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

libraryfunction.cpp > ...

```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 << endl;

    return 0;
}
```

header file

sqrt() is a library function

```
Enter a number:5
Square root of 5 = 2.23607
```

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 a legal identifier.
- **parameters:** are variables to hold values of arguments passed while function is called. A function may not contain parameter list, give **void** in the parentheses.

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

userdefinedfunction.cpp > ...

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

// declaring the function
int sum(int x, int y);

int main()
{
    int a = 10;
    int b = 20;
    int c;

    c = sum(a,b);   // calling the function

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

    return 0;
}

// defining the function
int sum(int x, int y)
{
    int s = x + y;
    return s;
}
```

Declaring a function (function prototype)

Calling a function

Defining a function outside from all functions

Actual parameter and Formal parameter

userdefinedfunction.cpp > ...

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

// declaring the function
int sum(int x, int y);

int main()
{
    int a = 10;
    int b = 20;
    int c;

    c = sum(a,b);   // calling the function

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

    return 0;
}

// defining the function
int sum(int x, int y)
{
    int s = x + y;
    return s;
}
```

Actual parameters(arguments)

When calling a function, the values of arguments are assigned to the parameters

Formal parameters

userdefinedfunction.cpp > ...

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

// declaring the function
int sum(int x, int y);

int main()
{
    int a = 10;
    int b = 20;
    int c;

