

C++ For C Coders 3

Data Structures
C++ for C Coders

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Default function arguments
Reference operator
const, const reference
new and delete operator
function overloading
command line processing

Default Function Arguments

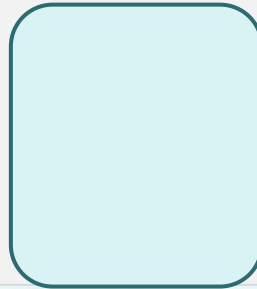
- In calling of the function, if the arguments are not given, default values are used.

```
int exp(int n, int k = 2) {  
    if (k == 2) return (n * n);  
    return (exp(n, k - 1) * n);  
}
```

Default Function Arguments

- In calling a function argument must be given from left to right without skipping any parameter

```
void foo(int i, int j=7);           // right
void goo(int i=3, int j);           //
void hoo(int i, int j=3, int k=7);  //
void moo(int i=1, int j=2, int k=3); //
void noo(int i=2, int j, int k=3);  //
```



Default Function Arguments

- In calling a function argument must be given from left to right without skipping any parameter

```
void foo(int i, int j=7);           // right
void goo(int i=3, int j);           // wrong
void hoo(int i, int j=3, int k=7);  // right
void moo(int i=1, int j=2, int k=3); // right
void noo(int i=2, int j, int k=3);  // wrong
```

Reference Operator &

- A reference allows to declare an alias to another variable.
- If the **aliased** variable lives, you can use indifferently the variable or the alias.

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

int main() {
    int x;
    int& foo = x;
    foo = 49;
    cout << x << endl;
    return 0;
}
```

Reference Operator &

- Use references to **avoid copying of large structures** when passing arguments. If we pass it without reference, a new copy of it is created which causes wastage of CPU time and memory.

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

struct Student {
    string name;
    string major;
    int SN;
};
```

Reference Operator &

- Use references to **avoid copying of large structures** when passing arguments. If we pass it without reference, a new copy of it is created which causes wastage of CPU time and memory.

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

struct Student {
    string name;
    string major;
    int SN;
};

void print(const Student& s) {
    cout << s.name << " " << s.major << endl;
}

int main() {
    Student one{"Handong", "CSEE", 1230456};
    print(one);
    return 0;
}
```

Using Reference

Reference Operator &

- Use references to **avoid copying of large structures** when passing arguments. If we pass it without reference, a new copy of it is created which causes wastage of CPU time and memory.

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

```
struct Student {
    string name;
    string major;
    int SN;
};
```

```
void print(const Student& s) {
    cout << s.name << " " << s.major << endl;
}

int main() {
    Student one{"Handong", "CSEE", 1230456};
    print(one);
    return 0;
}
```

Using Reference

```
void print(const Student* s) {
    cout << s->name << " " << s->major << endl;
}
```

```
int main() {
    Student one{"Handong", "CSEE", 1230456};
    print(&one);
    return 0;
}
```

Using Pointer

Reference Operator &

- Use references to **avoid copying of large structures** when passing arguments. If we pass it without reference, a new copy of it is created which causes wastage of CPU time and memory.

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

```
struct Student {
    string name;
    string major;
    int SN;
};
```

```
void print(const Student& s) {
    cout << s.name << " " << s.major << endl;
}

int main() {
    Student one{"Handong", "CSEE", 1230456};
    print(one);
    return 0;
}
```

Using Reference

```
void print(const Student s) {
    cout << s.name << " " << s.major << endl;
}

int main() {
    Student one{"Handong", "CSEE", 1230456};
    print(one);
    return 0;
}
```

w/o using reference & pointer

```
void print(const Student* s) {
    cout << s->name << " " << s->major << endl;
}

int main() {
    Student one{"Handong", "CSEE", 1230456};
    print(&one);
    return 0;
}
```

Using Pointer

Reference Operator &

- Fix the code to have an expected output. Use a reference variable in C++.

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

int main() {
    vector<int> vec{ 10, 20, 30, 40 };

    for (auto x: vec)
        x = x * x;

    for (auto x: vec)
        cout << x << " ";
    cout << '\n';
    return 0;
}
```

Expeded Output: 100 400 900 1600

Reference Operator &

- Fix the code to have an expected output. Use a reference variable in C++.

