C/C++ Program Design

LAB 6

CONTENTS

- Master how to use the Library Function
- Master how to declare, define, and call a User-Defined Function

2 Knowledge Points

2.1 Library Function

2.2 User-Defined Function

2.3 Recursive function

2.4 Pointers to functions

2.1 Library Function

Example: Library Function

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

int main() {
    double number, squareRoot;

    cout << "Enter a number:";
    cin >> number;

    // sqrt() is a library function to calculate square root
    squareRoot = sqrt(number);
    cout << "Square root of " << number << " = " << squareRoot;

    return 0;
}
```

header file

sqrt() is a library function

Output:

```
Enter a number:25
Square root of 25 = 5
```

2.2 User-Defined Function

Syntax of defining a function:

function header

```
return_type function_name (datatype parameter1, datatype parameter2, …)
{
        // function body
}
```

- **return type:** suggests what type the function will return. It can be int,char, string, pointer or even a class object. If a function does not return anything, it is mentioned with void.
- **function name:** is the name of the function, using the function name it is called.
- **parameters:** are variables to hold values of arguments passed while function is called. A function may or may not contain parameter list(**void**).

Function prototype:

The simplest way to get a prototype is to copy the **function header** and add a **semicolon**.

Here are some function prototypes:

```
// A function takes two integers as its parameters
// and returns an integer
int max(int, int);

// A function takes a char and an integer as its parameters
// and returns an integer
int fun(char, int);

// A function takes a char as its parameter
// and returns a pointer-to-char
char *call(char );

// A function takes a pointer-to-int and an integer
// as its parameters and returns a pointer-to-int
int *swap(int *, int);
```

Example: Declaring, Defining and Calling a function

sumfunction.cpp > ...

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

//Declaring a function
int sum(int x, int y);
int main()
{
    int a = 10;
    int b = 20;
    int c;

    //Calling a function
    c = sum(a,b);

    cout << a << " + " << b << " = " << c << endl;

    return 0;
}

// Defining a function
int sum(int x, int y)
{
    return (x + y);
}
```

Declaring a function (function prototype)

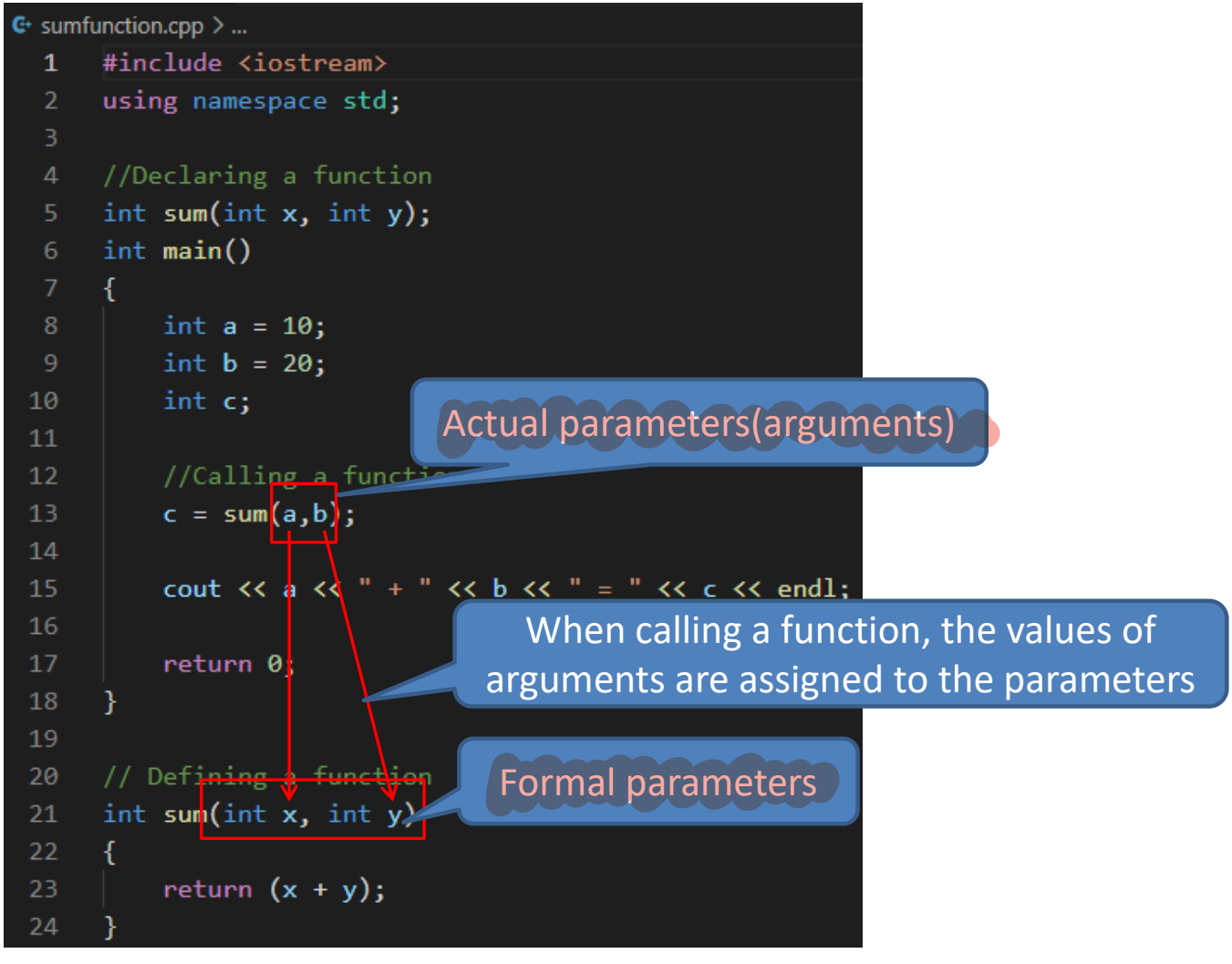
Calling a function

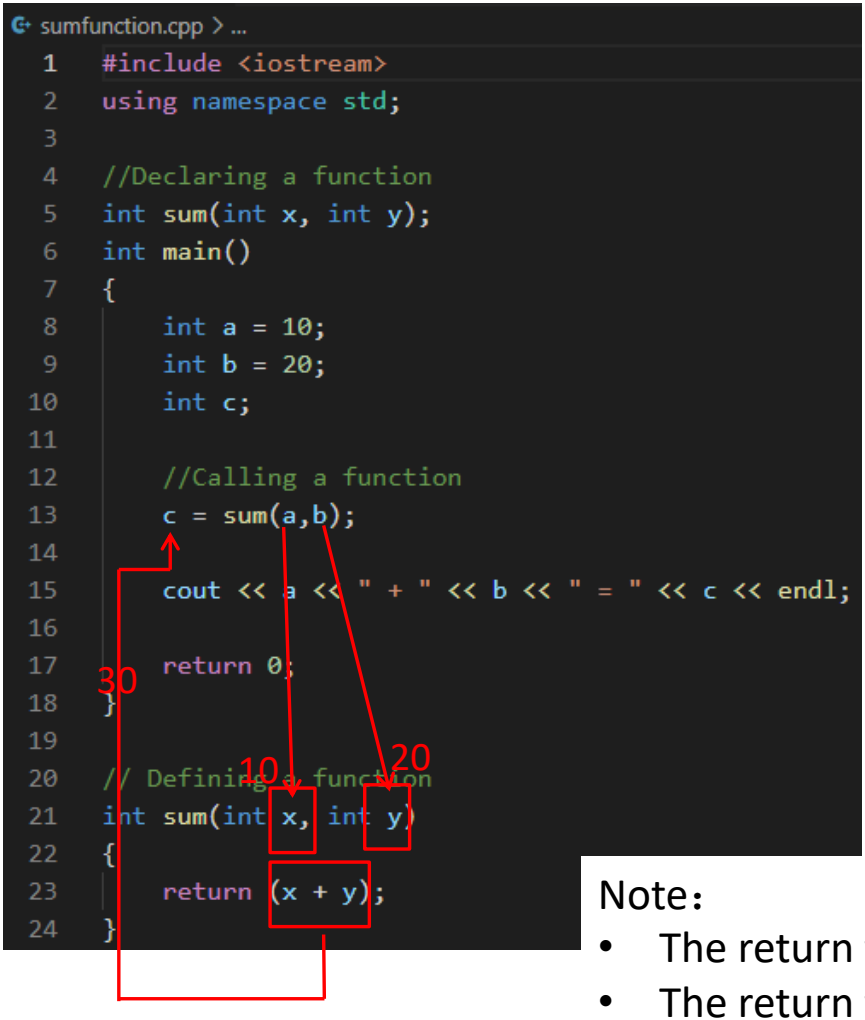
Defining a function
Outside from all functions

Output:

```
10 + 20 = 30
```

Actual parameter and Formal parameter





Note:

- The return type is **int**, so, **c** is of type **int**.
- The return type of function is defined in function declaration in sum(int x, int y);
- If no value is returned, **void** should be used.

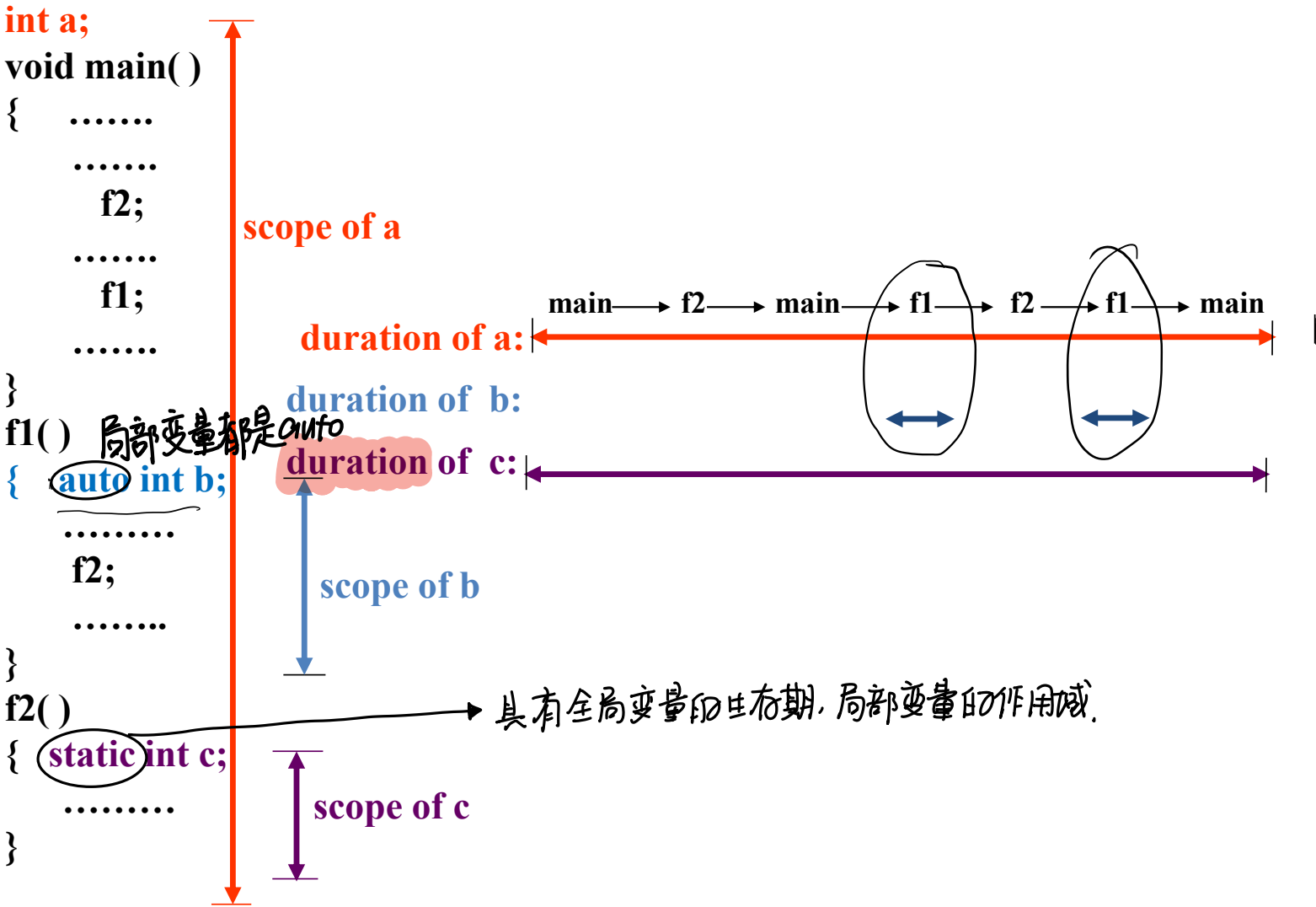
作用域 生存区

Scope and duration of variable

An variable's **scope** is where the variable can be referenced in a program. Some identifiers can be referenced throughout a program, others from only portions of a program.

A variable defined inside a function is referred to as a **local variable**. A **global variable** is defined outside functions.