    c = sum(a,b);   // calling the function

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

    return 0;
}

// defining the function
int sum(int x, int y)
{
    int s = x + y;
    return s;
}
```

10 20 30

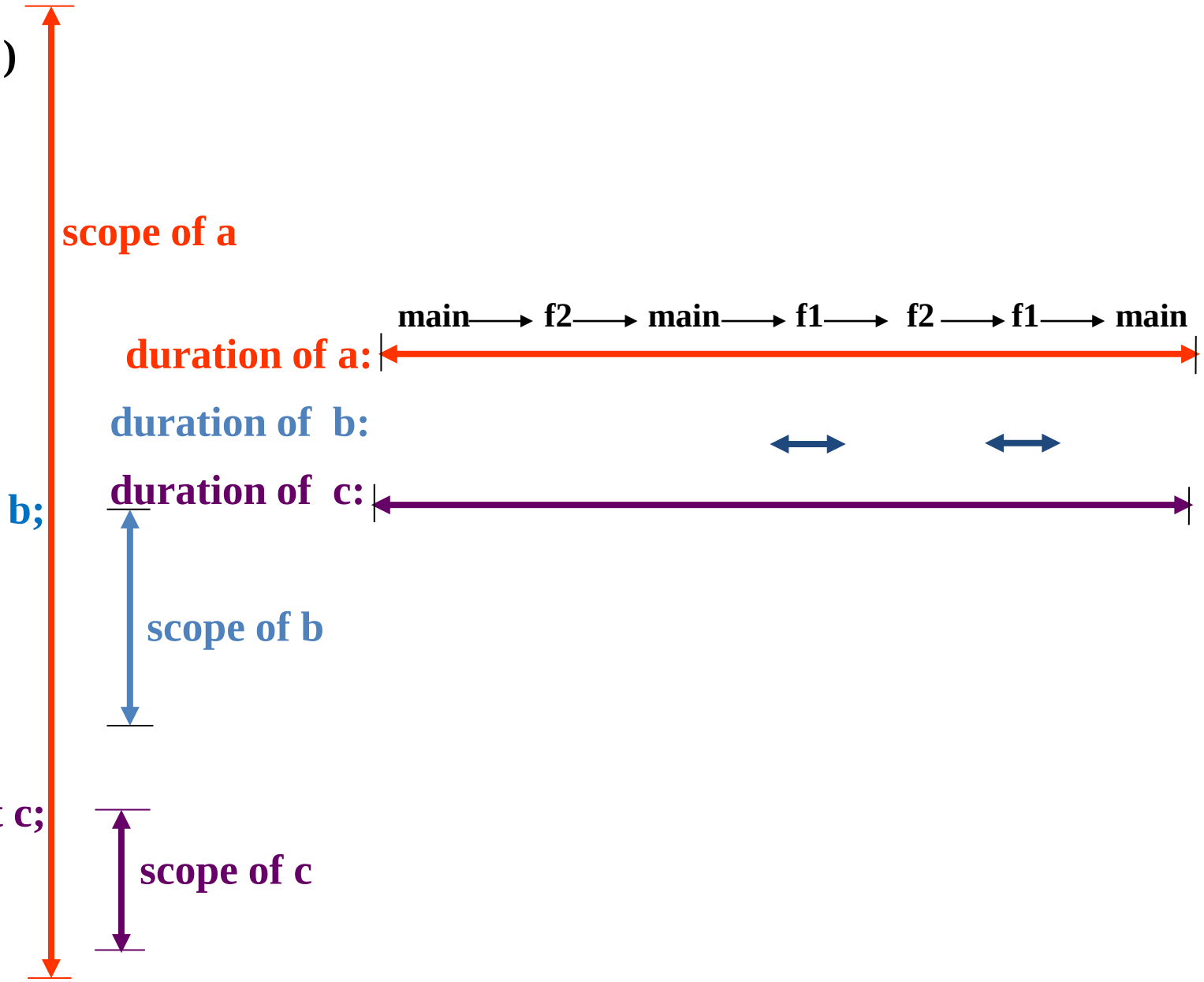
Process of the calling a function:

- The values of arguments are assigned to the those of parameters by the sequence of their definition from left to right one by one.
- The control flows into the function body and executes the statements inside the body.
- When it encounters the return statement, the control flow returns back to the calling function with a return value.

Scope and duration of a 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.
- The **scope of a local variable** is from where it is defined to the end of the block which it is included or the end of the function.
- The **scope of a global variable** is from where it is defined to the end of the file(or the program).
- An variable's **storage duration** is the period during which that variable exists in memory.

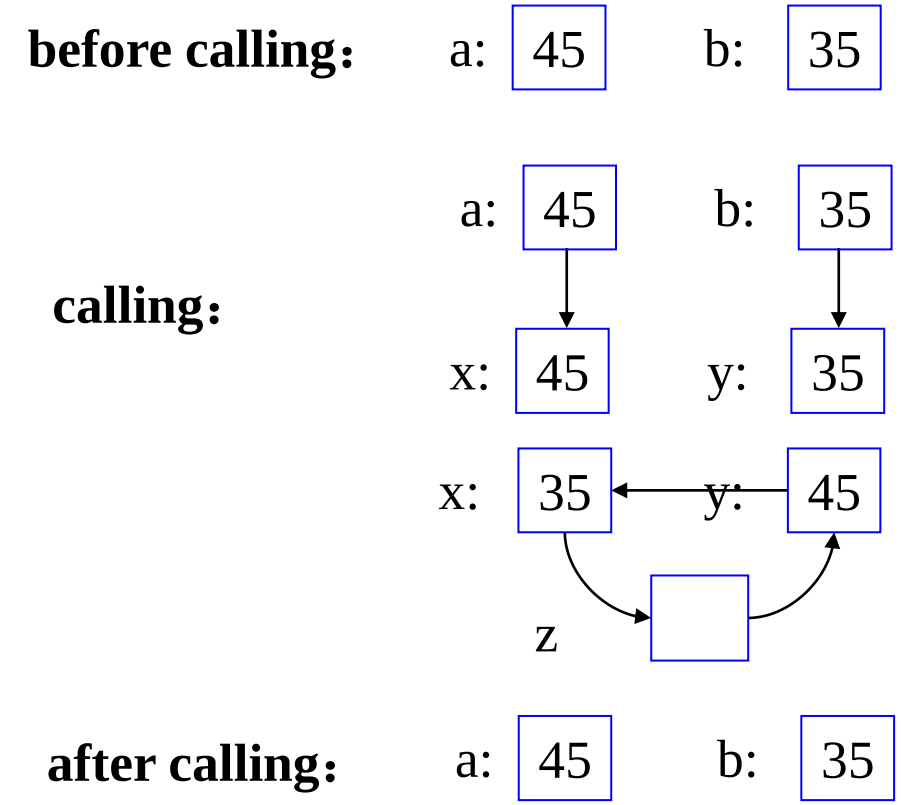
```
int a;
void main( )
{     .......
      .......
        f2;
      .......
        f1;
      .......
}
f1( )
{    auto int b;
      .........
       f2;
       ........
}
f2( )
{   static int c;
      .........
}
```



1. Passing arguments to a function by value

passbyvalue.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:" << endl;
    cout << "a = " << a << ",b = " << b << endl;

    swap(a,b);

    cout << "After swap:" << endl;
    cout << "a = " << a << ",b = " << b << endl;

    return 0;
}
```




```
Before swap:
a = 45,b = 35
After swap:
a = 45,b = 35
```

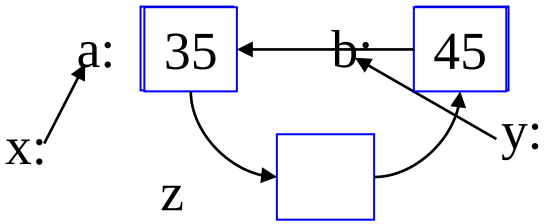
2. Passing arguments to a function by pointer

passbypointer.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:" << endl;
    cout << "a = " << a << ",b = " << b << endl;

    swap(&a,&b);

    cout << "After swap:" << endl;
    cout << "a = " << a << ",b = " << b << endl;

