

Programming with C++

COMP2011: C++ Function III — Declaration, Definition, Overloading, and Default Arguments

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Part I

Function Declaration and Function Definition

function prototype

`int max(int, int);`

↑
return
type

↑
name

signature

A handwritten diagram illustrating the components of a function prototype. The text 'function prototype' is written in pink at the top, with a pink bracket underneath it spanning the width of the code below. The code 'int max(int, int);' is written in blue. Below the code, three annotations are present: an orange arrow points from the word 'return' (part of 'return type') to the 'int' at the beginning of the code; another orange arrow points from the word 'name' to the 'max' in the code; and a green bracket is placed under the parameters '(int, int)', with the word 'signature' written in green below it.

Function Prototype

A **function prototype** consists of

- 1 **function name**
- 2 **return data type**
- 3 the **number** of formal parameters
- 4 the **data type** of the formal parameters

Example: Function Prototypes

```
// int factorial(int n) { ... }  
int factorial(int);  
  
// float euclidean_distance(float x1,float y1,float x2,float y2) { ... }  
float euclidean_distance(float, float, float, float);  
  
/* void print_tree(int tree_height, char tree_symbol,  
                  char trunk_symbol, char pot_symbol) { ... } */  
void print_tree(int, char, char, char);
```

Function Prototype ..

- The **identifier names** of the formal parameters are not part of the signature as the names are **immaterial**.

Example: Variable Names are Immaterial in a Function Prototype

```
/* All the following 3 function definitions are equivalent */
```

```
int max(int x, int y) { return (x > y) ? x : y; }
```

```
int max(int a, int b) { return (a > b) ? a : b; }
```

```
int max(int f, int g) { return (f > g) ? f : g; }
```

- A **function prototype** describes the **interface** of the function: what parameters it takes in and what value it returns.
- Technically, a **function prototype** is also called the **application programming interface** (API).

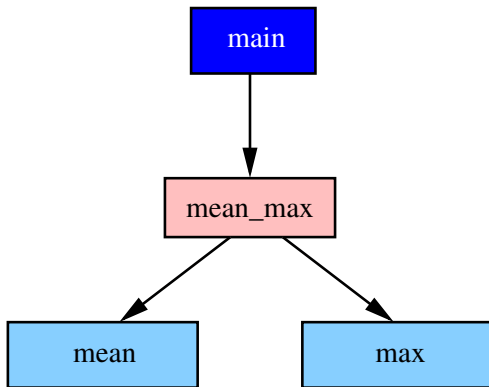
Function Declaration vs. Definition

- A function is **declared** by writing down its interface — its **function prototype**.
- A function is **defined** by writing down its **function header** *plus* its **function body**.
- A **function definition** will ask the compiler to generate **machine codes** according to the C++ codes in its function body.
- A **function declaration** just informs the compiler about the function's **interface** *without* generating any machine codes.
- A function may be **declared many times**, but a function can be **defined only once**.
- Of course, when a function is **defined**, it is also **declared**.
- But, simply **declaring** a function does **not define** the function.

Function Declaration vs. Definition ..

- In C++, all functions must be **declared before** they can be used, so that the compiler can
 - make sure the exact **number of arguments** are passed.
 - do **type checking** on the arguments passed to the function.
- That is, if function A wants to call function B, function B must be
 - **declared/defined before**, or
 - **declared inside** function A **before** calling function B.
- However, a function need not be defined before it can be used, although it must be defined **eventually somewhere** in the whole program in order that the program can be compiled to an executable.

Example: A Program with 3 Levels of Functions



Example: Declare Functions by Defining the Functions

```
#include <iostream>          /* File: fcn-prototype1.cpp */
using namespace std;

int max(int x, int y) { return (x > y) ? x : y; }
int mean(int x, int y) { return (x + y)/2; }

void mean_max(int x, int y, int& mean_num, int& max_num)
{
    mean_num = mean(x, y);
    max_num = max(x, y);
}

int main()
{
    int average, bigger;

    mean_max(6, 4, average, bigger);
    cout << "mean = " << average << endl << "max = " << bigger << endl;
    return 0;
}
```

Example: Declare Functions Globally

```
#include <iostream>      /* File: fcn-prototype2.cpp */
using namespace std;

void mean_max(int, int, int&, int&); // main only needs to know mean_max

int main()
{
    int average, bigger;
    mean_max(6, 4, average, bigger);
    cout << "mean = " << average << endl << "max = " << bigger << endl;
    return 0;
}

int max(int, int);      // mean_max needs to know max and mean
int mean(int, int);

void mean_max(int x, int y, int& mean_num, int& max_num)
{
    mean_num = mean(x, y);
    max_num = max(x, y);
}

int max(int x, int y) { return (x > y) ? x : y; }
int mean(int x, int y) { return (x + y)/2; }
```

Example: Declare Functions Locally

```
#include <iostream>      /* File: fcn-prototype3.cpp */
using namespace std;

int main()
{
    void mean_max(int, int, int&, int&);
    int average, bigger;

    mean_max(6, 4, average, bigger);
    cout << "mean = " << average << endl << "max = " << bigger << endl;
    return 0;
}

void mean_max(int x, int y, int& mean_num, int& max_num)
{
    int max(int, int);
    int mean(int, int);

    mean_num = mean(x, y);
    max_num = max(x, y);
}

int max(int x, int y) { return (x > y) ? x : y; }
int mean(int x, int y) { return (x + y)/2; }
```

Example: Forward Function Declaration

```
#include <iostream>      /* File: odd-even.cpp */
using namespace std;

bool even(int);

bool odd(int x) { return (x == 0) ? false : even(x-1); }

bool even(int x) { return (x == 0) ? true : odd(x-1); }

int main()
{
    int x;
    cin >> x;           // Assume x > 0

    cout << boolalpha << odd(x) << endl;
    cout << boolalpha << even(x) << endl;

    return 0;
}
```

Part II

Function Overloading



Signature of a Function

- Recall that in C++, all functions are **global**. That means, in general, all functions can “see” each other.
- Just as we use one’s signature to identify the person, we identify a function by its **name** and **signature**.
- A function’s **signature** is the list of **formal parameters** without their identifier names.
- **No** two C++ functions can have the **same name** *and* **same signature** but **different return type**.
- **BUT** two C++ functions can have the **same name** *but* **different signature** \Rightarrow **function overloading**.