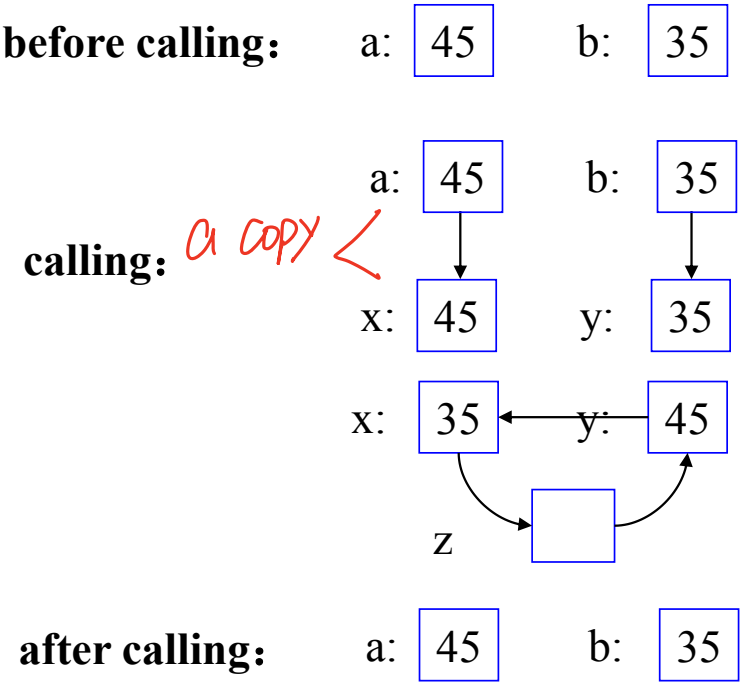
An variable's **storage duration** is the period during which that variable exits in memory.


int a;
void main( )
{ …….
…….
f2;
…….
f1;
…….
}
f1( ) 局部变量都是auto
{ auto int b;
……
f2;
……..
}
f2( )
{ static int c;
……
}
scope of a
scope of b
scope of c
duration of a:
duration of b:
duration of c:
main
f2
main
f1
f2
f1
main
具有全局变量的生存期，局部变量的作用域.

1. Passing arguments to a function by value

passvalue.cpp > ...

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

void swap(int x, int y)
{
    int z;
    z = x;
    x = y;
    y = z;
}

int main()
{
    int a = 45, b = 35;
    cout << "Before Swap\n";
    cout << "a = " << a << ",b = " << b << endl;

    swap(a,b);

    cout << "After Swap\n";
    cout << "a = " << a << ",b = " << b << endl;

    return 0;
}
```



Output:

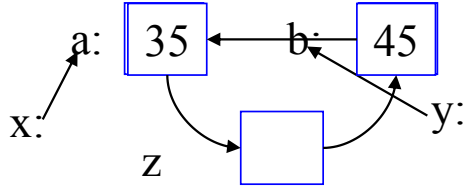
```
Before Swap
a = 45,b = 35
After Swap
a = 45,b = 35
```

2. Passing arguments to a function by pointer