    return 0;
}
```

before calling: a: 45 b: 35

calling:



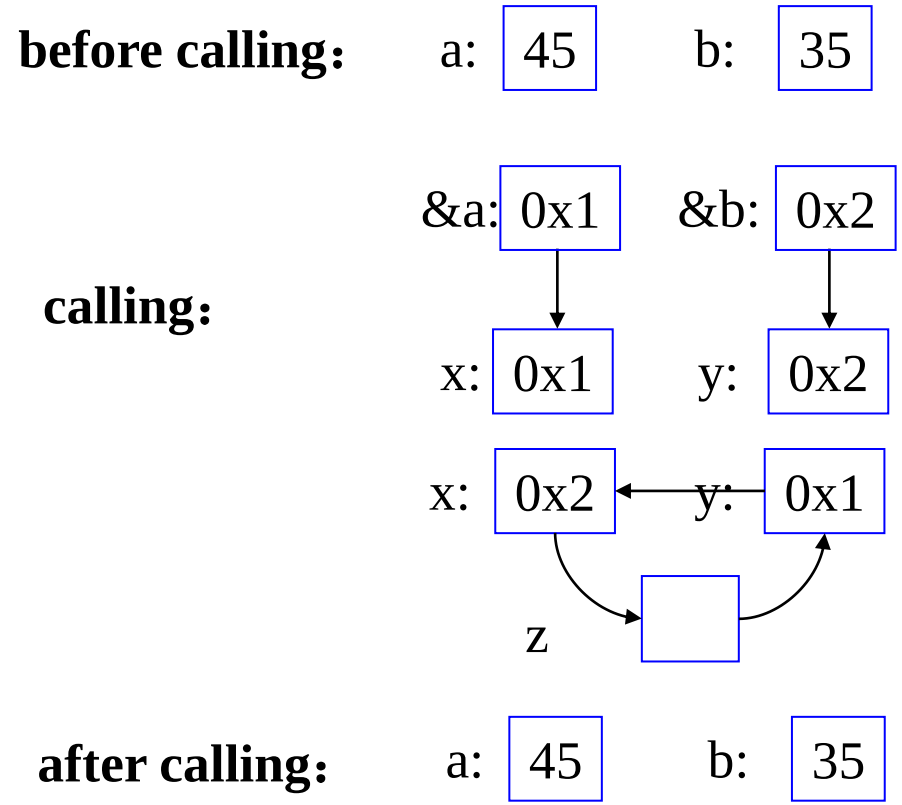
after calling: a: 35 b: 45

```
Before swap:
a = 45,b = 35
After swap:
a = 35,b = 45
```

swappointer.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:" << endl;
    cout << "a = " << a << ",b = " << b << endl;

    swap(&a,&b);

    cout << "After swap:" << endl;
    cout << "a = " << a << ",b = " << b << endl;

    return 0;
}
```

swap the pointers, does it work?




```
Before swap:
a = 45,b = 35
After swap:
a = 45,b = 35
```

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

passarray.cpp > ...

```cpp
#include <iostream>
#define SIZE 5

int sumAllElements(int a[], int n);

int main()
{
    int arr[SIZE] = {10,20,30,40,50};

    int total = sumAllElements(arr, SIZE);

    std::cout << "The sum of all elements is: " << total << std::endl;

    return 0;
}

int sumAllElements(int a[], int n)
{
    int total =0;
    for(int i = 0; i < n; i++)
        total += a[i];

    return total;
}
```

Using array name as the argument

a = arr

Using array as a parameter

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

passarray2.cpp > sumAllElements(int *, int)

```cpp
#include <iostream>
#define SIZE 5

int sumAllElements(int *pa, int n);

int main()
{
    int arr[SIZE] = {10,20,30,40,50};

    int total = sumAllElements(arr, SIZE);

    std::cout << "The sum of all elements is: " << total << std::endl;

    return 0;
}

int sumAllElements(int *pa, int n)
{
    int total =0;
    for(int i = 0; i < n; i++)
    {
        total += *pa;  // total += pa[i];
        pa++;
    }

    return total;
}
```

Using array name as the argument

p = arr; or
p = &arr[0];

Using pointer as a parameter

3. Passing arrays to a function
(The values in an array can be modified inside the function body)

pass1darray.cpp > sum(int *, int *, int)

```cpp
#include <iostream>
#define SIZE 5

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

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

    // passing arrays to function
    sum(a,b,SIZE);

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

    return 0;
}

void sum(int *pa, int *pb, int n)
{
    for(int i = 0; i < n; i++)
    {
        *pa += *pb;
        pa++;
        pb++;
    }

}
```

Modify the value which the pointer is pointed to

```
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)

pass1dconstarray.cpp > sum(int *, int *, int)

```cpp
#include <iostream>
#define SIZE 5

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

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

    // passing arrays to function
    sum(a,b,SIZE);

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

    return 0;
}
```

Use the **pointer-to-const** form to protect data!!

In definition, if the **const** is omitted, it will cause compiling error.

```cpp
void sum(int *pa, int *pb, int n)
{
    for(int i = 0; i < n; i++)
    {
        *pa += *pb;
        pa++;
        pb++;
    }
}
```

```
maydlee@LAPTOP-U1MO0N2F:/mnt/d/mycode/CcodeVS/lab06_examples$ g++ pass1dconstarray.cpp
/usr/bin/ld: /tmp/cca6HiqL.o: in function `main':
pass1dconstarray.cpp:(.text+0xd6): undefined reference to `sum(int const*, int const*, int)'
collect2: error: ld returned 1 exit status
```

3. Passing arrays to a function
(protect the value of the argument from modifying, please use const)

pass1dconstarray.cpp > sum(int *, int *, int)

```cpp
#include <iostream>
#define SIZE 5

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

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

    // passing arrays to function
    sum(a,b,SIZE);

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

    return 0;
}
```

Use the **pointer-to-const** form to protect data!!

