Week 3
Functions & Arrays
Gaddis: Chapters 6 and 7
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Function Definitions

- Function definition pattern:

\[ \text{datatype identifier (parameter1, parameter2, ...)} \{ \]
\[ \text{statements . . .} \]
\[ \}\]

Where a parameter is:

\[ \text{datatype identifier} \]

- \( \text{datatype} \): the type of data returned by the function.
- \( \text{identifier} \): the name by which it is possible to call the function.
- \( \text{parameters} \): Like a regular variable declaration, act within the function as a regular local variable. Allow passing arguments to the function when it is called.
- \( \text{statements} \): the function's body, executed when called.

Function Call, Return Statement

- \text{Function call expression}

\[ \text{identifier (expression1, . . .) \]} \]

- Causes control flow to enter body of function named identifier.
- \( \text{parameter1} \) is initialized to the value of \( \text{expression1} \), and so on for each parameter
- \( \text{expression1} \) is called an \text{argument}.
- \text{Return statement: return expression;}

- inside a function, causes function to stop, return control to caller.
- The value of the return \( \text{expression} \) becomes the value of the function call

Example: Function

```cpp
// function example
#include <iostream>
using namespace std;
int addition (int a, int b) {
    int result;
    result = a + b;
    return result;
}
int main () {
    int z;
    z = addition (5, 3);
    cout << "The result is " << z << endl;
}
```

- What are the parameters? arguments?
- What is the value of: \( \text{addition (5,3)} \)?
- What is the output?
Void function

- A function that returns no value:

```cpp
void printAddition (int a, int b) {
   int result;
   result=a+b;
   cout << "the answer is: " << result << endl;
}

- use void as the return type.
- the function call is now a statement (it does not have a value)

```cpp
int main () {
   printAddition (5,3);
   return 0;
}
```

Prototypes

- In a program, function definitions must occur before any calls to that function
- To override this requirement, place a prototype of the function before the call.
- The pattern for a prototype:

```cpp
datatype identifier (type1, type2, ...);
```

Arguments passed by value

- Pass by value: when an argument is passed to a function, its value is copied into the parameter.
- It is implemented using variable initialization (in the background):

```cpp
int param = argument;
```
- Changes to the parameter in the function body do not affect the value of the argument in the call
- The parameter and the argument are stored in separate variables; separate locations in memory.

Example: Pass by Value

```cpp
#include <iostream>
using namespace std;

void changeMe(int);

int main() {
   int number = 12;
   cout << "number is " << number << endl;
   changeMe(number);
   cout << "Back in main, number is " << number << endl;
   return 0;
}

void changeMe(int myValue) {
   myValue = 200;
   cout << "myValue is " << myValue << endl;
}
```

Output:
number is 12
myValue is 200
Back in main, number is 12
changeMe failed to change the argument!
Parameter passing by Reference

- **Pass by reference**: when an argument is passed to a function, the function has direct access to the original argument (no copying).
- Pass by reference in C++ is implemented using a reference parameter, which has an ampersand (&) in front of it:

  ```cpp
  void changeMe (int &myValue);
  ```

- A reference parameter acts as an **alias** to its argument, it is **NOT** a separate storage location.
- Changes to the parameter in the function DO affect the value of the argument.

### Example: Pass by Reference

```cpp
#include <iostream>
using namespace std;

void changeMe(int &);

int main() {
  int number = 12;
  cout << "number is " << number << endl;
  changeMe(number);
  cout << "Back in main, number is " << number << endl;
  return 0;
}

void changeMe(int &myValue) {
  myValue = 200;
  cout << "myValue is " << myValue << endl;
}
```

Output:
```
number is 12
myValue is 200
Back in main, number is 200
```

### Example: Boolean functions

