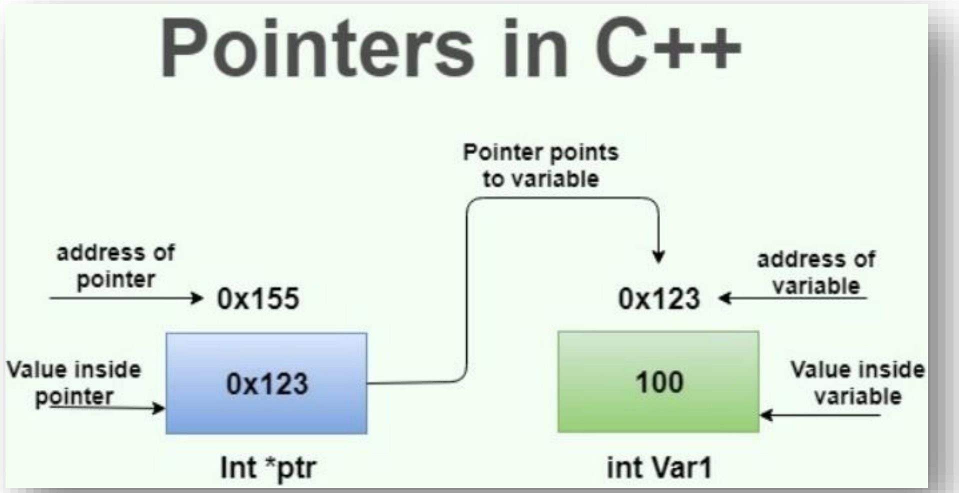
ALGORITHM & PROGRAMMING

Chapter 8- Pointer



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Lecture overview

❑ Overall lectures

1. Introduction to algorithm
2. Basic data types and statements
3. Control structures and Loop
4. Array
5. Data structure
6. Sub-programs
7. Recursive
8. *Pointers*
9. Linked Lists
10. Stacks and Queues
11. Sorting algorithms
12. Trees

C++

Outline

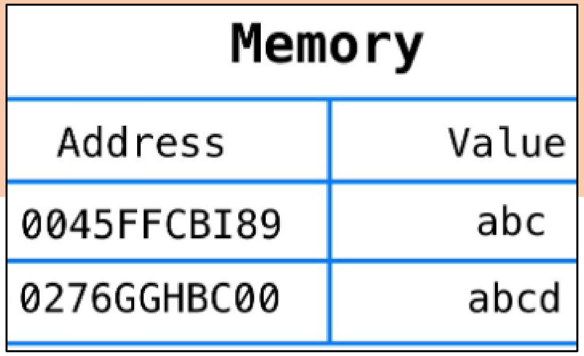
- What is pointer?
- What are the advantages of using pointer?
- How to use pointer
- Examples

Introduction

❑ Computer Memory

- To understand pointers, you should have knowledge about address in computer memory

- A computer memory location has an address and holds a content (value)
- The address is a numerical number (expressed in hexadecimal)
- An integer value consumes 4 bytes of memory

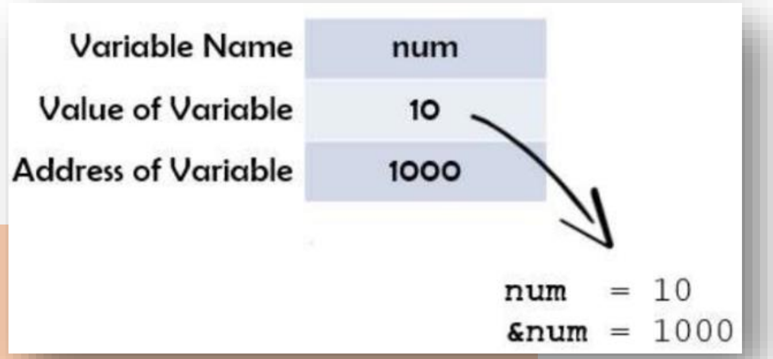


Memory	
Address	Value
0045FFCBI89	abc
0276GGHBC00	abcd

Introduction

❑ Computer Memory

- Each variable we create in the program has a location in the computer's memory
- The value of the variable is stored in the assigned location
- To know where the data of normal variable is stored, we use operator &
  - & gives the address occupied by a variable