```cpp
void sum(const int *pa, const int *pb, int n)
{
    for(int i = 0; i < n; i++)
    {
        *pa += *pb;
        pa++;
        pb++;
    }
}
```

Modifying the value which **pa** is pointed to is not allowed.

```
maydlee@LAPTOP-U1MO0N2F:/mnt/d/mycode/CcodeVS/lab06_examples$ g++ pass1dconstarray.cpp
pass1dconstarray.cpp: In function 'void sum(const int*, const int*, int)':
pass1dconstarray.cpp:29:13: error: assignment of read-only location '* pa'
   29 |         *pa += *pb;
      |         ~~~~^~~~~~
```

4. Passing multidimensional array to a function

Passing two-dimensional array as a parameter, the length of column can not be omitted.

```
#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;
}
```

```
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;
}
```

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;
}
```

```cpp
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?

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
```

```
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

passstring.cpp > mcopy(char *, int)

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

void mcopy(char *s, int m);

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

    cout << "Enter the starting number you want to copy:\n";
    cin >> m;

    mcopy(str,m);

    cout << "The copied string is:" << 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.

```
Enter a string:
Today is a sunny day.
Enter the starting number you want to copy:
3
The copied string is:day is a sunny day.
```

6. Passing structure to a function

pass_structurebyvalue.cpp > ...

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

void printstudent(student record);

int main()
{
    student record;

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

    printstudent(record);

    return 0;
}

void printstudent(student st)
{
    std::cout << "Id is:" << st.id << std::endl;
    std::cout << "Name is:" << st.name << std::endl;
    std::cout << "Score is:" << st.score << std::endl;
}
```

Passing structure to function by value

pass_structurebypointer.cpp > ...

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

void printstudent(student *record);

int main()
{
    student record;

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

    printstudent(&record);
    return 0;
}

void printstudent(student *st)
{
    std::cout << "Id is:" << st->id << std::endl;
    std::cout << "Name is:" << st->name << std::endl;
    std::cout << "Score is:" << st->score << std::endl;
}
```

Passing structure to function by pointer

Multiple files

student1.h > ...

just include once

```
#pragma once

struct student
{
    int id;
    char name[20];
    float score;
};

void printstudent(student *record);
```

student_multifile.cpp > main()

```
#include <cstring>
#include "student1.h"

int main()
{
    student record;

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

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

Header file:

- const variable or macro definition
- structure declaration
- function prototype

When the preprocessor spots an **#include** directive, it looks for the following filename and includes the contents of that file within the current file.

student.cpp > ...

look for file in standard system directories

look for file in your current directory first, and then in the standard system directories.

```
#include <iostream>
#include "student1.h"

void printstudent(student *st)
{
    std::cout << "Id is:" << st->id << std::endl;
    std::cout << "Name is:" << st->name << std::endl;
    std:cout << "Score is:" << st->score << std::endl;
}
```

compile all the source files, with default executable name

```
maydlee@LAPTOP-U1MO0N2F:/mnt/d/mycode/CcodeVS/lab06_examples$ g++ student_multifile.cpp student.cpp
maydlee@LAPTOP-U1MO0N2F:/mnt/d/mycode/CcodeVS/lab06_examples$ ./a.out
Id is:1
Name is:Raju
Score is:86.5
```

Multiple files

student2.h > ...

```
#ifndef STUDENT_H_
#define STUDENT_H_

struct student
{
    int id;
    char name[20];
    float score;
};

void printstudent(student *record);

#endif
```

Using conditional compilation directives to avoid duplicate including.

student.cpp > ...

```
#include <iostream>
//#include "student1.h"
#include "student2.h"

void printstudent(student *st)
{
    std::cout << "Id is:" << st->id << std::endl;
    std::cout << "Name is:" << st->name << std::endl;
    std::cout << "Score is:" << st->score << std::endl;
}
```

student_multifile.cpp > ...

```
#include <cstring>
//#include "student1.h"
#include "student2.h"

int main()
{
    student record;

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

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

compile all the source files, with a given executable name

```
maydlee@LAPTOP-U1MO0N2F:/mnt/d/mycode/CcodeVS/lab06_examples$ g++ -o main student_multifile.cpp student.cpp
maydlee@LAPTOP-U1MO0N2F:/mnt/d/mycode/CcodeVS/lab06_examples$ ./main
Id is:1
Name is:Raju
Score is:86.5
```

7. Return an array (or a pointer) from a function

returnarray.cpp > ...

```cpp
#include <iostream>
#define SIZE 5
using namespace std;

int * fun()
{
    int arr[SIZE];

    //Some operation on arr
    for(int i = 0; i < SIZE; i++)
        arr[i] = (i+1) * 10;

    return arr;
}
int main()
{
    int *ptr = fun();

    for(int i = 0; i < SIZE; i++)
        cout << ptr[i] << " ";
    return 0;
}
```

arr is a local variable

Return the address of a local variable is wrong.