```cpp
bool isEven(int number) {
  bool status;
  if (number % 2 == 0) {
    status = true; // number is even if there is no remainder.
  } else {
    status = false; // Otherwise, the number is odd.
  }
  return status;
}

int main() {
  int val;
  cout << "Enter an integer and I will tell you ";
  cout << "if it is even or odd: 
; cin >> val;
  if (isEven(val)) {
    cout << val << " is even.\n";
  } else {
    cout << val << " is odd.\n";
  }
}
```

### Arrays

- **An array** is:
  - A series of elements of the same type
  - placed in contiguous memory locations
  - that can be individually referenced by adding an index to a unique identifier.
- **To declare an array**:
  ```cpp
  datatype identifier [size];
  ```
  - datatype is the type of the elements
  - identifier is the name of the array
  - size is the number of elements (constant)
Array initialization

- To specify contents of the array in the definition:
  
  ```
  float scores[3] = {86.5, 92.1, 77.5};
  ```

  - creates an array of size 3 containing the specified values.
  
  ```
  float scores[10] = {86.5, 92.1, 77.5};
  ```

  - creates an array containing the specified values followed by 7 zeros (partial initialization).
  
  ```
  float scores[] = {86.5, 92.1, 77.5};
  ```

  - creates an array of size 3 containing the specified values (size is determined from list).

Array access

- to access the value of any of the elements of the array individually as if it was a normal variable:
  
  ```
  scores[2] = 89.5;
  ```

  - scores[2] is a variable of type float
  - use it anywhere a float variable can be used.

  rules about subscripts:
  - always start at 0, last subscript is size-1
  - must have type int but can be any expression

  watchout: square brackets are used both to declare the array and to access elements.

Arrays: operations

- Valid operations over entire arrays:
  - function call: myFunc(scores, x);

- **Invalid** operations over entire arrays:
  - assignment: array1 = array2;
  - comparison: array1 == array2
  - output: cout << array1;
  - input: cin >> array2

  - Must do these element by element, probably using a for loop

Processing arrays

- **Assignment**: copy one array to another
  
  ```
  const int SIZE = 4;
  int oldValues[SIZE] = {10, 100, 200, 300};
  int newValues[SIZE];
  for (int count = 0; count < SIZE; count++)
    newValues[count] = oldValues[count];
  ```

- **Output**: displaying the contents of an array
  
  ```
  const int SIZE = 5;
  int numbers[SIZE] = {10, 20, 30, 40, 50};
  for (int count = 0; count < SIZE; count++)
    cout << numbers[count] << endl;
  ```
Processing arrays

Summing and averaging of an array of scores:

```cpp
const int NUM_SCORES = 8;
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];
} double average =
    static_cast<double>(total) / NUM_SCORES;
```

Finding highest and lowest values in arrays

- **Maximum**: Need to track the highest value seen so far. Start with highest = first element.

```cpp
const int SIZE = 5;
int array[SIZE] = {10, 100, 200, 30};
int highest = array[0];
for (int count = 1; count < SIZE; count++)
    if (array[count] > highest)
        highest = array[count];
cout << “The maximum value is “ << highest << endl;
```

Comparing arrays

- **Equality**: Are the arrays exactly the same?
  - Must examine entire array to determine true
  - Only one counter-example proves it is false

```cpp
const int SIZE = 5;
int firstArray[SIZE] = {10, 100, 200, 300};
int secondArray[SIZE] = {10, 100, 201, 300};
bool arraysEqual = true; //assume true, until proven false
for (int count = 0; count < SIZE && arraysEqual; count++)
    if (firstArray[count] != secondArray[count])
        arraysEqual=false;
if (arraysEqual)
    cout << “The arrays are equal” << endl;
else
    cout << “The arrays are not equal” << endl;
```

Arrays as parameters

- In the **function definition**, the parameter type is a variable name with an empty set of brackets: [ ]
  - Do NOT give a size for the array inside [ ]
  ```cpp
  void showArray(int values[], int size)
  ```
- In the **prototype**, empty brackets go after the element datatype.
  ```cpp
  void showArray(int[], int)
  ```
- In the **function call**, use the variable name for the entire array.
  ```cpp
  showArray(numbers, 5)
  ```
- An array is **always passed by reference.**
Example: Partially filled arrays

```cpp
int sumList (int list[], int size) { //sums elements in list array
    int total = 0;
    for (int i=0; i < size; i++) {
        total = total + list[i];
    }
    return total;
}
const int CAPACITY = 100;
int main() {
    int scores[CAPACITY];
    int count = 0; //tracks number of elems in array
    cout << "How many programming assignment scores?" << endl;
    cin >> count;
    if (count <= 100) {
        cout << "Enter the scores, one per line: " << endl;
        for (int i=0; i<count; i++)
            cin >> scores[i];
        int sum = sumList(scores, count);
        cout << "average: " << sum/static_cast<double>(count) << endl;
    } else
        cout << "There can be at most 100 scores." << endl;
```