

# Programming with C++

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

Dr. Cecilia Chan  
Cindy Li  
Brian Mak

Department of Computer Science & Engineering  
The Hong Kong University of Science and Technology  
Hong Kong SAR, China



# Part I

## Function Declaration and Function Definition

# Some Function Terminology

function prototype

`int max(int, int);`

↑  
return  
type

↑  
name

signature

A handwritten diagram on a light background. At the top, the words "function prototype" are written in pink cursive and underlined with a pink bracket. Below this, the code "int max(int, int);" is written in blue. Underneath the code, there are three annotations in orange and green. An orange arrow points from the word "return" (part of "return type") to the "int" at the start of the code. Another orange arrow points from the word "name" to the "max" in the code. A green bracket underlines 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)**.

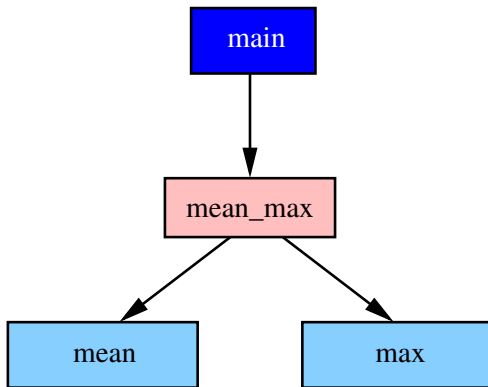
# Function Declaration vs. Definition

- 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: cin.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, sizeof(s));           // terminator = newline  
cin.getline(s, sizeof(s), '.');      // 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;
}
```