Example: No 2 Function Prototypes Differ Only in Return Type

```
// The following 2 function definitions of  
// pick_one cannot appear in the same program  
  
int pick_one(int x, float y) { return x; }  
float pick_one(int x, float y) { return y; }
```

Function Overloading

C++ allows **several functions** to have the **same name** but **different types** of input parameters.

Example: Overloaded Functions

```
int max(int x, int y) { return (x > y) ? x : y; }
int max(int x, int y, int z) { return max(max(x,y), z); }
double max(double a, double b) { return (a > b) ? a : b; }

void swap(int& a, int& b) { int temp = a; a = b; b = temp; }
void swap(float& a, float& b) { float temp = a; a = b; b = temp; }
void swap(double& a, double& b) { double temp = a; a = b; b = temp; }

int absolute(int a) { return (a < 0) ? -a : a; }
int absolute(int& a) { return (a = (a < 0) ? -a : a); }
```

Question: How can you call the following version of `absolute()`?

`int absolute(int&);`

Example: Invalid Function Overloading

```
/* Identifier names of formal parameters are immaterial */
```

```
int max(int x, int y) { return (x > y) ? x : y; }
```

```
int max(int a, int b) { return (a > b) ? a : b; }
```

```
/* Return type is not part of the signature */
```

```
void swap(int& a, int& b) { int temp = a; a = b; b = temp; }
```

```
int swap(int& a, int& b) { int temp = a; a = b; b = temp; return a; }
```


Overloaded Function Resolution

- When an **overloaded function** is called, C++ will determine exactly which function among those with the **same name** should be called — **function resolution**.
- **Function resolution** is done by comparing the types of
 - actual parameters passed in a function call, and
 - formal parameters in the function definition.and find the **best match** in the following order:

- 1 **exact match**
- 2 match after some type **promotion**
 - `char/bool/short --> int`
 - `float --> double`
- 3 match after some **standard type conversion**
 - between integral types
 - between floating types
 - between integral and floating types
- 4 match after some **user-defined type conversion** (later)

Example: Function Resolution

```
int test(int a, double b);  
int test(double a, int b);
```

- If you make the following function call: `test(3, 4.6)`, the compiler will pick the **first version**.
- If you make the following function call: `test('a', 4.6)`, the compiler will again pick the **first version** by converting 'a' to an int.
- If you make the following function call: `test(3.2, 4.6)`, it can either
 - match to the first version by narrowing conversion of the first parameter to int.
 - match to the second version by narrowing conversion of the second parameter to int.
 - since neither one is more preferable than the other one
⇒ **compilation error!**

Default Function Argument

- Sometimes, we would like a function to have certain **default** behaviour, but still allow the user to **change** it.
- C++ allows the user to call a function with **fewer arguments** if all he wants is its **default behaviour**, and with **more arguments** if he wants some **particular behaviour** of the function.
- A function may have more than 1 **default argument**.
- But all **default arguments** must be specified at the **end** of the **formal parameter list**.

```
/* The following 2 prototypes are equivalent */  
void func(int x, float& y, char gender = 'M', bool alive = true);  
void func(int, float&, char = 'M', bool = true);
```

- The default argument(s) may be specified in a **function declaration** or **function definition**, but not both.
 - usually we put it on the **function declaration**. **Why?**
- A function with **default arguments** looks like several **overloaded functions**, but it is not.

Example: getline() Again

- The true `getline` function header is:

```
cin.getline(char s[], int max-num-char, char terminator='\n');
```

- Thus, you may call it as

```
cin.getline(char s[], int max-num-char);
```

and the default terminator is the newline character.

Example: Different getline Calls

```
const int MAX_LINE_LEN = 1000;
char s[MAX_LINE_LEN+1];

cin.getline(s, MAX_LINE_LEN+1); // terminator = newline
cin.getline(s, MAX_LINE_LEN+1, '.'); // terminator = full stop
```

Example: Increment with Default Argument

```
#include <iostream>      /* File: increment-default-arg.cpp */
using namespace std;

int increment(int x, int step = 1)
{
    return (x + step);
}

int main()
{
    cout << increment(10) << endl;
    cout << increment(10, 5) << endl;

    return 0;
}
```

Example: Sort with Default Argument

```
#include <iostream>      /* File: sort-default-arg.cpp */
using namespace std;

enum sort_order {ASCENDING, DESCENDING};

void swap(int& a, int& b) { int temp = a; a = b; b = temp; }

void sort(int& x, int& y, sort_order order = ASCENDING)
{
    if (order == ASCENDING) { if (x > y) swap(x, y); }
    else { if (x < y) swap(x, y); }
}

int main()
{
    int a = 24, b = 8;
    sort(a, b); cout << a << '\t' << b << endl;
    sort(a, b, DESCENDING); cout << a << '\t' << b << endl;
    return 0;
}
```