```
maydlee@LAPTOP-U1MO0N2F:/mnt/d/mycode/CcodeVS/lab06_examples$ g++ returnarray.cpp
returnarray.cpp: In function 'int* fun()':
returnarray.cpp:13:12: warning: address of local variable 'arr' returned [-Wreturn-local-addr]
   13 |     return arr;
      |            ^~~
returnarray.cpp:7:9: note: declared here
    7 |     int arr[SIZE];
      |         ^~~
maydlee@LAPTOP-U1MO0N2F:/mnt/d/mycode/CcodeVS/lab06_examples$ ./a.out
Segmentation fault
```

A warning is caused when compiling.

The program can not be executed.

Three correct ways of returning an array (or a pointer):

- Return a static array
- Return a dynamically allocated array (or a pointer)
- Return a parameter pointer

returnstaticarray.cpp > ...

```cpp
#include <iostream>
#define SIZE 5

int * fun()
{
    static int arr[SIZE];

    //Some operation on arr
    for(int i = 0; i < SIZE; i++)
        arr[i] = (i+1) * 10;

    return arr;
}
int main() {
    int *ptr = fun();

    for(int i = 0; i < SIZE; i++)
        std::cout << ptr[i] << " ";
    std::cout << std::endl;

    return 0;
}
```

arr is a static array

return the static **arr**

arr is a dynamically allocated array

return the dynamically allocated array **arr**

release the memory in caller

returndynamicarray.cpp > ...

```cpp
#include <iostream>
#define SIZE 5

int * fun()
{
    int *arr = new int[SIZE];

    //Some operation on arr
    for(int i = 0; i < SIZE; i++)
        arr[i] = (i+1) * 10;

    return arr;
}

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

    for(int i = 0; i < SIZE; i++)
        std::cout << ptr[i] << " ";
    std::cout << std::endl;

    delete [] ptr;

    return 0;
}
```

Return a parameter pointer

returnpointer.cpp > main()

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

char * match(char *s, char ch)
{
    while(*s != '\0')
    {
        if(*s == ch)
            return s;
        else
            s++;
    }
    return (NULL);
}

```

You can return the parameter pointer

```cpp
int main() {
    char ch, str[81], *p = NULL;

    cout << "Please input a string:\n";
    cin.getline(str,81);
    cout << "Please input a character:\n";
    ch = getchar();

    if((p = match(str,ch)) != NULL)
    {
        cout << ch << " is in the string." << endl;
        cout << "The rest of string is: " << p << endl;
    }
    else
        cout << ch << " is not in the string." << endl;

    return 0;
}
```

```
Please input a string:
Enjoy the holiday.
Please input a character:
h
h is in the string.
The rest of string is: he holiday.
```

```
Please input a string:
Class is over.
Please input a character:
m
m is not in the string.
```

passstring.cpp > mcopy(char *, int)

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

void mcopy(char *s, int m);

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

    cout << "Enter the starting number you want to copy:\n";
    cin >> m;

    mcopy(str,m);

    cout << "The copied string is:" << str << endl;

    return 0;
}

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

In previous example, we change contents of the argument string by the parameter. This time, we do not want to do that. How can we do? Do not modify the original string, return the parameter pointer to the caller.

returnpointer2.cpp > mpos(char *, int)

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

char * mpos(char *s, int m);

int main()
{
    char str[81], *p=NULL;
    int m;
    cout << "Enter a string:\n";
    cin.getline(str,81);

    cout << "Enter the starting number you want to copy:\n";
    cin >> m;

    if((p = mpos(str,m)) != NULL)
    {
        cout << "The orignal string is:" << str << endl;
        cout << "The copied string is:" << p << endl;
    }
    else
        cout << m << " is illegal." << endl;

