values to it (changing the memory after the array).

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