```
passpointer.cpp > ...
1   #include <iostream>
2   using namespace std;
3
4   void swap(int *x, int *y)
5   {
6       int z;
7       z = *x;
8       *x = *y;
9       *y = z;
10  }
11
12  int main()
13  {
14      int a = 45, b = 35;
15      cout << "Before Swap\n";
16      cout << "a = " << a << ",b = " << b << endl;
17
18      swap(&a, &b);
19
20      cout << "After Swap\n";
21      cout << "a = " << a << ",b = " << b << endl;
22
23      return 0;
24  }
```

before calling: a: 45 b: 35

calling:



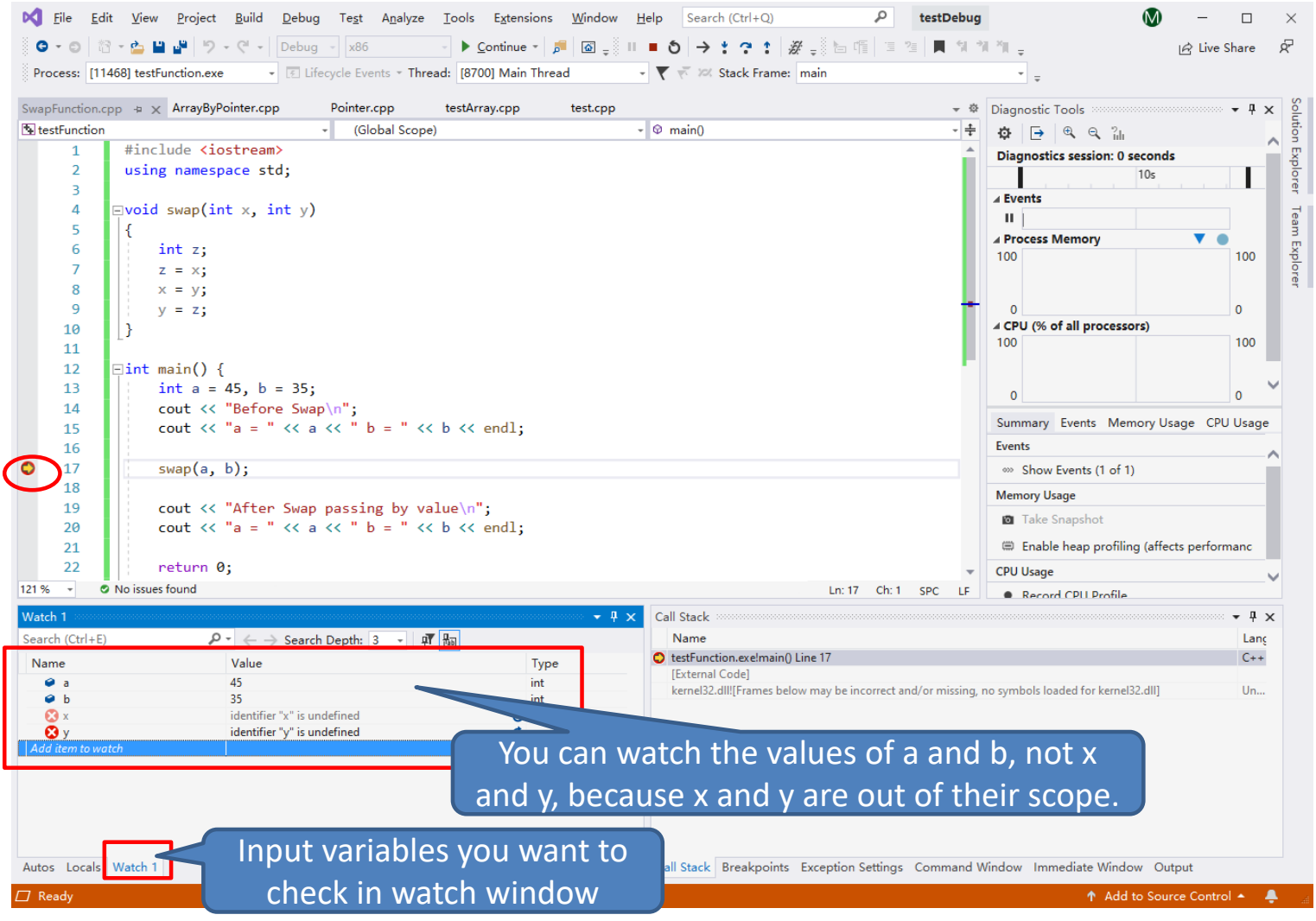
after calling: a: 35 b: 45

Output:

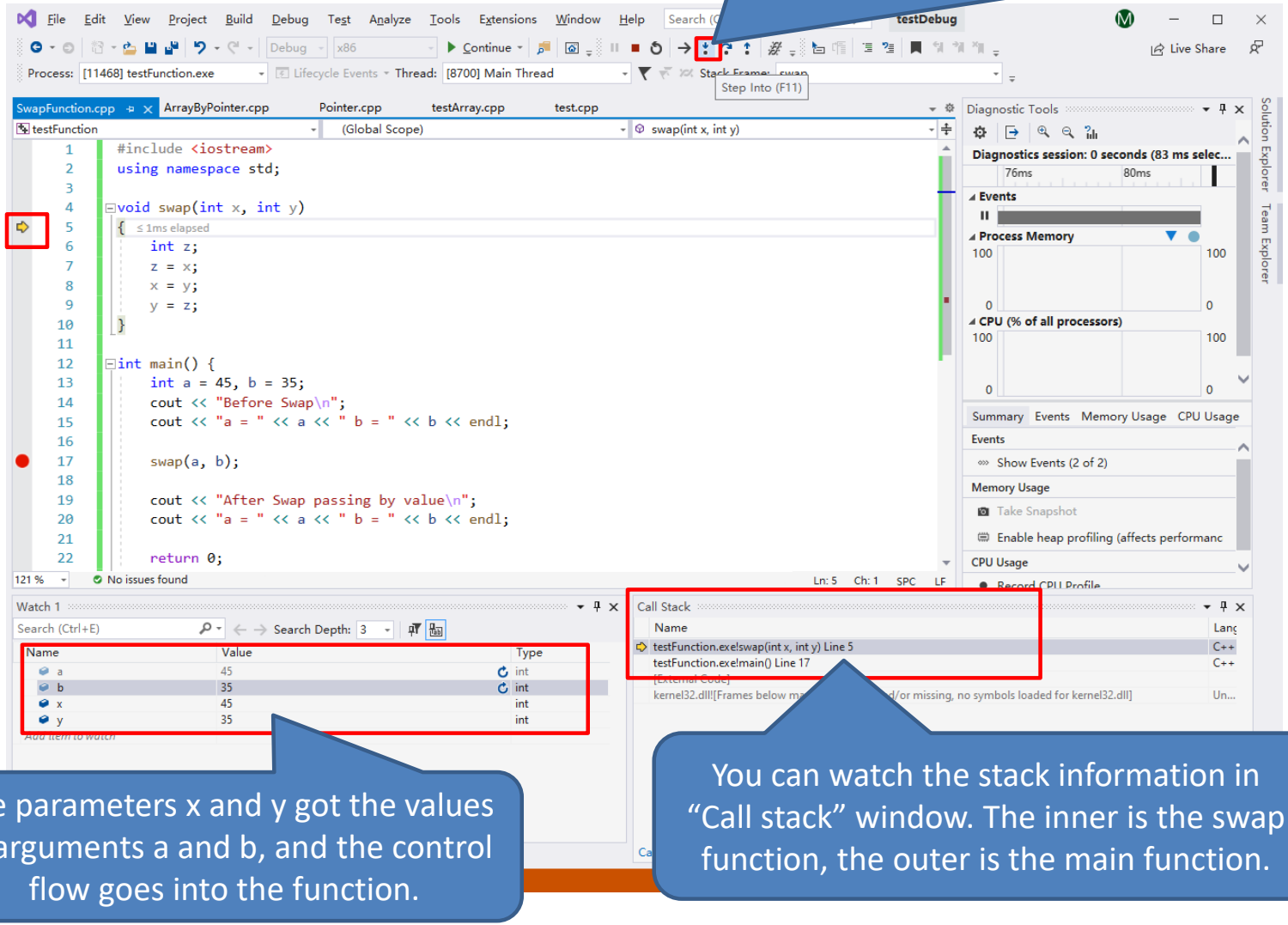
```
Before Swap
a = 45,b = 35
After Swap
a = 35,b = 45
```

How to check in functions in Visual Studio 2019?

Set a breakpoint and Start Debugging (shortcut:F5)

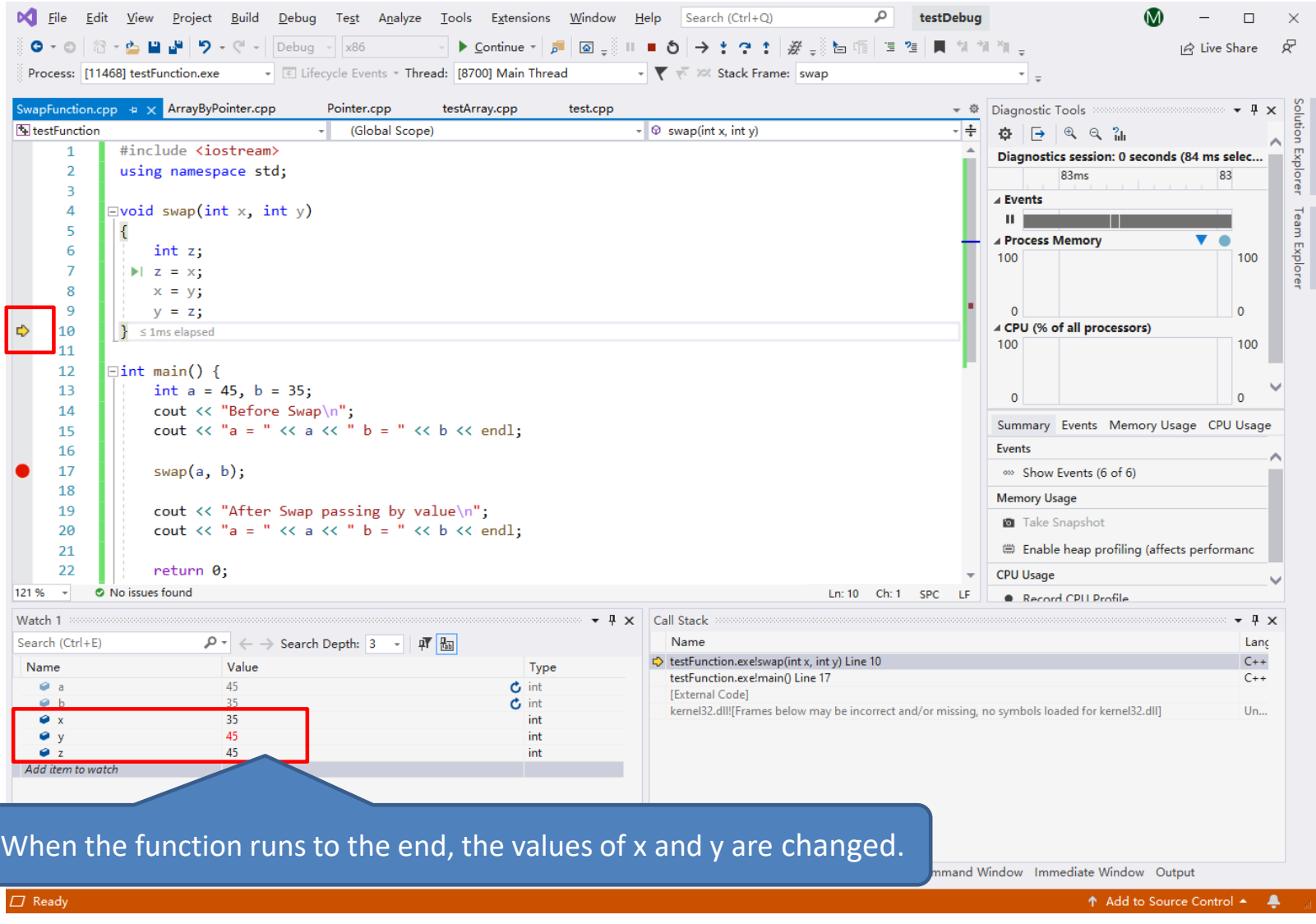


Press “step into(F11)” to run the program not only step by step but also into the function

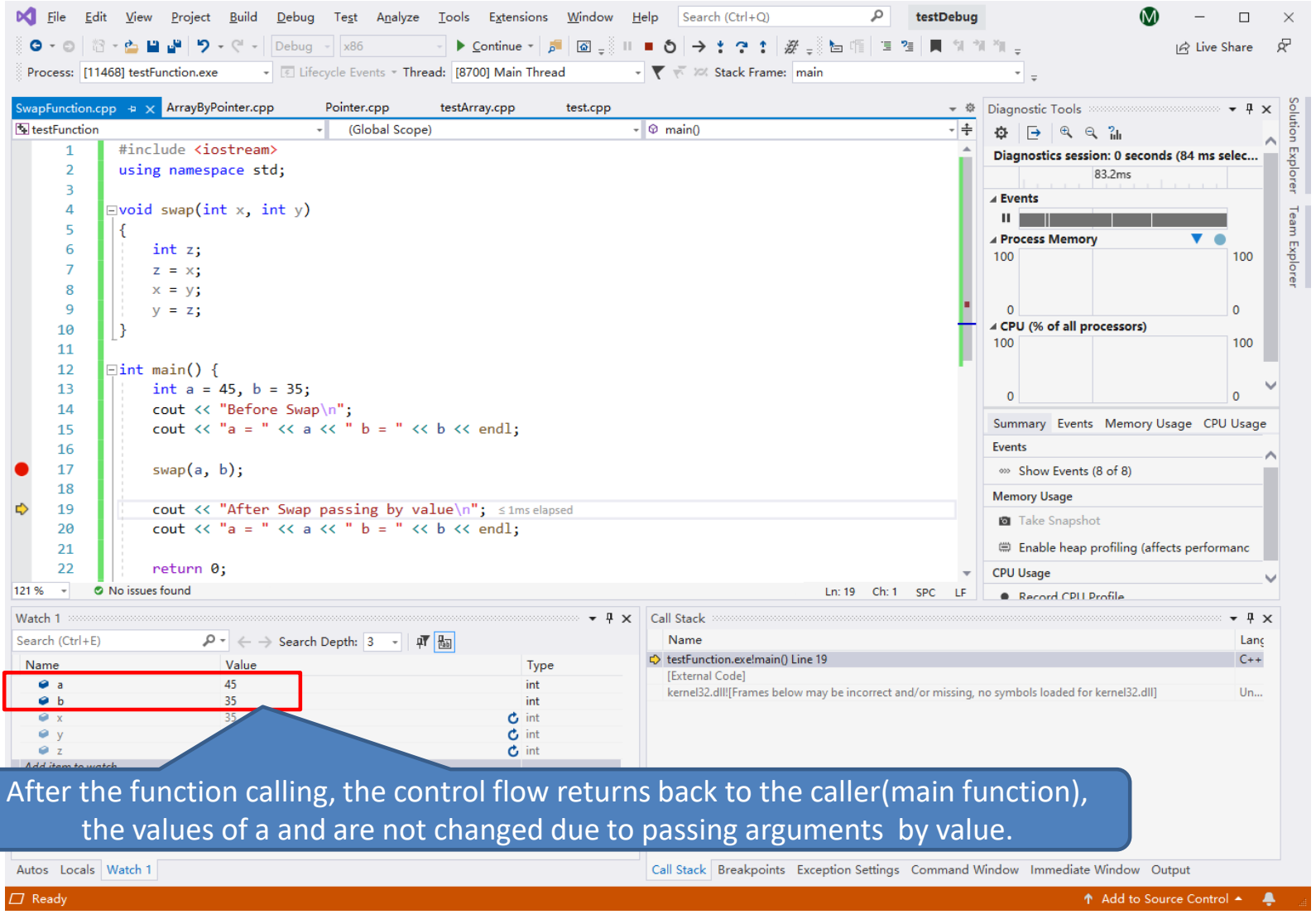


The parameters x and y got the values of arguments a and b, and the control flow goes into the function.

You can watch the stack information in “Call stack” window. The inner is the swap function, the outer is the main function.

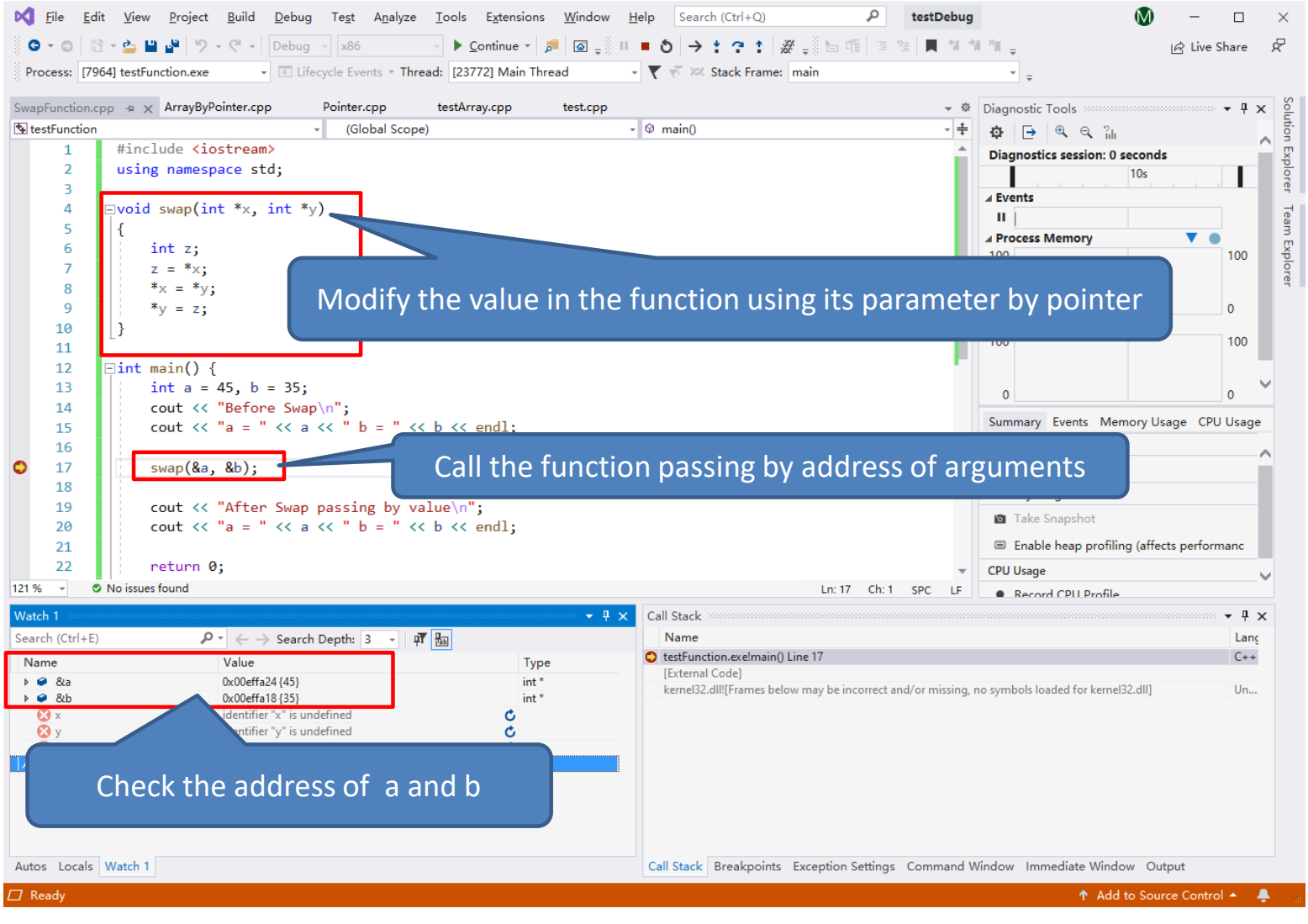


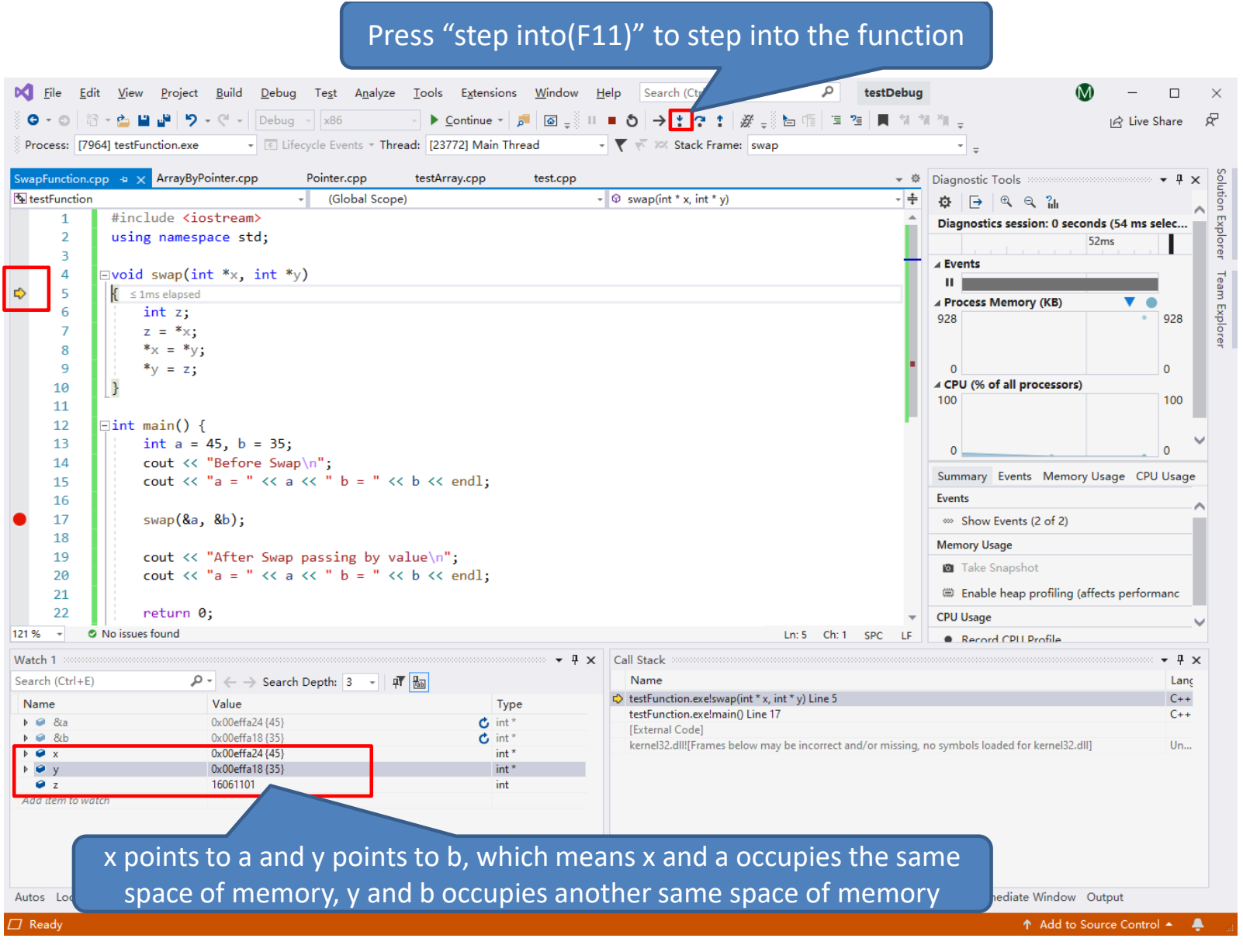
When the function runs to the end, the values of x and y are changed.

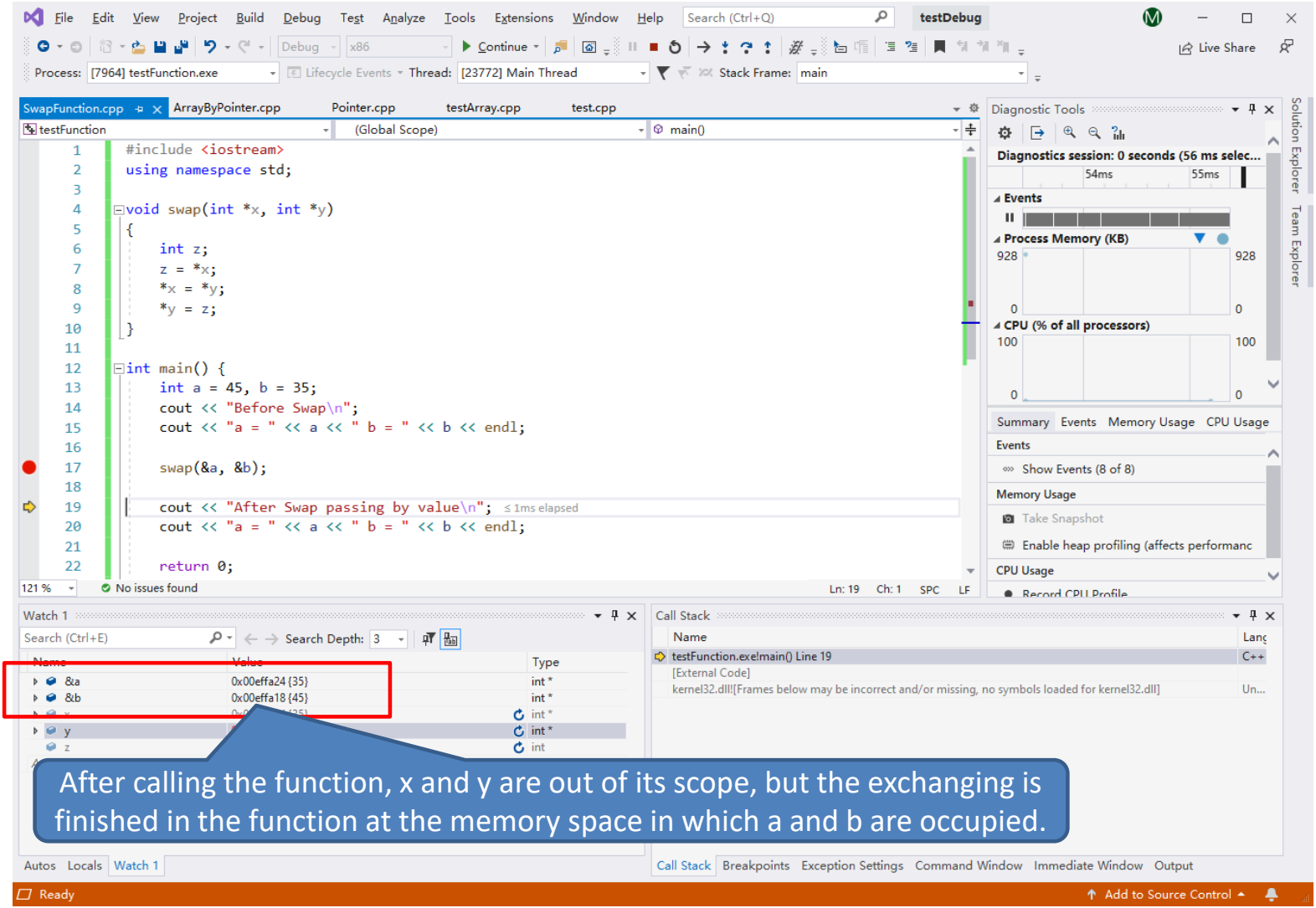


After the function calling, the control flow returns back to the caller(main function), the values of a and are not changed due to passing arguments by value.

Passing arguments to a function by pointer

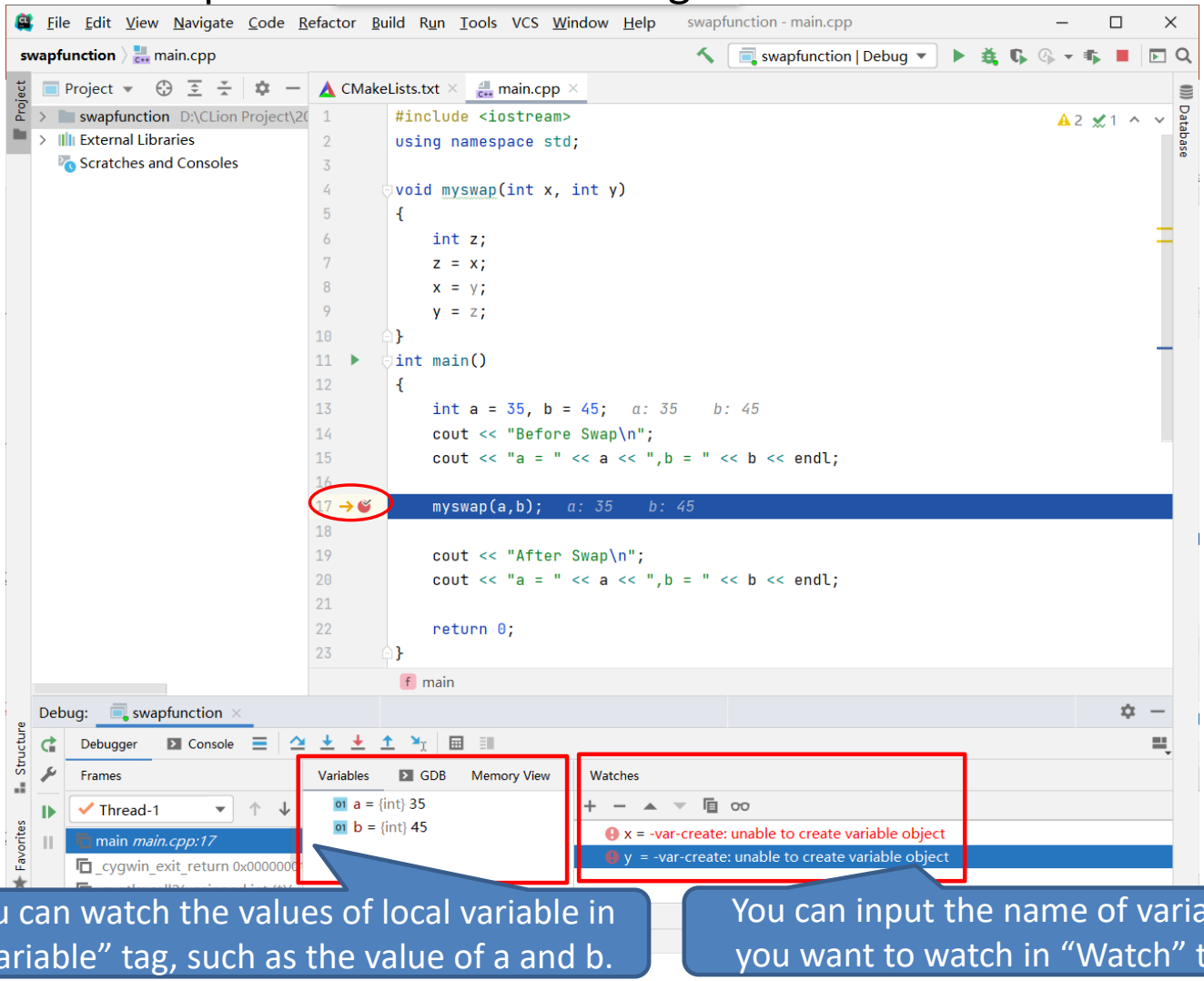


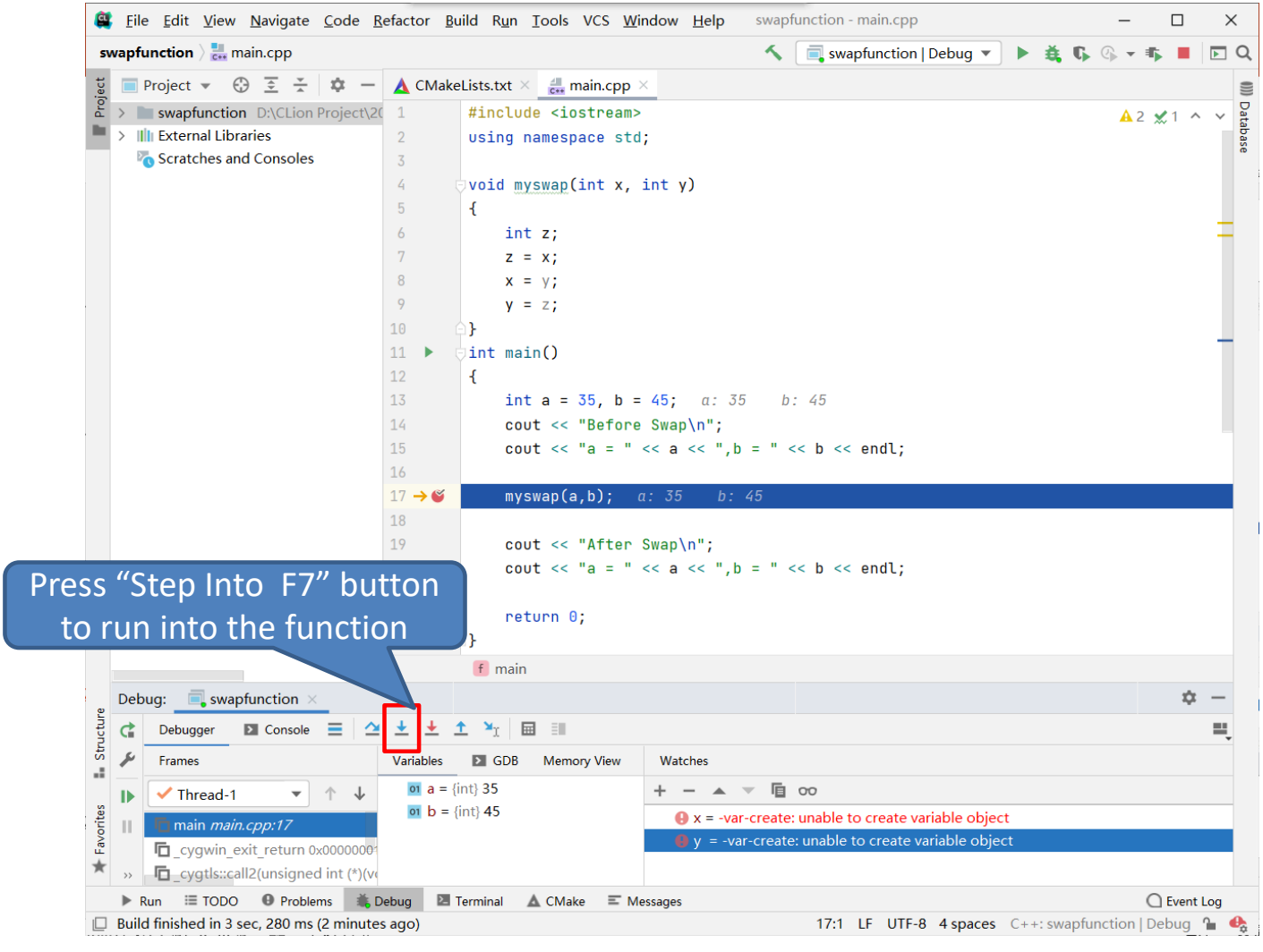

Press “step into(F11)” to step into the function
File Edit View Project Build Debug Test Analyze Tools Extensions Window Help
testDebug
Live Share
Process: [7964] testFunction.exe
Thread: [23772] Main Thread
Stack Frame: swap
SwapFunction.cpp ArrayByPointer.cpp Pointer.cpp testArray.cpp test.cpp
testFunction
(Global Scope)
swap(int * x, int * y)
#include <iostream>
using namespace std;
void swap(int *x, int *y)
{ ≤ 1ms elapsed
int z;
z = *x;
*x = *y;
*y = z;
}
int main() {
int a = 45, b = 35;
cout << "Before Swap\n";
cout << "a = " << a << " b = " << b << endl;
swap(&a, &b);
cout << "After Swap passing by value\n";
cout << "a = " << a << " b = " << b << endl;
return 0;
121 %
No issues found
Ln: 5 Ch: 1 SPC LF
Diagnostic Tools
Diagnostics session: 0 seconds (54 ms selec...
52ms
Events
Process Memory (KB)
928
928
0
0
CPU (% of all processors)
100
100
0
0
Summary Events Memory Usage CPU Usage
Events
Show Events (2 of 2)
Memory Usage
Take Snapshot
Enable heap profiling (affects performanc
CPU Usage
Record CPU Profile
Solution Explorer
Team Explorer
Watch 1
Search (Ctrl+E)
Search Depth: 3
Name Value Type