    return 0;
}
```

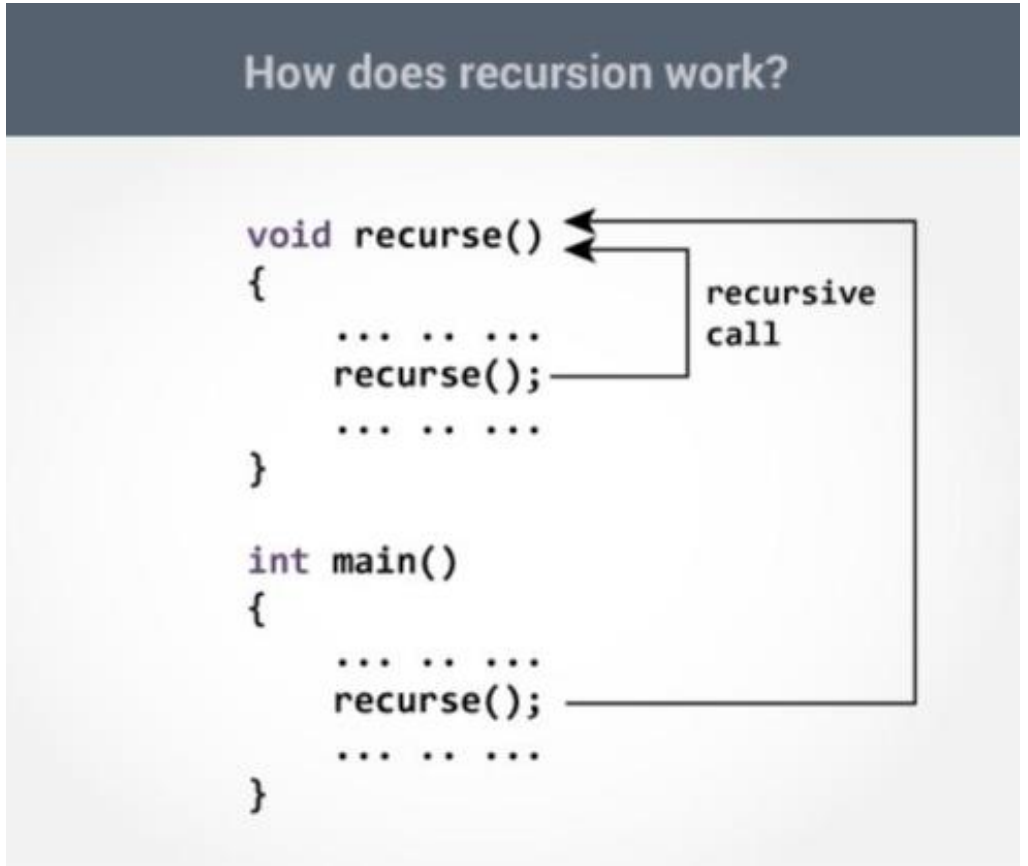
```cpp

char * mpos(char *s, int m)
{
    if(m < 0 || m > strlen(s))
        return NULL;

    return (s+m-1);
}
```

```
Enter a string:
Today is a sunny day.
Enter the starting number you want to copy:
3
The copied string is:day is a sunny day.
```

A pointer can be defined as const-pointer-to-char, if it is certain that it does not modify the value of the object to which it points .

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

recursionfunction.cpp > ...

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

long factorial(int n);

int main()
{
    long fact;
    int num;
    while(true)
    {
        cout << "Enter a positive integer:";
        cin >> num;
        if(num <= 0)
            cout << "The input number must be greater than 0!\n";
        else
            break;
    }

    fact = factorial(num);
    cout << "Factorial of " << num << " is:" << fact << endl;

    return 0;

}

long factorial(int n)
{
    if(n == 1)
        return 1;
    return n * factorial(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**!

```
Enter a positive integer:0
The input number must be greater than 0!
Enter a positive integer:-3
The input number must be greater than 0!
Enter a positive integer:20
Factorial of 20 is:2432902008176640000
```

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:

```
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

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

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

```
#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

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

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

```
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
```

qsort() in general utilities library stdlib.h

The quick sort method is one of the most effective sorting algorithms. **qsort()** function sorts an array of data object.

void qsort(void *base, size_t nmemb, size_t size, int(*compar)(const void *, const void *));

void *base: pointer to the beginning of the array to be sorted, it permits any data pointer type to be typecast to a pointer-to-void.

size_t nmemb: number of items to be sorted.

size_t size: the size of the data object, for example, if you want to sort an array of double, you would sizeof(double).

int (*compar)(const void *, const void *): a pointer to a function that returns an **int** and take two arguments, each of which is a pointer to type const void. These two pointers point to the items being compared.

qsorter.cpp > showarray(const double [], int)

```cpp
// using qsort() to sort groups of numbers
#include <iostream>
#include <stdlib.h>

#define NUM 10
void fillarray(double ar[], int n);
void showarray(const double ar[], int n);
int mycomp(const void *p1, const void *p2);

int main()
{
    double vals[NUM];

    fillarray(vals,NUM);
    std::cout << "Random list:\n";
    showarray(vals,NUM);

    qsort(vals,NUM,sizeof(double),mycomp);
    std::cout << "\nSorted list:" << std::endl;
    showarray(vals,NUM);

    return 0;
}

void fillarray(double ar[], int n)
{
    for(int i = 0; i < n; i++)
        ar[i] = (double)rand() / ((double)rand() + 0.1);
}

void showarray(const double ar[], int n)
{
    for(int i = 0; i < n; i++)
        std::cout << ar[i] << "  ";
    std::cout << std::endl;
}

int mycomp(const void *p1, const void *p2)
{
    //need to use pointers to double to access values
    const double *pd1 = (const double *) p1;
    const double *pd2 = (const double *) p2;

    if(*pd1 < *pd2)
        return -1;
    else if(*pd1 > *pd2)
        return 1;
    else
        return 0;
}
```

convert void pointer to the pointer of proper type

give the sorting rule

```
Random list:
2.13039  0.980787  4.61474  0.436358  0.501426  0.759134  0.710526  1.03933  0.88626  0.233295

Sorted list:
0.233295  0.436358  0.501426  0.710526  0.759134  0.88626  0.980787  1.03933  2.13039  4.61474
```

qsorter2.cpp > main()