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

int main() {
    vector<int> vec{ 10, 20, 30, 40 };

    for (auto& x: vec)
        x = x * x;

    for (auto x: vec)
        cout << x << " ";
    cout << '\n';
    return 0;
}
```

Expeded Output: 100 400 900 1600

Example swap(): Reference Operator &

- Complete swap() using pointers in C.

Solution in C/C++

```
void swap(int a, int b) {  
    int temp = a;  
    a = b;  
    b = temp;  
}  
  
int main() {  
    int i = 3, j = 5;  
    swap( i, j);  
    printf("%d, %d\n", i, j);  
}
```

& is an address operator.

5 3

Example swap(): Reference Operator &

- Complete swap() using pointers in C.

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

```
int main() {  
    int i = 3, j = 5;  
    swap( i, j);  
    printf("%d, %d\n", i, j);  
}
```

& is an address operator.

Solution in C/C++

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

```
int main() {  
    int i = 3, j = 5;  
    swap(&i, &j);  
    printf("%d, %d\n", i, j);  
}
```

Example swap(): Reference Operator &

- Complete swap() in C++

Solution in C++

```
void swap(int a, int b) {  
    int temp = a;  
    a = b;  
    b = temp;  
}  
  
int main() {  
    int i = 3, j = 5;  
    swap(i, j);  
    cout << i << " " << j << endl;  
}
```

& is a reference operator.

Example swap(): Reference Operator &

- Complete swap() in C++

```
void swap(int a, int b) {  
    int temp = a;  
    a = b;  
    b = temp;  
}  
  
int main() {  
    int i = 3, j = 5;  
    swap(i, j);  
    cout << i << " " << j << endl;  
}
```

& is a reference operator.

Solution in C++

```
void swap(int& a, int& b) {  
    int temp = a;  
    a = b;  
    b = temp;  
}  
  
int main() {  
    int i = 3, j = 5;  
    swap(i, j);  
    cout << i << " " << j << endl;  
}
```

& is a reference operator.

Example swap(): Comparison using pointer and reference

C/C++

```
void swap(int *a, int *b) {  
    int temp = *a;  
    *a = *b;  
    *b = temp;  
}  
  
int main() {  
    int i = 3, j = 5;  
    swap(&i, &j);  
    printf("%d, %d\n", i, j);  
}
```

& is an address operator.

C++

```
void swap(int& a, int& b) {  
    int temp = a;  
    a = b;  
    b = temp;  
}  
  
int main() {  
    int i = 3, j = 5;  
    swap(i, j);  
    cout << i << " " << j << endl;  
}
```

& is a reference operator.

Using C++ Template

- You still need two exact same functions but types in C++ unless using **Template**.

```
void swap(int& a, int& b) {
    int z = a;
    a = b;
    b = z;
}
void swap(double& a, double& b) {
    double z = a;
    a = b;
    b = z;
}
int main() {
    int i = 1, j = 2;
    double x = 10, y = 20;
    swap(i, j);
    swap(x, y);
    cout << i << " " << j << endl;
    cout << x << " " << y << endl;
}
```

Using C++ Template

- You still need two exact same functions but types in C++ unless using **Template**.