&a 0x00effa24 {45} int *
&b 0x00effa18 {35} int *
x 0x00effa24 {45} int *
y 0x00effa18 {35} int *
z 16061101 int
Add item to watch
Call Stack
Name Lang
testFunction.exe!swap(int * x, int * y) Line 5 C++
testFunction.exe!main() Line 17 C++
[External Code]
kernel32.dll![Frames below may be incorrect and/or missing, no symbols loaded for kernel32.dll] Un...
x points to a and y points to b, which means x and a occupies the same space of memory, y and b occupies another same space of memory
Autos
diate Window Output
Ready
Add to Source Control

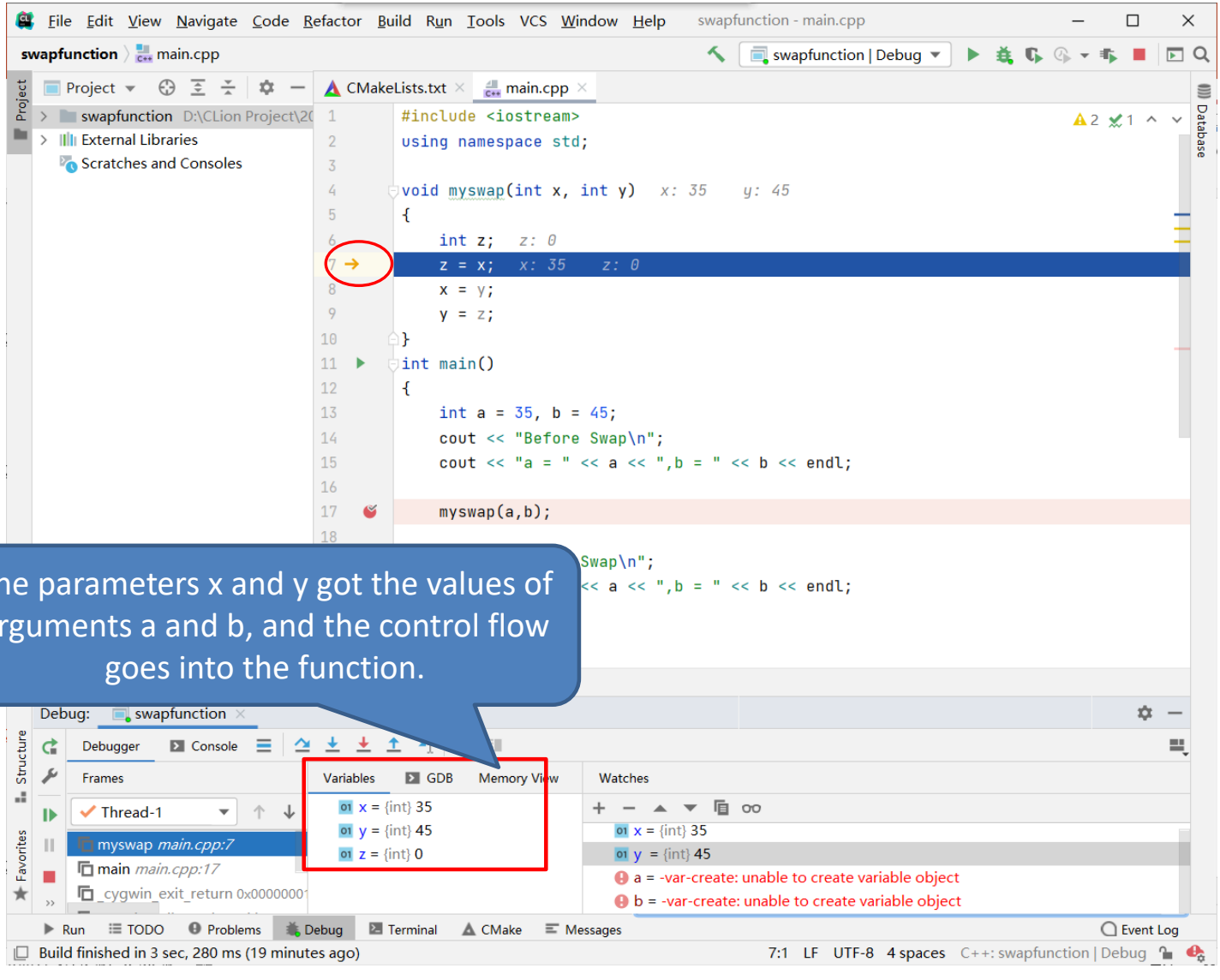

File Edit View Project Build Debug Test Analyze Tools Extensions Window Help
Search (Ctrl+Q)
testDebug
Debug
x86
Continue
Live Share
Process: [7964] testFunction.exe
Lifecycle Events
Thread: [23772] Main Thread
Stack Frame: main
SwapFunction.cpp
ArrayByPointer.cpp
Pointer.cpp
testArray.cpp
test.cpp
testFunction
(Global Scope)
main()
#include <iostream>
using namespace std;
void swap(int *x, int *y)
{
int z;
z = *x;
*x = *y;
*y = z;
}
int main() {
int a = 45, b = 35;
cout << "Before Swap\n";
cout << "a = " << a << " b = " << b << endl;
swap(&a, &b);
cout << "After Swap passing by value\n";
≤ 1ms elapsed
cout << "a = " << a << " b = " << b << endl;
return 0;
121 %
No issues found
Ln: 19 Ch: 1 SPC LF
Diagnostic Tools
Diagnostics session: 0 seconds (56 ms selec...
54ms
55ms
Events
Process Memory (KB)
928
928
0
0
CPU (% of all processors)
100
100
0
0
Summary
Events
Memory Usage
CPU Usage
Events
Show Events (8 of 8)
Memory Usage
Take Snapshot
Enable heap profiling (affects performanc
CPU Usage
Record CPU Profile
Solution Explorer
Team Explorer
Watch 1
Search (Ctrl+E)
Search Depth: 3
Name
Value
Type
&a
0x00effa24 {35}
int *
&b
0x00effa18 {45}
int *
int *
y
int *
z
int
Call Stack
Name
Lang
testFunction.exe!main() Line 19
C++
[External Code]
kernel32.dll![Frames below may be incorrect and/or missing, no symbols loaded for kernel32.dll]
Un...
After calling the function, x and y are out of its scope, but the exchanging is finished in the function at the memory space in which a and b are occupied.
Autos
Locals
Watch 1
Call Stack
Breakpoints
Exception Settings
Command Window
Immediate Window
Output
Ready
Add to Source Control

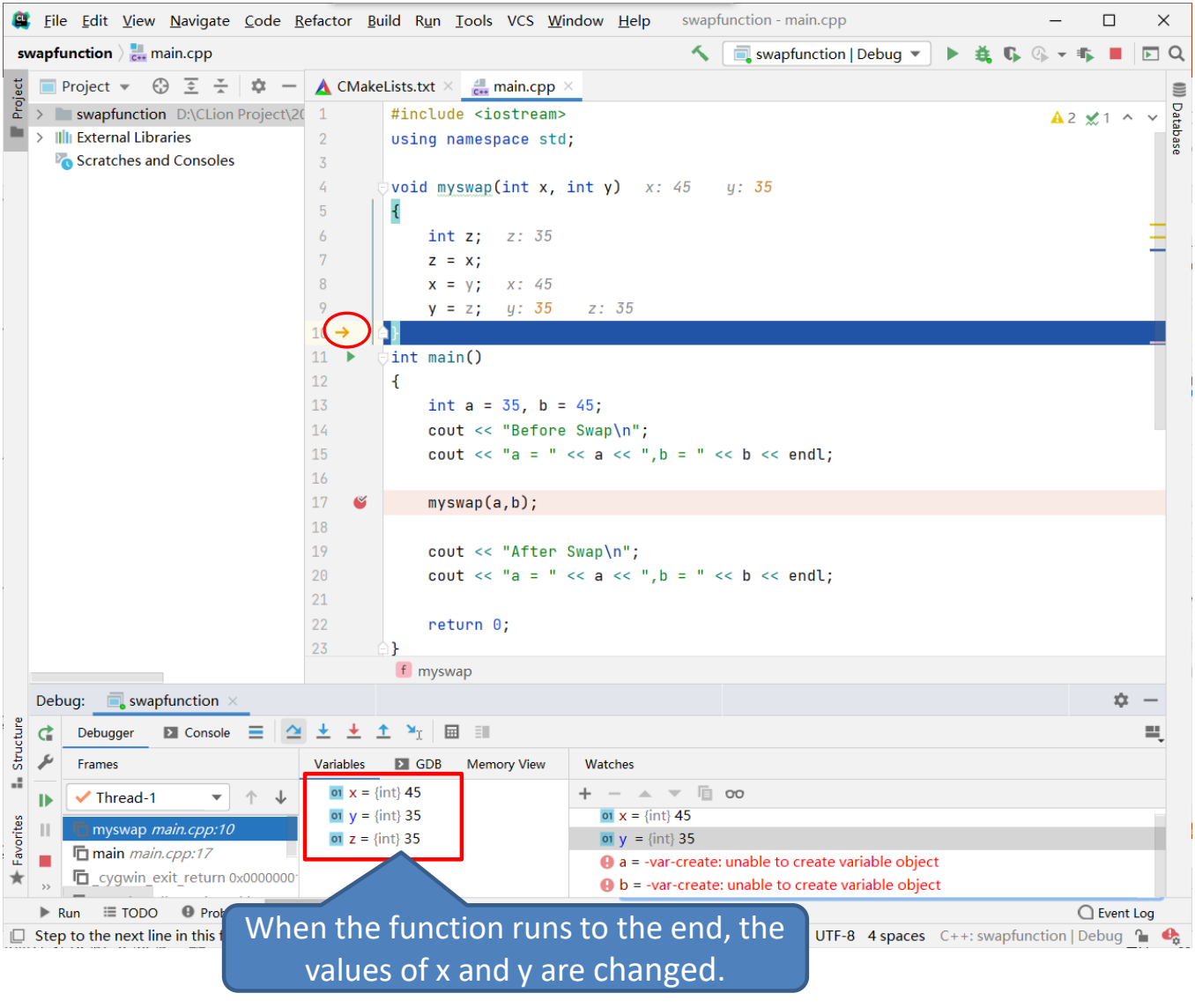
How to check in functions in CLion?

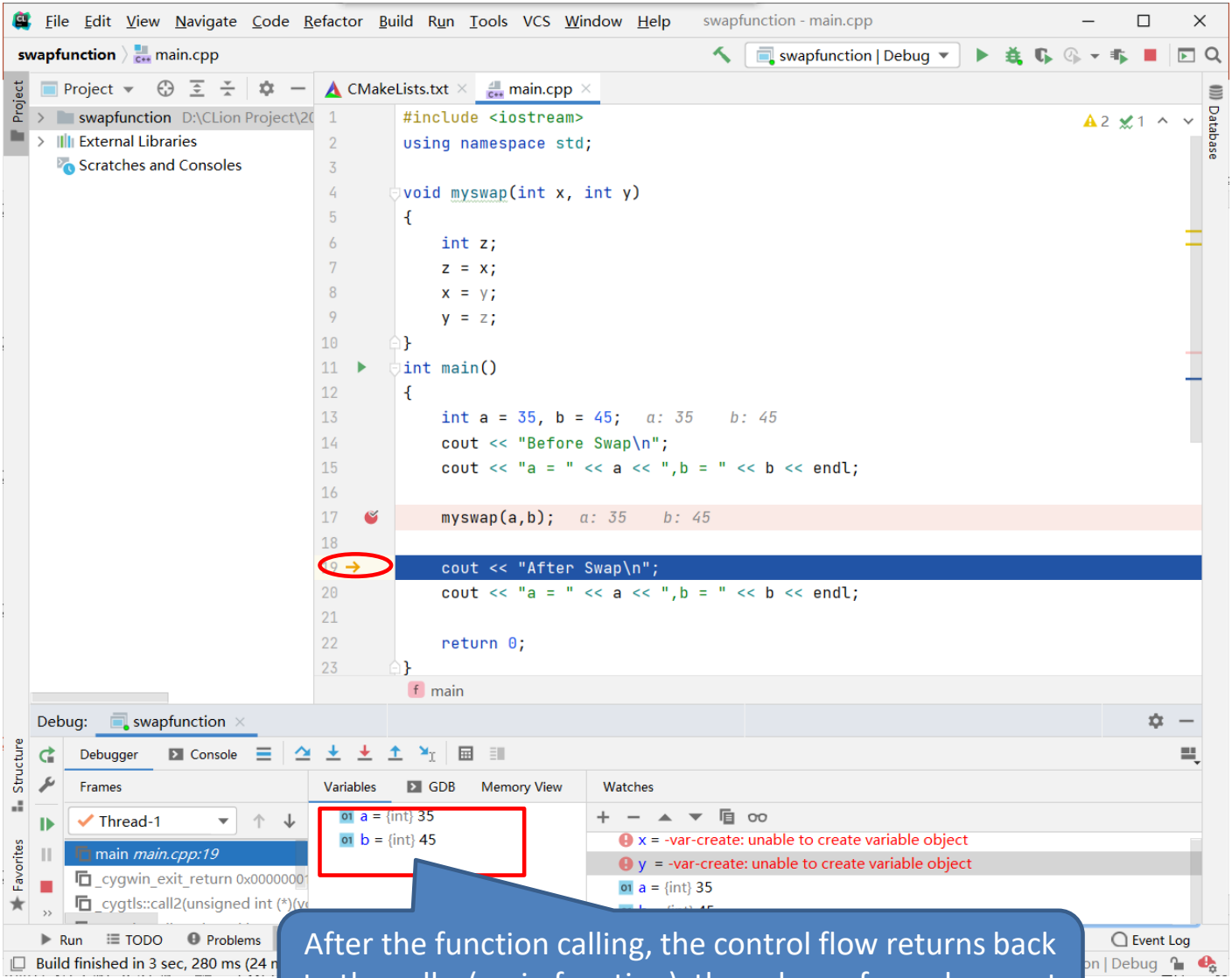
Set a breakpoint and choose Debug item



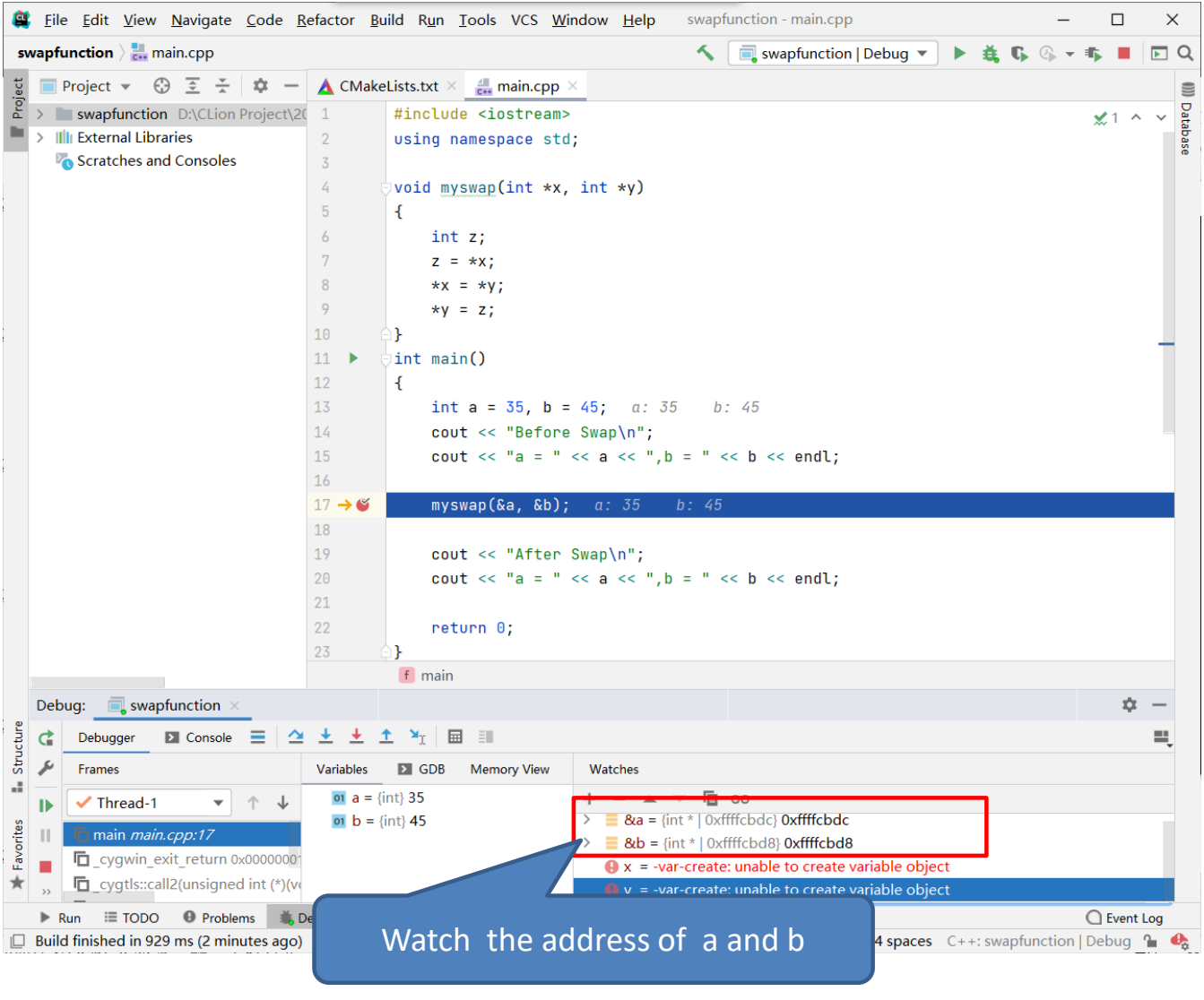

File Edit View Navigate Code Refactor Build Run Tools VCS Window Help
swapfunction - main.cpp
swapfunction | Debug
Project
swapfunction D:\CLion Project\2
External Libraries
Scratches and Consoles
CMakeLists.txt
main.cpp
#include <iostream>
using namespace std;
void myswap(int x, int y)
{
int z;
z = x;
x = y;
y = z;
}
int main()
{
int a = 35, b = 45; a: 35 b: 45