```cpp
#include <iostream>
#include <cstring>

using namespace std;
#define SIZE 5

struct student
{
    char name[20];
    int age;
};

void display(const student *s,int n);
int mycomp(const void *p1, const void *p2);
```

```cpp
int main()
{
    student stu[SIZE] = {{"Alice",19},{"Bob",20},{"Alice",16},{"Leo",20},{"Billy",19}};

    cout << "Original students:\n";
    display(stu,SIZE);

    qsort(stu,SIZE,sizeof(student),mycomp);
    cout << "\nSorted students:" << endl;
    display(stu,SIZE);

    return 0;
}
```

```cpp
void display(const student *s,int n)
{
    for(int i = 0; i < n; i++)
    {
        cout << "Name: " << s[i].name << ", age: " << s[i].age << endl;
    }
}
```

```
Original students:
Name: Alice, age: 19
Name: Bob, age: 20
Name: Alice, age: 16
Name: Leo, age: 20
Name: Billy, age: 19

Sorted students:
Name: Alice, age: 16
Name: Alice, age: 19
Name: Billy, age: 19
Name: Bob, age: 20
Name: Leo, age: 20
```

```c
int mycomp(const void *p1, const void *p2)
{
    // need to use pointers to struct student to access values
    const student *ps1 = (const student *) p1;
    const student *ps2 = (const student *) p2;

    int res;
    res = strcmp(ps1->name, ps2->name);
    if(res != 0)
        return res;
    else
    {
        if(ps1->age < ps2->age)
            return -1;
        else if(ps1->age > ps2->age)
            return 1;
        else
            return 0;
    }

}
```

If the name is the same, sort by age

Debugging program inside function by step into

File Edit Selection View Go Run Terminal Help passbyvalue.cpp - lab06_examples [WSL: Ubuntu] - Visual

g++ - Build ar

passbyvalue.cpp | launch.json | returnarray.cpp

Step Into (F11)

Click the “step into” button

VARIABLES

Locals

a: 45

b: 35

Registers

variables in main function

passbyvalue.cpp > main()

```
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:" << endl;
16      cout << "a = " << a << ",b = " << b << endl;
17
18      swap(a,b);
19
20      cout << "After swap:" << endl;
21      cout << "a = " << a << ",b = " << b << endl;
22
23      return 0;
24  }
```

Passing by value

WATCH

break point

CALL STACK PAUSED ON BREAKPOINT

main() passbyvalue.cpp 18:1

R.. g++ - Build ar

passbyvalue.cpp | launch.json | returnarray.cpp

passbyvalue.cpp > swap(int, int)

VARIABLES

Locals

z: 32767

x: 21845

y: 1431655296

Registers

variables in swap function

WATCH

CALL STACK PAUSED ON STEP

swap(int x, int y) pass...

main() passbyvalue.cpp 18:1

```
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:" << endl;
16     cout << "a = " << a << ",b = " << b << endl;
17
18     swap(a,b);
19
20     cout << "After swap:" << endl;
21     cout << "a = " << a << ",b = " << b << endl;
22
23     return 0;
24 }
```

R.. g++ - Build ar

VARIABLES

Locals

z: 45

x: 35

y: 45

Registers

The values of x and y are exchanged, but after swap calling, they are not existed.

WATCH

CALL STACK PAUSED ON STEP

swap(int x, int y) pass...

main() passbyvalue.cpp 18:1

passbyvalue.cpp launch.json returnarray.cpp

passbyvalue.cpp > swap(int, int)

```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:" << endl;
    cout << "a = " << a << ",b = " << b << endl;

    swap(a,b);

    cout << "After swap:" << endl;
    cout << "a = " << a << ",b = " << b << endl;

    return 0;
}
```

R.. g++ - Build ar

passbyvalue.cpp | launch.json | returnarray.cpp

passbyvalue.cpp > main()

VARIABLES

Locals

a: 45

b: 35

Registers

The values of a and b remain unchanged

WATCH

CALL STACK PAUSED ON STEP

main() passbyvalue.cpp 20:1

```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:" << endl;
    cout << "a = " << a << ",b = " << b << endl;

    swap(a,b);

    cout << "After swap:" << endl;
    cout << "a = " << a << ",b = " << b << endl;

    return 0;
}
```

R.. g++ - Build ar

returnpointer.cpp | returnpointer2.cpp | qsc

passbypointer.cpp > main()

VARIABLES

Locals

a: 45

b: 35

Registers

WATCH

&a: 0x7fffffffdcf0

&b: 0x7fffffffdcf4

The addresses of a and b

CALL STACK PAUSED ON BREAKPOINT

main() passbypointer.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:" << endl;
    cout << "a = " << a << ",b = " << b << endl;

    swap(&a,&b);

    cout << "After swap:" << endl;
    cout << "a = " << a << ",b = " << b << endl;

    return 0;
}
```

Passing by pointer

R.. g++ - Build ar

returnpointer.cpp | returnpointer2.cpp | qsc

passbypointer.cpp > swap(int *, int *)

VARIABLES

Locals

z: 32767

x: 0x7fffffffdcf0

y: 0x7fffffffdcf4

Registers

x points to a and y points to b, because their values are the address of a and b respectively.