```
void swap(int& a, int& b) {  
    int z = a;  
    a = b;  
    b = z;  
}  
void swap(double& a, double& b) {  
    double z = a;  
    a = b;  
    b = z;  
}  
int main() {  
    int i = 1, j = 2;  
    double x = 10, y = 20;  
    swap(i, j);  
    swap(x, y);  
    cout << i << " " << j << endl;  
    cout << x << " " << y << endl;  
}
```

```
template <typename T>  
void swap(T &a, T &b) {  
    T z = a;  
    a = b;  
    b = z;  
}  
  
int main() {  
    int i = 1, j = 2;  
    double x = 10, y = 20;  
    swap(i, j);  
    swap(x, y);  
    cout << i << " " << j << endl;  
    cout << x << " " << y << endl;  
}
```

const Reference

- To prevent the function from changing the parameter accidentally, we pass the argument as **constant reference** to the function.

```
struct Person {  
    char name[40];  
    int age;  
};  
void print(Person k){  
    cout << "Name: " << k.name << endl;  
    cout << "Age: " << k.age << endl;  
}  
  
int main(){  
    Person man{"Adam", 316};  
    print(man);  
    return 0;  
}
```

← C style coding in C++

const Reference

- To prevent the function from changing the parameter accidentally, we pass the argument as **constant reference** to the function.

```
struct Person {  
    char name[40];  
    int age;  
};  
void print(const Person& k) {  
    cout << "Name: " << k.name << endl;  
    cout << "Age: " << k.age << endl;  
}  
  
int main(){  
    Person man{"Adam", 316};  
    print(man);  
    return 0;  
}
```

← C style coding in C++

← k is constant reference parameter

What is good about passing by const reference?

- Instead of 44 bytes, only 4 bytes (address) are sent to the function.
- Calling function knows that Person k would not be changed.

Return by reference

- By default in C++, when a function returns a value, it is copied into stack. The calling function reads this value from stack and copies it into its variables.
- An alternative to “return by value” is “return by reference”, in which the value returned is not copied into stack.
- One result of using “return by reference” is that the function which returns a parameter by reference **can be used on the left side of an assignment** statement.

```
funcReturnByRef(a_parm) = a_value;
```

the left side of an assignment

Return by reference

- Modify the following programs such that it sets the maximum element to zero.

```
int max(int a[], int n) {  
    int x = 0;  
    for (int i = 0 ; i < n; i++)  
        if (a[i] > a[x]) x = i;  
    return a[x];  
}  
  
int main() {  
    int a[] = {12, 42, 33, 99, 63};  
    int n = 5;  
  
    for (int i = 0; i < n; i++)  
        cout << a[i] << " ";  
}
```

12 42 33 0 63

Return by reference

- Modify the following programs such that it sets the maximum element to zero.

```
// returns an integer  
// reference of the  
// max element
```

The left side returns by the reference such that it can be placed at the left side of an assignment

```
int& max(int a[], int n) {  
    int x = 0;  
    for (int i = 0; i < n; i++)  
        if (a[i] > a[x]) x = i;  
    return a[x];  
}  
  
int main() {  
    int a[] = {12, 42, 33, 99, 63};  
    int n = 5;  
    max(a, n) = 0; // overwrite the max  
                   // element with 0  
    for (int i = 0; i < n; i++)  
        cout << a[i] << " ";  
}
```

12 42 33 0 63

Never return a local variable by reference

- Since a function that uses “return by reference” returns an actual memory address, it is important that the variable in this memory location remain in existence after the function returns.

```
int& foo() {  
    int x;  
    ...  
    return x;      // Compiler warning: reference to local variable 'x' returned  
                  // Run Time ERROR since x does not exist anymore after returned
```

- Local variables can be return by their values

```
int foo() {  
    int i;          // Local variable, created in stack  
    ...  
    return i;       // OK! does not exist anymore
```


Quiz 1

- Predict the output of the following programs when compiled or executed.
- Select all that apply.

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

int& foo() {
    int x = 10;
    return x;
}

int main() {
    cout << foo();
    return 0;
}
```

- (A) Syntax error
- (B) Compile warning
- (C) Compile error
- (D) Run time error
- (E) Logic error
- (F) 10
- (G) 20