cout << "Before Swap\n";
cout << "a = " << a << ",b = " << b << endl;
myswap(a,b); a: 35 b: 45
cout << "After Swap\n";
cout << "a = " << a << ",b = " << b << endl;
return 0;
}
main
Press “Step Into F7” button to run into the function
Debug: swapfunction
Debugger
Console
Frames
Variables
GDB
Memory View
Watches
Thread-1
main main.cpp:17
_cygwin_exit_return 0x0000000
_cygtls::call2(unsigned int (*)(v
a = {int} 35
b = {int} 45
x = -var-create: unable to create variable object
y = -var-create: unable to create variable object
Run
TODO
Problems
Debug
Terminal
CMake
Messages
Event Log
Build finished in 3 sec, 280 ms (2 minutes ago)
17:1 LF UTF-8 4 spaces C++: swapfunction | Debug

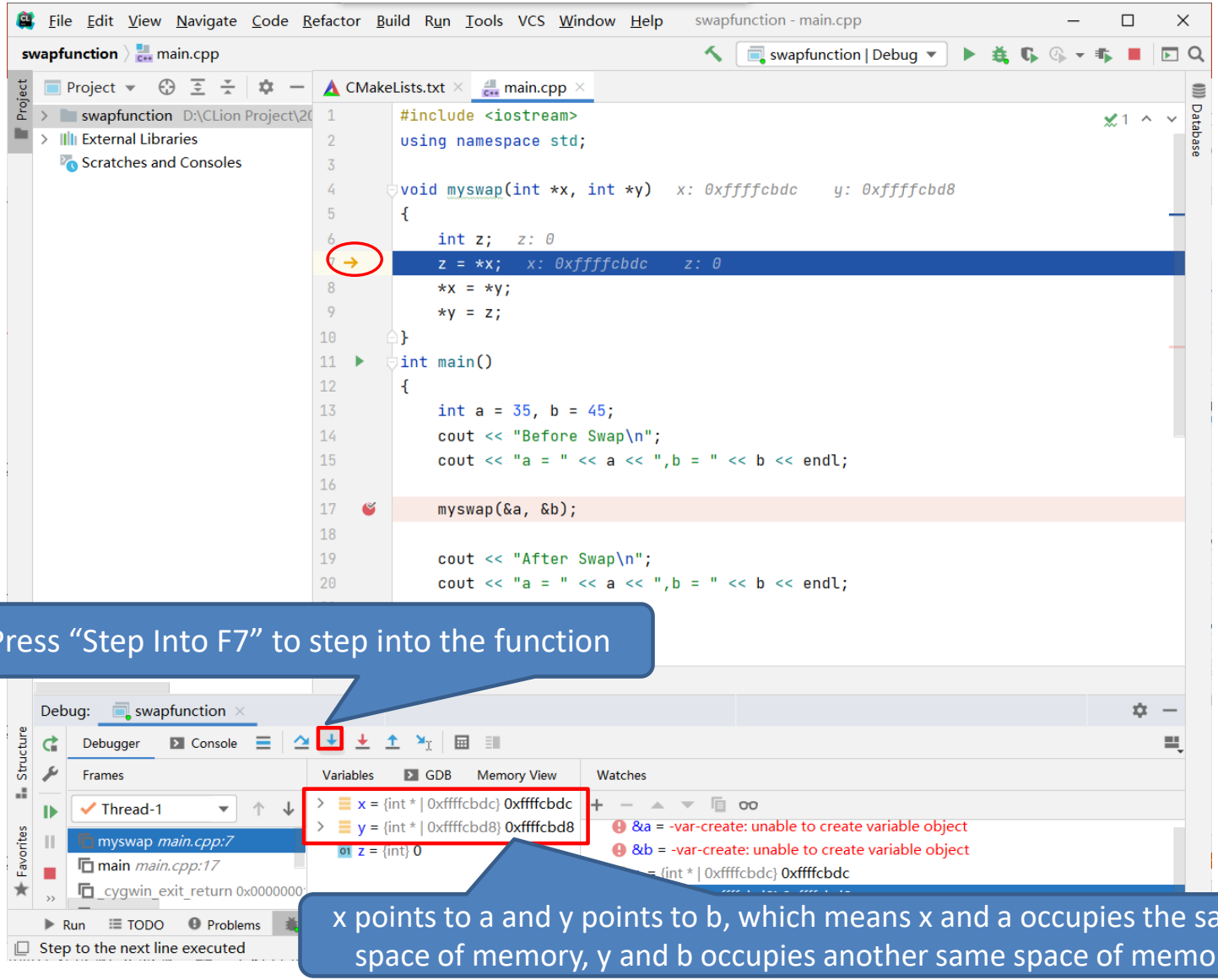

File Edit View Navigate Code Refactor Build Run Tools VCS Window Help
swapfunction - main.cpp
swapfunction | Debug
Project
swapfunction D:\CLion Project\2
External Libraries
Scratches and Consoles
CMakeLists.txt
main.cpp
#include <iostream>
using namespace std;
void myswap(int x, int y) x: 35 y: 45
{
int z; z: 0
z = x; x: 35 z: 0
x = y;
y = z;
}
int main()
{
int a = 35, b = 45;
cout << "Before Swap\n";
cout << "a = " << a << ",b = " << b << endl;
myswap(a,b);
Swap\n";
<< a << ",b = " << b << endl;
The parameters x and y got the values of arguments a and b, and the control flow goes into the function.
Debug: swapfunction
Debugger
Console
Frames
Thread-1
myswap main.cpp:7
main main.cpp:17
_cygwin_exit_return 0x0000000
Variables
GDB
Memory View
x = {int} 35
y = {int} 45
z = {int} 0
Watches
x = {int} 35
y = {int} 45
a = -var-create: unable to create variable object
b = -var-create: unable to create variable object
Run
TODO
Problems
Debug
Terminal
CMake
Messages
Event Log
Build finished in 3 sec, 280 ms (19 minutes ago)
7:1 LF UTF-8 4 spaces C++: swapfunction | Debug

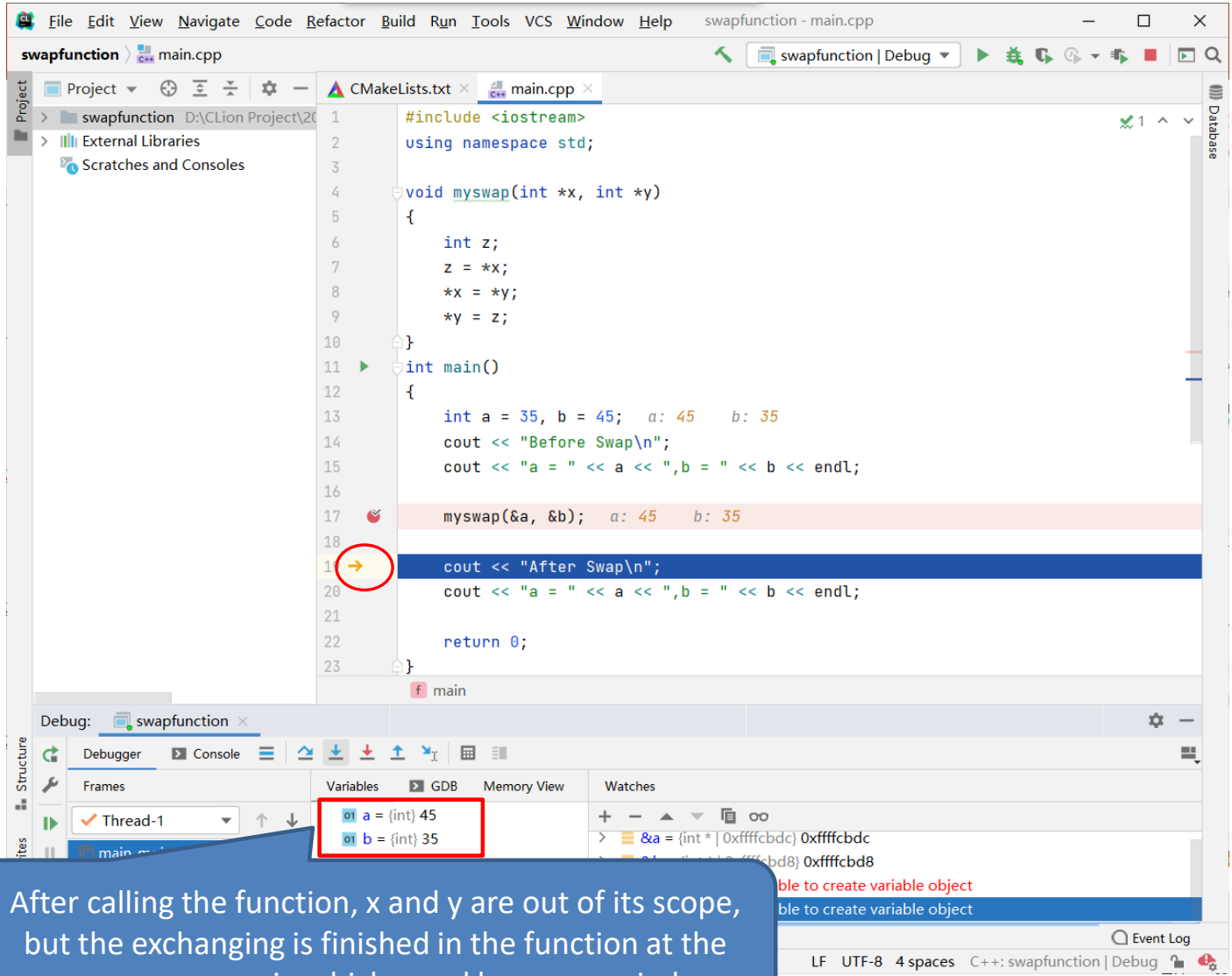

File Edit View Navigate Code Refactor Build Run Tools VCS Window Help
swapfunction - main.cpp
swapfunction | Debug
CMakeLists.txt
main.cpp
#include <iostream>
using namespace std;
void myswap(int x, int y) x: 45 y: 35
{
int z; z: 35
z = x;
x = y; x: 45
y = z; y: 35 z: 35
}
int main()
{
int a = 35, b = 45;
cout << "Before Swap\n";
cout << "a = " << a << ",b = " << b << endl;
myswap(a,b);
cout << "After Swap\n";
cout << "a = " << a << ",b = " << b << endl;
return 0;
}
myswap
Debug: swapfunction
Debugger
Console
Frames
Variables
GDB
Memory View
Watches
Thread-1
myswap main.cpp:10
main main.cpp:17
x = {int} 45
y = {int} 35
z = {int} 35
x = {int} 45
y = {int} 35
a = -var-create: unable to create variable object
b = -var-create: unable to create variable object
When the function runs to the end, the values of x and y are changed.


File Edit View Navigate Code Refactor Build Run Tools VCS Window Help
swapfunction - main.cpp