WATCH

&a: 0x7ffff7b97d08 <a>

&b: 0x7ffff7b729f0 <inv16>

CALL STACK PAUSED ON STEP

swap(int * x, int * y) p..

main() passbypointer.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:" << endl;
    cout << "a = " << a << ",b = " << b << endl;

    swap(&a,&b);

    cout << "After swap:" << endl;
    cout << "a = " << a << ",b = " << b << endl;

    return 0;
}
```

R.. g++ - Build ar

returnpointer.cpp | returnpointer2.cpp | qsc

passbypointer.cpp > swap(int *, int *)

VARIABLES

Locals

z: 45

x: 0x7fffffffdcf0

y: 0x7fffffffdcf4

Registers

WATCH

&a: 0x7ffff7b97d08 <a>

&b: 0x7ffff7b729f0 <inv16>

*x: 35

*y: 45

The two values are exchanged in swap function.

CALL STACK PAUSED ON STEP

swap(int * x, int * y) p..

main() passbypointer.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:" << endl;
16     cout << "a = " << a << ",b = " << b << endl;
17
18     swap(&a,&b);
19
20     cout << "After swap:" << endl;
21     cout << "a = " << a << ",b = " << b << endl;
22
23     return 0;
24 }
```

R.. g++ - Build ar

returnpointer.cpp | returnpointer2.cpp | qsc

passbypointer.cpp > main()

VARIABLES

Locals

a: 35

b: 45

Registers

The two values are exchanged after calling swap function.

WATCH

&a: 0x7fffffffdcf0

&b: 0x7fffffffdcf4

*x: -var-create: unable to …

*y: -var-create: unable to …

CALL STACK PAUSED ON STEP

main() passbypointer.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:" << endl;
    cout << "a = " << a << ",b = " << b << endl;

    swap(&a,&b);

    cout << "After swap:" << endl;
    cout << "a = " << a << ",b = " << b << endl;

    return 0;
}
```

3 Exercises

1. Write a program that will display the calculator menu. The program will prompt the user to choose the operation choice(from 1 to 5). Then it asks the user to input two integer values for the calculation. See the sample below.

```
=====================================================
                    MENU
=====================================================
      1.Add
      2.Subtract
      3.Multiply
      4.Divide
      5.Modulus
Enter your choice(1~5):1
Enter your integer numbers:2 6

Result:8
Press y or Y to continue:y
Enter your choice(1~5):3
Enter your integer numbers:6 9

Result:54
Press y or Y to continue:Y
Enter your choice(1~5):5
Enter your integer numbers:22 3

Result:1
Press y or Y to continue:n

Process finished with exit code 0
```

The program also asks the user to decide whether he/she wants to continue the operation. If he/she inputs ‘y’, the program will prompt the user to choose the operation gain. Otherwise, the program will terminate.

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

void Displaymenu()
{
    // complete code here
}

int Add(int a, int b)
{
  // complete code here
}

int Substract(int a, int b)
{
   // complete code here
}

int Multiply(int a, int b)
{
    // complete code here
}

int Divide(int a, int b)
{
      //complete code here
}

int Modulus(int a, int b)
{
   // complete code here
}
```

```
int main()
{
    //show menu
    Displaymenu();
    int YourChoice;
    int a, b;
    char confirm;
    do
    {
        cout << "Enter your choice(1~5):";
        cin >> YourChoice;
        cout << "Enter your integer numbers:";
        cin >> a >> b;
        cout << "\n";
        switch(YourChoice)
        {
            // complete code here

        }
        cout << "Press y or Y to continue:";
        cin >> confirm;
    }while(confirm == 'y' || confirm == 'Y');

    return 0;
}
```

2. Here is a structure declaration:

```
struct box
{
char maker[40];
float height;
float width;
float length;
float volume;
};
```

(1) Write a function that passes a box structure by value and display the value of each member.

(2) Write a function that passes the address of a box structure and that sets the volume member to the product of the other three dimensions.

(3) Write a simple program that uses these two function.

A sample run might look like this:

```
Before setting volume:
Maker: Jack Smith
Height: 3.4
Width: 4.5
Length: 5.6
Volume: 0
After setting volume:
Maker: Jack Smith
Height: 3.4
Width: 4.5
Length: 5.6
Volume: 85.68
```

3. Write a program that uses the following functions:

- **int fill_array(double arr[], int size)** prompts the user to enter double values to be entered in the array. It ceases taking input when the array is full or when the user enters non-numeric input, and it returns the actual number of entries.
- **void show_array(double *arr, int size)** displays the contents of the array.
- **void reverse_array(double *arr, int size)** is a recursive function, it reverses the order of the values stored in the array.

The program should use these functions to fill an array, show the array, reverse the array; revers all except the first and last element of the array, and then show the array. A sample run might look like this:

Output:

```
Enter the size of an array:6
Enter value #1: 1
Enter value #2: 2
Enter value #3: 3
Enter value #4: 4
Enter value #5: 5
Enter value #6: 6
1 2 3 4 5 6
6 5 4 3 2 1
6 2 3 4 5 1
```