



# Programming Fundamentals

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# Objectives


In this chapter, you will:

- Learn about standard (predefined) functions and discover how to use them in a program
- Learn about user-defined functions
- Examine value-returning functions, including actual and formal parameters
- Explore how to construct and use a value-returning, user-defined function in a program



# Introduction

- Functions are like building blocks
- They allow complicated programs to be divided into manageable pieces
- Some advantages of functions:
  - A programmer can focus on just that part of the program and construct it, debug it, and perfect it
  - Different people can work on different functions simultaneously
  - Can be re-used (even in different programs)
  - Enhance program readability



# Introduction (continued)

- Functions
  - Called modules
  - Like miniature programs
  - Can be put together to form a larger program

# Predefined Functions

- In algebra, a function is defined as a rule or correspondence between values, called the function's arguments, and the unique value of the function associated with the arguments
  - If  $f(x) = 2x + 5$ , then  $f(1) = 7$ ,  $f(2) = 9$ , and  $f(3) = 11$ 
    - 1, 2, and 3 are arguments
    - 7, 9, and 11 are the corresponding values

# Predefined Functions (continued)

- Some of the predefined mathematical functions are:
  - `sqrt(x)`
  - `pow(x, y)`
  - `floor(x)`
- Predefined functions are organized into separate libraries
- I/O functions are in `iostream` header
- Math functions are in `cmath` header

# Predefined Functions (continued)

- `pow(x, y)` calculates  $x^y$ 
  - `pow(2, 3) = 8.0`
  - Returns a value of type `double`
  - `x` and `y` are the parameters (or arguments)
    - The function has two parameters
- `sqrt(x)` calculates the nonnegative square root of `x`, for `x >= 0.0`
  - `sqrt(2.25)` is `1.5`
  - Type `double`



# Predefined Functions (continued)

- The `floor` function `floor(x)` calculates largest whole number not greater than `x`
  - `floor(48.79)` is `48.0`
  - Type `double`
  - Has only one parameter



# Predefined Functions (continued)

TABLE 6-1 Predefined Functions

Function	Header File	Purpose	Parameter(s) Type	Result
<code>abs (x)</code>	<code>&lt;cstdlib&gt;</code>	Returns the absolute value of its argument: <code>abs (-7) = 7</code>	<code>int</code>	<code>int</code>
<code>ceil (x)</code>	<code>&lt;cmath&gt;</code>	Returns the smallest whole number that is not less than <code>x</code> : <code>ceil (56.34) = 57.0</code>	<code>double</code>	<code>double</code>
<code>cos (x)</code>	<code>&lt;cmath&gt;</code>	Returns the cosine of angle <code>x</code> : <code>cos (0.0) = 1.0</code>	<code>double</code> (radians)	<code>double</code>
<code>exp (x)</code>	<code>&lt;cmath&gt;</code>	Returns $e^x$ , where $e = 2.718$ : <code>exp (1.0) = 2.71828</code>	<code>double</code>	<code>double</code>
<code>fabs (x)</code>	<code>&lt;cmath&gt;</code>	Returns the absolute value of its argument: <code>fabs (-5.67) = 5.67</code>	<code>double</code>	<code>double</code>

# Predefined Functions (continued)

TABLE 6-1 Predefined Functions (continued)

Function	Header File	Purpose	Parameter(s) Type	Result
<code>floor(x)</code>	<code>&lt;cmath&gt;</code>	Returns the largest whole number that is not greater than <code>x</code> : <code>floor(45.67) = 45.00</code>	<code>double</code>	<code>double</code>
<code>pow(x, y)</code>	<code>&lt;cmath&gt;</code>	Returns $x^y$ ; If <code>x</code> is negative, <code>y</code> must be a whole number: <code>pow(0.16, 0.5) = 0.4</code>	<code>double</code>	<code>double</code>
<code>tolower(x)</code>	<code>&lt;cctype&gt;</code>	Returns the lowercase value of <code>x</code> if <code>x</code> is uppercase; otherwise, returns <code>x</code>	<code>int</code>	<code>int</code>
<code>toupper(x)</code>	<code>&lt;cctype&gt;</code>	Returns the uppercase value of <code>x</code> if <code>x</code> is lowercase; otherwise, returns <code>x</code>	<code>int</code>	<code>int</code>

## EXAMPLE 6-1

//How to use predefined functions.

```
#include <iostream>
#include <cmath>
#include <cctype>
#include <cstdlib>
```

```
using namespace std;
```

```
int main()
```

```
{
```

```
    int    x;
```

```
    double u, v;
```

```
    cout << "Line 1: Uppercase a is "
          << static_cast<char>(toupper('a'))
          << endl;
```