swapfunction | Debug
CMakeLists.txt
main.cpp
#include <iostream>
using namespace std;
void myswap(int x, int y)
{
int z;
z = x;
x = y;
y = z;
}
int main()
{
int a = 35, b = 45; a: 35 b: 45
cout << "Before Swap\n";
cout << "a = " << a << ",b = " << b << endl;
myswap(a,b); a: 35 b: 45
cout << "After Swap\n";
cout << "a = " << a << ",b = " << b << endl;
return 0;
}
Debug: swapfunction
Debugger
Console
Frames
Variables
GDB
Memory View
Watches
Thread-1
main main.cpp:19
a = {int} 35
b = {int} 45
x = -var-create: unable to create variable object
y = -var-create: unable to create variable object
a = {int} 35
Run
TODO
Problems
Event Log
Build finished in 3 sec, 280 ms
After the function calling, the control flow returns back to the caller(main function), the values of a and are not changed due to passing arguments by value.

Passing arguments to a function by pointer




File Edit View Navigate Code Refactor Build Run Tools VCS Window Help
swapfunction - main.cpp
swapfunction | Debug
CMakeLists.txt
main.cpp
#include <iostream>
using namespace std;
void myswap(int *x, int *y) x: 0xffffcbdc y: 0xffffcbd8
{
int z; z: 0
z = *x; x: 0xffffcbdc z: 0
*x = *y;
*y = z;
}
int main()
{
int a = 35, b = 45;
cout << "Before Swap\n";
cout << "a = " << a << ",b = " << b << endl;
myswap(&a, &b);
cout << "After Swap\n";
cout << "a = " << a << ",b = " << b << endl;
Press “Step Into F7” to step into the function
Debug: swapfunction
Debugger Console
Frames
Variables GDB Memory View
Watches
Thread-1
myswap main.cpp:7
main main.cpp:17
x = {int * | 0xffffcbdc} 0xffffcbdc
y = {int * | 0xffffcbd8} 0xffffcbd8
z = {int} 0
&a = -var-create: unable to create variable object
&b = -var-create: unable to create variable object
Run TODO Problems
Step to the next line executed
x points to a and y points to b, which means x and a occupies the same space of memory, y and b occupies another same space of memory



After calling the function, x and y are out of its scope, but the exchanging is finished in the function at the memory space in which a and b are occupied.

3. Passing arrays to a function
(array name as parameters and arguments)

passarray.cpp > main()

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

void sum(int arr1[], int arr2[],int n);

int main()
{
    int a[5] = {10,20,30,40,50};
    int b[5] = {1,2,3,4,5};

    cout << "Before calling the function, the contents of a are:\n";
    for(int i = 0; i < 5; i++)
        cout << a[i] << "  ";

    sum(a,b,5);

    cout << "\nAfter calling the function, the contents of a are:\n";
    for(int i = 0; i < 5; i++)
        cout << a[i] << "  ";
    cout << endl;

    return 0;
}
void sum(int arr1[],int arr2[],int n)
{
    int temp;
    for(int i = 0; i < n; i++)
    {
        temp = arr1[i] + arr2[i];
        arr1[i] = temp;
    }
}
```