References vs Pointers

- References are **less powerful** than pointers, but still **extremely useful**.
 - Once a reference is created, it cannot be later made to reference another object; it cannot be reset. References cannot be NULL.
 - A reference must be initialized when declared. References in C++ cannot be used for implementing data structures like Linked List, Tree, etc.
- References are **safer** and **easier** to use:
 - **Safer:** References are less likely to become invalid since they must be initialized.
 - **Easier:** References don't need a dereferencing operator to access the value. They can be used like normal variables.
'&' operator is needed only at the time of declaration. Also, members of an object reference can be accessed with dot operator ('.'), unlike pointers where arrow operator (->) is needed to access members.

malloc & free vs. new & delete

- In C, dynamic memory allocation is done with malloc() and free().
- The C++ new and delete operators performs dynamic memory allocation.

```
int *p = (int *)malloc(sizeof(int) * N);
```

```
for (int i = 0; i < N; i++)  
    p[i] = i;
```

```
free(p);
```

```
int *p = new int[N];
```

```
for (int i = 0; i < N; i++)  
    p[i] = i;
```

```
delete[] p;
```

Using new & delete

- The **new** operator allocates memory and **delete** frees it.

```
int *pi = new int;           // pi points to uninitialized int
int *pi = new int(7);        // which pi points has value 7
string *ps = new string("hello"); // ps points "hello", cout << *ps << endl;
string st = "hello";         // string st("hello"), cout << st << endl;

int *pia = new int[7];       // block of seven uninitialized ints
int *pia = new int[7]();     // block of seven ints values initialized to 0

string *psa = new string[5]; // block of 5 empty strings
string *psa = new string[5](); // block of 5 empty strings
int *pia = new int[5]{0, 1, 2, 3, 4}; // block of 5 ints initialized
string *psa = new string[2]{"a", "the"}; // block of 2 strings initialized

delete pi;
delete[] pia;
```

No Function Overloading in C

- Function overloading is a feature of object-oriented programming where two or more functions can have the same name but different parameters.

This code would **not** work since no overloading supported in C

```
int main() {  
    int i = 3, j = 5;  
    swap(&i, &j);  
    printf("%d, %d\n", i, j);  
  
    double x = 3, y = 5;  
    swap(&x, &y);  
    printf("%f, %f\n", x, y);  
}
```

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



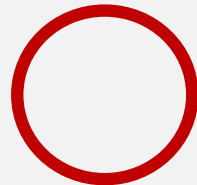
Function Overloading in C++

- Function overloading is a feature of object-oriented programming where two or more functions can have the same name but different parameters.

C++ Function overloading

```
int main() {  
    int i = 3, j = 5;  
    swap(i, j);  
    cout << i << " " << j << endl;  
  
    double x = 3, y = 5;  
    swap(x, y);  
    cout << x << " " << y << endl;  
}
```

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



Command line processing

- Open Atom editor
 - Filename: **args.cpp**
 - Add the source code.
 - Save the file.
- Compile and Execute

```
$ g++ args.cpp -o args
$ ./args Why not change the world?
```
- Read more about this in github:
/nowic/ArgcArgv.md
- Write a function **args_to_strs()** that returns an array of strings to replace both argc and argv;
 - Use **vector<string>**
- Once you complete it, move the function into a new file called **args_to.cpp**.
- Test **args.cpp** and **args_to.cpp**.

```
// args.cpp
#include <iostream>
using namespace std;

int main(const int argc, char** argv) {
    cout << "You entered: "
         << argc << " arguments:" << endl;

    for (int i = 0; i < argc; ++i)
        cout << argv[i] << endl;
    return 0;
}
```

Multiple Source Files

- If you have multiple files to compile and link, for example,
 - Filename: **args.cpp**
 - Filename: **args_to.cpp**
- Compile and execute

```
$ g++ args.cpp args_to.cpp -o args
$ ./args
```


(3)

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