//Line 1

```
    u = 4.2;
```

//Line 2

```
    v = 3.0;
```

//Line 3

```
    cout << "Line 4: " << u << " to the power of "
          << v << " = " << pow(u, v) << endl;
```

//Line 4

```
    cout << "Line 5: 5.0 to the power of 4 = "
          << pow(5.0, 4) << endl;
```

//Line 5

```
    u = u + pow(3.0, 3);
```

//Line 6

```
    cout << "Line 7: u = " << u << endl;
```

//Line 7

```
    x = -15;
```

//Line 8

```
    cout << "Line 9: Absolute value of " << x
          << " = " << abs(x) << endl;
```

//Line 9

```
    return 0;
```

```
}
```

# Predefined Functions (continued)

► Example 6-1 sample run:

```
Line 1: Uppercase a is A  
Line 4: 4.2 to the power of 3 = 74.088  
Line 5: 5.0 to the power of 4 = 625  
Line 7: u = 31.2  
Line 9: Absolute value of -15 = 15
```

# Built in Functions

- `# include <cmath>`
- `sqrt (x)`
- `exp(x)`
- `abs(x)`
- `fabs(x)`
- `pow(x,y)`
- `floor(x)`
- `ceil(x)`
- `cos(x)`
- `sin(x)`



# User-Defined Functions

- Value-returning functions: have a return type
  - Return a value of a specific data type using the `return` statement
- Void functions: do not have a return type
  - *Do not* use a `return` statement to return a value



# Value-Returning Functions

- To use these functions you must:
  - Include the appropriate header file in your program using the include statement
  - Know the following items:
    - Name of the function
    - Number of parameters, if any
    - Data type of each parameter
    - Data type of the value returned: Called the type of the function





# Value-Returning Functions (continued)

- Because the value returned by a value-returning function is unique, we must:
  - Save the value for further calculation
  - Use the value in some calculation
  - Print the value
- A value-returning function is used in an assignment or in an output statement
- One more thing is associated with functions:
  - The code required to accomplish the task

# Value-Returning Functions (continued)

```
int abs(int number)
int abs(int number)
{
    if (number < 0)
        number = -number;

    return number;
}
```

```
double pow(double base, double exponent)
```

```
double u = 2.5;
double v = 3.0;
double x, y, w;
```

```
x = pow(u, v);           //Line 1
y = pow(2.0, 3.2);       //Line 2
w = pow(u, 7);           //Line 3
```

# Value-Returning Functions (continued)

- Heading: first four properties above
  - Example: `int abs (int number)`
- Formal Parameter: variable declared in the heading
  - Example: `number`
- Actual Parameter: variable or expression listed in a call to a function
  - Example: `x = abs (t)`

# Syntax: Value-Returning Function

← Syntax:

```
functionType functionName(formal parameter list)
{
    statements
}
```

← `functionType` is also called the data type or return type



# Syntax: Formal Parameter List

```
dataTyp identifier, dataTyp identifier, ...
```



# Function Call

```
functionName(actual parameter list)
```

# Syntax: Actual Parameter List

- ← The syntax of the actual parameter list is:

```
expression or variable, expression or variable, ...
```

- ← Formal parameter list can be empty:

```
functionType functionName()
```

- ← A call to a value-returning function with an empty formal parameter list is:

```
functionName()
```





# `return` Statement

- Once a value-returning function computes the value, the function returns this value via the `return` statement
  - It passes this value outside the function via the `return` statement