general

用 arr.size() 也可

Using array as a parameter

arr1 = &a[0] or **arr1 = a**

```
Before calling the function, the contents of a are:
10  20  30  40  50
After calling the function, the contents of a are:
11  22  33  44  55
```

The values of elements in array **a** are changed.

3. Passing arrays to a function (pointers as parameters and array name as arguments)

passarray2.cpp > ...

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

void sum(int *p1, int *p2,int n);

int main()
{
    int a[5] = {10,20,30,40,50};
    int b[5] = {1,2,3,4,5};

    cout << "Before calling the function, the contents of a are:\n";
    for(int i = 0; i < 5; i++)
        cout << a[i] << "  ";

    sum(a,b,5);

    cout << "\nAfter calling the function, the contents of a are:\n";
    for(int i = 0; i < 5; i++)
        cout << a[i] << "  ";
    cout << endl;

    return 0;
}
void sum(int *p1,int *p2,int n)
{
    int temp;
    for(int i = 0; i < n; i++)
    {
        temp = *p1 + *p2;
        *p1 = temp;
        p1++;
        p2++;
    }
}
```

Using pointer as a parameter

p1 = a or **p1 = &a[0]**

```
Before calling the function, the contents of a are:
10  20  30  40  50
After calling the function, the contents of a are:
11  22  33  44  55
```

The values of elements in array **a** are changed.

3. Passing arrays to a function

(protect the value of the argument from modifying, please use const pointer

passarray3.cpp > ...

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

void sum(const int *p1, const int *p2,int n);

int main()
{
    int a[5] = {10,20,30,40,50};
    int b[5] = {1,2,3,4,5};

    cout << "Before calling the function, the contents of a are:\n";
    for(int i = 0; i < 5; i++)
        cout << a[i] << "  ";

    sum(a,b,5);

    cout << "\nAfter calling the function, the contents of a are:\n";
    for(int i = 0; i < 5; i++)
        cout << a[i] << "  ";
    cout << endl;

    return 0;
}
void sum(const int *p1,const int *p2,int n)
{
    int temp;
    for(int i = 0; i < n; i++)
    {
        temp = *p1 + *p2;
        *p1 = temp;
        p1++;
        p2++;
    }
}
```

只能读取，不能修改

recommended to use the **pointer-to-const** form to protect data!!

Using const pointer as a parameter

The value of array can not be modified.

```
passarray3.cpp: In function 'void sum(const int*, const int*, int)':
passarray3.cpp:30:13: error: assignment of read-only location '* p1'
   30 |         *p1 = temp;
      |         ~~~~^~~~~~
```

4. Passing multidimensional array to a function

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

```
void square(const int arr[][3],int n);
```

```
int main()
{
    int a[2][3] = {
        {1,2,3},{4,5,6}
    };
    square(a,2);

    return 0;
}
```

```
void square(int arr[][3],int n)
{
    int temp;
    for(int i = 0; i < n; i++)
        for(int j = 0; j < 3; j++)
        {
            temp = arr[i][j];
            cout << temp * temp << " ";
        }

    cout << endl;
}
```

仅第1维可省略

```
void square(int (*p)[3],int n)
{
    int temp;
    for(int i = 0; i < n; i++)
        for(int j = 0; j < 3; j++)
        {
            temp = *(*(p + i) + j);
            cout << temp * temp << " ";
        }
    cout << endl;
}
```

指向行向量的指针

the same as **p[i][j]**

```
void square(const int (*p)[3],int n)
{
    int temp;
    for(int i = 0; i < n; i++)
        for(int j = 0; j < 3; j++)
        {
            temp = p[i][j];
            cout << temp * temp << " ";
        }
    cout << endl;
}
```

```
void square(const int **p,int n)
{
    int temp;
    for(int i = 0; i < n; i++)
        for(int j = 0; j < 3; j++)
        {
            temp = p[i][j];
            cout << temp * temp << " ";
        }
    cout << endl;
}
```

If the function definition is like this, can we invoke the function by two-dimensional array name?

二级指针不知如何移动

Compiling errors in VS code

```
/usr/bin/ld: /tmp/ccIRcptd.o: in function `main':
pass2darray.cpp:(.text+0x52): undefined reference to `square(int const (*) [3], int)'
collect2: error: ld returned 1 exit status
```

二级指针不可访问到二维数组

abc	E0167	argument of type "int (*)[3]" is incompatible with parameter of type "const int **"
⊗	C2664	'void square(const int **,int)': cannot convert argument 1 from 'int [2][3]' to 'const int **'

Compiling errors in Visual Studio

```
error: cannot convert 'int (*)[3]' to 'const int**'
   68 |     square(arr);
      |            ^~~
      |            |
      |            int (*)[3]
note:   initializing argument 1 of 'void square(const int**)'
   48 | void square(const int **p)
      |             ~~~~~~~~~~~~~^
```

Compiling errors in CLion

5. Passing C-style string to a function

passcstring.cpp > ...

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

void mcopy(char *s,int m);

int main()
{   void mcopy(char *s,int m);
    char str[81];
    int m;
    cout<<"Enter a string:\n";
    cin.getline(str,80);

    cout<<"Enter m:\n";
    cin>>m;

    mcopy(str,m);

    cout << str << endl;

    return 0;
}

void mcopy(char *s,int m)
{
   strcpy(s,s+m-1);
}
```

You can use **character array** or **pointer-to-char** as a parameter.

Output:

```
Enter a string:
Today is a sunny day.
Enter m:
6
 is a sunny day.
```

6. Passing structure to a function

```c
#include <stdio.h>
#include <string.h>
struct student
{
    int id;
    char name[20];
    float score;
};

void PrintStudent(struct student record);

int main() {
    struct student record;

    record.id = 1;
    strcpy_s(record.name, "Raju");
    record.score = 86.5;

    PrintStudent(record);

    return 0;
}

void PrintStudent(struct student record)
{
    printf("Id is: %d\n", record.id);
    printf("Name is: %s\n", record.name);
    printf("Score is: %.1f\n", record.score);
}
```

Passing structure to function by value

student.h

```c
#pragma once
struct student
{
    int id;
    char name[20];
    float score;
};

void PrintStudent(struct student* record);
```

Passing structure to function by pointer

student.cpp

函数定义

```c
#include <iostream>
#include <string.h>
#include "student.h"

void PrintStudent(struct student* record)
{
    printf("Id is: %d\n", record->id);
    printf("Name is: %s\n", record->name);
    printf("Score is: %.1f\n", record->score);
}
```

main.cpp

```c
#include <iostream>
#include <string.h>
#include "student.h"

int main()
{
    struct student record;

    record.id = 1;
    strcpy_s(record.name, "Raju");
    record.score = 86.5;

    PrintStudent(&record);
    return 0;
}
```

7. Return an array from a function

returnarray.cpp > main()

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

int * fun()
{
    int arr[5];
    for(int i = 0; i < 5; i++)
        arr[i] = (i + 1) * 10;

    return arr;
}

int main()
{
    int *p = fun();

    for(int i = 0; i < 5; i++)
        cout << p[i] << " ";
    cout << endl;

    return 0;
}
```

arr is a local variable

Return the address of a local variable is not right.

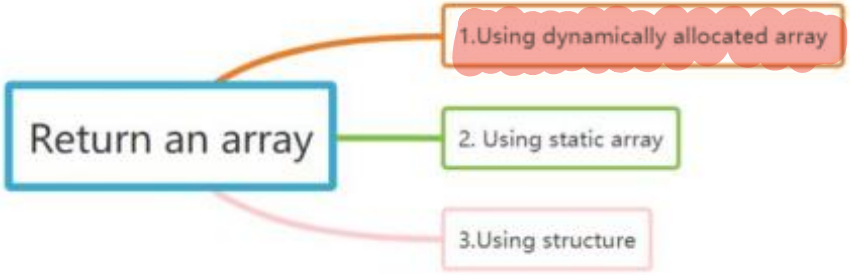
```
returnarray.cpp: In function ‘int* fun()’:
returnarray.cpp:10:12: warning: address of local variable ‘arr’ returned [-Wreturn-local-addr]
   10 |     return arr;
      |            ^~~
returnarray.cpp:6:9: note: declared here
    6 |     int arr[5];
      |         ^~~
```

```
Segmentation fault (core dumped)
```

You can not run the program.

Return an array from function by using dynamically allocated array:

Three correct ways of returning array:



不可反局部变量指针

returnarray.cpp > ...

```cpp
#include <iostream>
using namespac

int * fun()
{
    int *arr = new int[5];
    for(int i = 0; i < 5; i++)
        arr[i] = (i + 1) * 10;

    return arr;
}

int main()
{
    int *p = fun();

    for(int i = 0; i < 5; i++)
        cout << p[i] << " ";
    cout << endl;
    delete []p;

    return 0;
}
```

arr is a dynamically allocated array

release the memory in caller

Output:

```
10 20 30 40 50
```

Return an array from function by using a static array:

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

int * fun()
{
    static int arr[5];
    for(int i = 0; i < 5; i++)
        arr[i] = (i + 1) * 10;

    return arr;
}

int main()
{
    int *p = fun();

    for(int i = 0; i < 5; i++)
        cout << p[i] << " ";
    cout << endl;

    return 0;
}
```

arr is a static array

return the static arr

Output:

```
10 20 30 40 50
```

Return an array from function by using a structure:

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

struct arrWrap
{
    int arr[5];
};

struct arrWrap fun()
{
    struct arrWrap x;
    for(int i = 0; i < 5; i++)
        x.arr[i] = (i + 1) * 10;
    return x;
}

int main()
{
    struct arrWrap x = fun();

    for(int i = 0; i < 5; i++)
        cout << x.arr[i] << " ";
    cout << endl;

    return 0;
}
```

arr is a member of a structure

Return the structure

Output:

```
10 20 30 40 50
```

7. Return pointer from a function

returnpointer.cpp > ...

```
30
31  #include <iostream>
32  #include <cstring>
33  using namespace std;
34
35  char *match(char *s, char ch)
36  {    while(*s != '\0')
37          if(*s == ch)
38              return(s);
39          else
40                  s++;
41      return(NULL);
42  }
43
44  int main()
45  {  char ch, str[81], *p = NULL;
46      cout<<"Please input a string:\n";
47      cin.getline(str,80);
48      cout << "Please input a character:\n";
49      ch = getchar( );
50
51      if( ( p = match(str, ch) ) != NULL )
52          cout<< p <<endl;
53      else
54          cout << "Not Found\n";
55
56      return 0;
57  }
```

You can return the parameter pointer

```
Please input a string:
Enjoy the holiday.
Please input a character:
h
he holiday.
```

```
Please input a string:
Class is over.
Please input a character:
m
Not Found
```

//2020

C++ program to swap two numbers using pass **by reference**

passreference.cpp > main()

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

void swap(int &x, int &y)
{
    int z;
    z = x;
    x = y;
    y = z;
}

int main()
{
    int a = 45, b = 35;
    cout << "Before Swap\n";
    cout << "a = " << a << ",b = " << b << endl;

    swap(a,b);

    cout << "After Swap(passing by reference)\n";
    cout << "a = " << a << ",b = " << b << endl;

    return 0;
}
```

output:

```
Before Swap
a = 45,b = 35
After Swap(passing by reference)
a = 35,b = 45
```

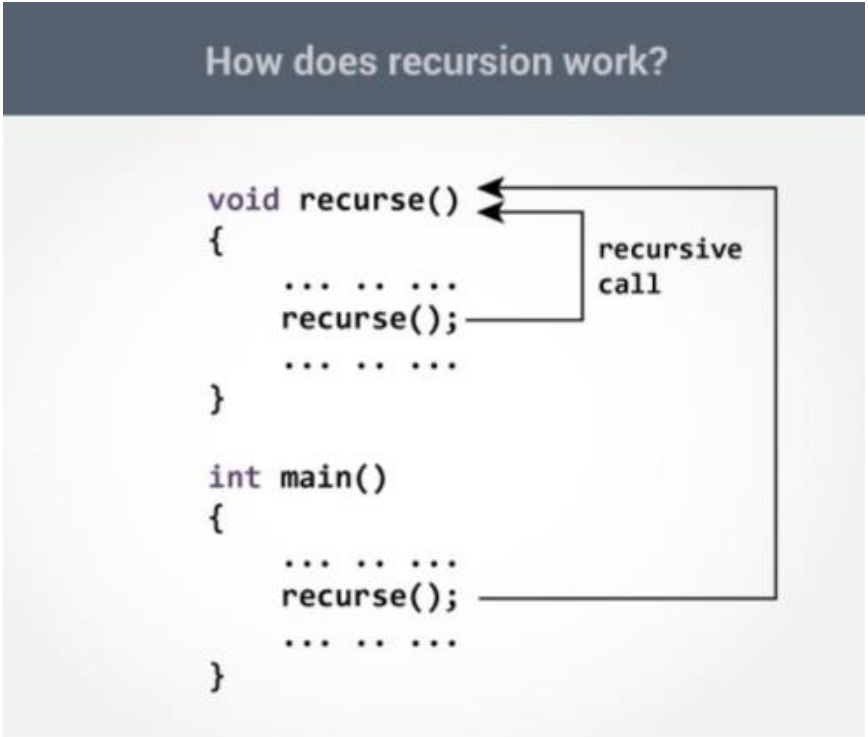
C++ program to demonstrate 6 differences between pointer and reference.

Use references when you can, and pointers when you have to.

```cpp
#include <iostream>
using namespace std;
struct demo
{
    int a;
};

int main()
{
    int x = 5;
    int y = 6;
    demo d;

    int *p;
    p = &x;
    p = &y;  //1. Pointer reinitialization allowed

    int &r = x;
    // &r = y;  //2.Compile Error
    r = y;      //2. x value becomes 6

    p = NULL;
    // &r = NULL; //3.Compile error
    p++;     //3.Points to next memory location
    r++;    //3. x value becomes 7;
    cout << &p << " " << &x << endl;   //4.Different address
    cout << &r << " " << &x << endl;  //4.Same address

    demo *q = &d;
    demo &qq = d;
    q->a = 8;
    //q.a = 8;  //5.Compile Error
    qq.a = 8;
    //qq->a = 8;   //5. Compile Error

    cout << p << endl;    //6.Prints the address
    cout << r << endl;    //6.Prints the value of x
    return 0;
}
```

2.3 Recursive function

A function that **calls itself** is known as **recursive function**. And, this technique is known as **recursion**.



Recursion is used to solve various mathematical problems by dividing it into smaller problems.

Example: compute factorial with recursive function

Compute factorial of a number Factorial of n = 1*2*3…*n

recursivefunction.cpp > ...

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

long fractorial(int n);

int main()
{
    long fract;
    int value;
    while(true)
    {
        cout << "Enter a positive integer:";
        cin >> value;
        if(value < 0)
            cout << "The input must be greater than 0!\n";
        else
            break;
    }
    fract = fractorial(value);
    cout << "Factorial of " << value << " = " << fract << endl;

    return 0;
}

long fractorial(int n)
{
    if(n == 1)
        return 1;
    else
        return n * fractorial(n-1);
}
```

base condition

- Factorial function: f(n) = n*f(n-1),
- base condition: if n<=1 then f(n) = 1

return 5 * factorial(4) = 120
- return 4 * factorial(3) = 24
  - return 3 * factorial(2) = 6
    - return 2 * factorial(1) = 2
      - return 1 * factorial(0) = 1

Calling itself until the function reaches to the **base condition**!

Output:

```
Enter a positive integer:-4
The input must be greater than 0!
Enter a positive integer:5
Factorial of 5 = 120
```

Direct recursion vs indirect recursion

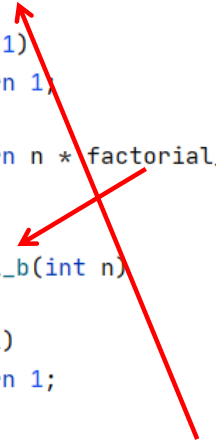
Direct recursion: When function calls itself, it is called direct recursion

Direct Recursion

```
#include <iostream>
using namespace std;
int factorial(int n);

int main()
{
    int num = 5;
    cout << factorial(num);

    return 0;
}

int factorial(int n)
{
    if(n < 1)
        return (1);
    else
        return (n * factorial( n: n-1));
}
```

Indirect recursion: When function calls another function and that function calls the calling function, then this is called indirect recursion.

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

int factorial_a(int n);
int factorial_b(int n);

int main()
{
    int num = 5;
    cout << factorial_a(num);

    return 0;
}

int factorial_a(int n)
{
    if( n <= 1)
        return 1;
    else
        return n * factorial_b( n: n-1);
}

int factorial_b(int n)
{
    if(n <= 1)
        return 1;
    else
        return n * factorial_a( n: n-1);
}
```



Indirect Recursion

Disadvantages of Recursion:

- **Recursive programs are generally slower than nonrecursive programs**. Because it needs to make a function call so the program must save all its current state and retrieve them again later. This consumes more time making recursive programs slower.

- **Recursive programs requires more memory to hold intermediate states in a stack**. Non recursive programs don’t have any intermediate states, hence they don’t require any extra memory.

2.4 Pointers to Functions(Function Pointer)

Declare a pointer to a function:

return_type (*pointername)(parameter lists);

Return type of a function

The address of a function will be stored in the pointer, which indicates that the pointer is pointed to a function. Note () can not be omitted.

Parameters of a function

Example:

函数名字是一个指针

```
int findmax(int, int);
int (*funptr)(int,int);
funptr = findmax;
int max = funptr(3,5);
```

Declaring a function

Declaring a pointer to a function

Assigning the address of a function to the pointer

Calling the function by the pointer

Example:

Compute the definite integral, suppose calculate the following definite integrals

$$\int_a^b f(x)dx=(b-a)/2*(f(a)+f(b))$$

$$\int_0^1 x^2\,dx \qquad \int_1^2 \sin x/x\,dx$$

```
#include <iostream>
#include <cmath>
using namespace std;
double calc(double (*funp)(double),double a,double b);
double f1(double x1);
double f2(double x2);

int main()
{
    double result;
    double (*funp)(double);

    result = calc(f1, a: 0.0, b: 1.0);
    cout<<"1: result= " << result << endl;
    funp = f2;
    result = calc(funp, a: 1.0, b: 2.0);
    cout<<"2: result= " << result << endl;

    return 0;
}
```

function pointer as a parameter 作函数指针

Declaring a function pointer

Calling the function by function name

Assigning the address of function f2 to the pointer

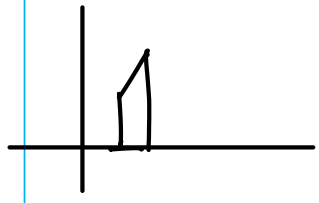
Calling the function by function pointer

$$\int_a^b f(x)dx=(b-a)/2*(f(a)+f(b))$$

```
double calc ( double (*funp)(double), double a, double b )
{  double z;
    z = (b-a) / 2 * ( (*funp)(a) + (*funp)(b) );
    return ( z );
}

double f1 ( double x )
{
    return (x * x);
}

double f2 ( double x )
{
    return (sin(x) / x);
}
```

$$\int_0^1 x^2 dx$$

$$\int_1^2 \sin x/x \, dx$$



Output:

```
1: result= 0.5
2: result= 0.64806
```