# Syntax: `return` Statement

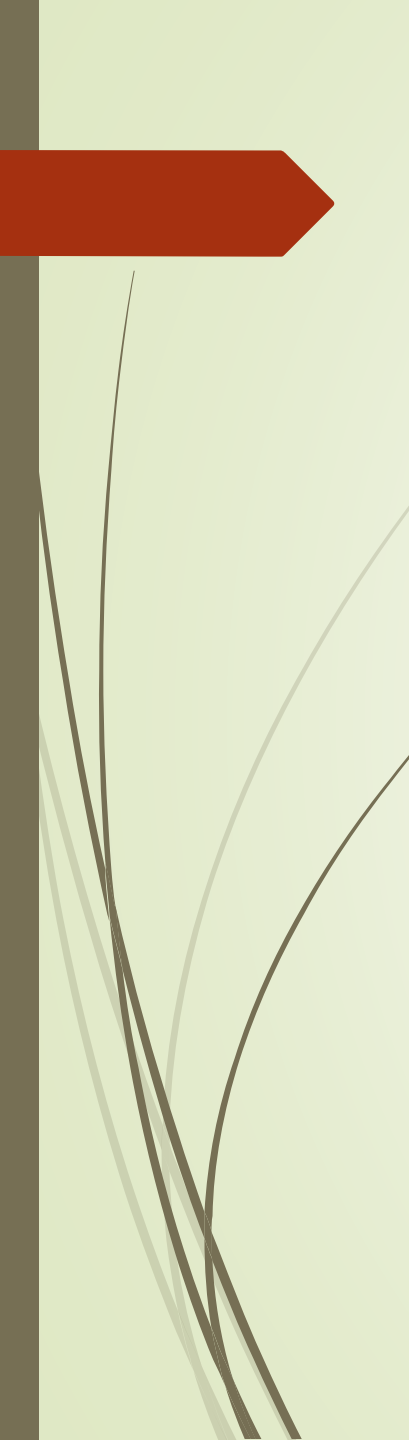
- The `return` statement has the following syntax:

```
return expr;
```

- In C++, `return` is a reserved word
- When a return statement executes
  - Function immediately terminates
  - Control goes back to the caller
- When a `return` statement executes in the function `main`, the program terminates



Make a function that will compute the largest of two numbers passed to it



```
double larger(double x, double y)
{
    double max;

    if (x >= y)
        max = x;
    else
        max = y;

    return max;
}
```

You can also write this function as follows:

```
double larger(double x, double y)
{
    if (x >= y)
        return x;
    else
        return y;
}
```

```
double larger(double x, double y)
{
    if (x >= y)
        return x;

    return y;
}
```

**NOTE**

1. In the definition of the function `larger`, `x` and `y` are formal parameters.
2. The `return` statement can appear anywhere in the function. Recall that once a `return` statement executes, all subsequent statements are skipped. Thus, it's a good idea to return the value as soon as it is computed.

# Function Prototype

- Function prototype: function heading without the body of the function
- Syntax:

```
functionType functionName(parameter list);
```



```
//Program: Largest of three numbers
```

```
#include <iostream>
```

```
using namespace std;
```

```
double larger(double x, double y);
```

```
double compareThree(double x, double y, double z);
```

```
int main()
```

```
{
```

```
    double one, two; //Line 1
```

```
    cout << "Line 2: The larger of 5 and 10 is " //Line 2  
          << larger(5, 10) << endl;
```

```
    cout << "Line 3: Enter two numbers: "; //Line 3
```

```
    cin >> one >> two; //Line 4
```

```
    cout << endl; //Line 5
```

```
    cout << "Line 6: The larger of " << one  
          << " and " << two << " is "  
          << larger(one, two) << endl; //Line 6
```

```
    cout << "Line 7: The largest of 23, 34, and " //Line 7  
          << "12 is " << compareThree(23, 34, 12)  
          << endl;
```

```
    return 0;
```

```
}
```

# Function Prototype (continued)

```
double larger(double x, double y)
{
    if (x >= y)
        return x;
    else
        return y;
}

double compareThree (double x, double y, double z)
{
    return larger(x, larger(y, z));
}
```

**Sample Run:** In this sample run, the user input is shaded.

Line 2: The larger of 5 and 10 is 10

Line 3: Enter two numbers: 25 73

Line 6: The larger of 25 and 73 is 73

Line 7: The largest of 23, 34, and 12 is 34





# Flow of Execution

- Execution always begins at the first statement in the function `main`
- Other functions are executed only when they are called
- Function prototypes appear before any function definition
  - The compiler translates these first
- The compiler can then correctly translate a function call



# Flow of Execution (continued)

- A function call results in transfer of control to the first statement in the body of the called function
- After the last statement of a function is executed, control is passed back to the point immediately following the function call
- A value-returning function returns a value
  - After executing the function the returned value replaces the function call statement



# Scope of an Identifier

- The scope of an identifier refers to where in the program an identifier is accessible
- Local identifier - identifiers declared within a function (or block)
- Global identifier – identifiers declared outside of every function definition
- C++ does not allow nested functions
  - The definition of one function cannot be included in the body of another function



# Side Effects of Global Variables

- If more than one function uses the same global variable and something goes wrong
  - It is difficult to find what went wrong and where
- Problems caused by global variables in one area of a program might be misunderstood as problems caused in another area



# References

1. C++ Programming: From Problem Analysis to Program Design, Third Edition
2. <https://www.just.edu.jo/~yahya-t/cs115/>