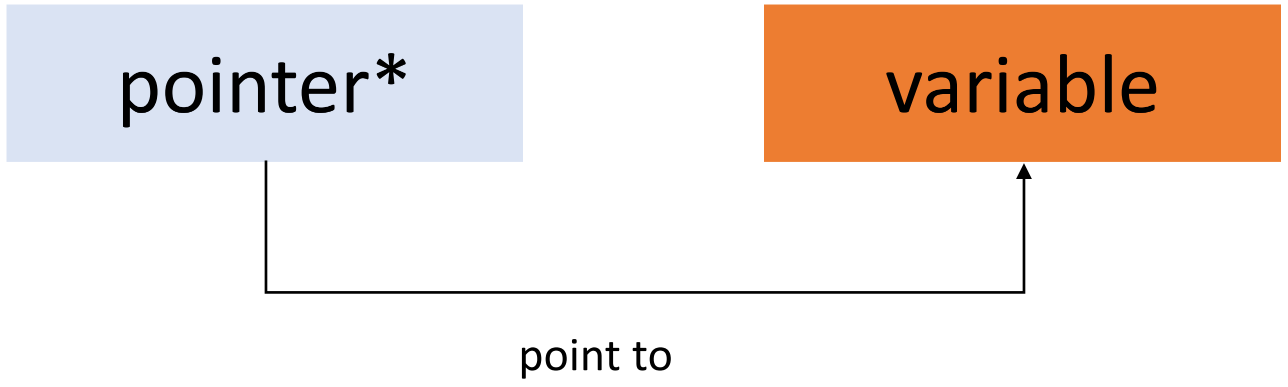


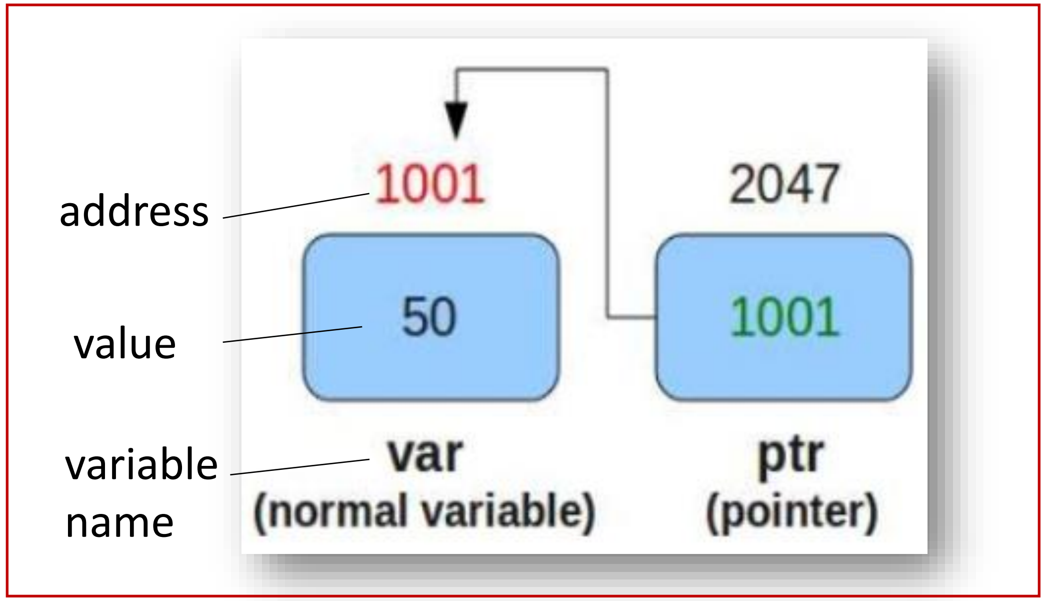
- Example:
  - If *num* is a variable, then *&num* gives the address of that variable

Introduction

❑ What is pointer?

- A pointer is a variable that holds the memory address of another variable of the same type.
- Pointers are used to access the memory address and values at that address.



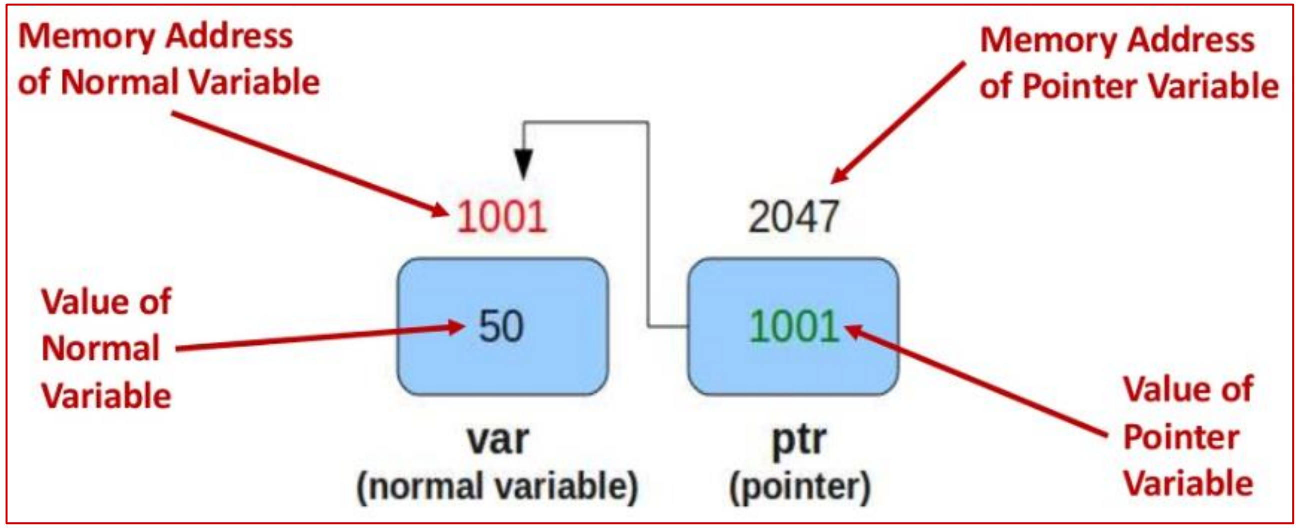


An example of a pointer variable pointing to a normal variable

Pointer Vs. Normal variable

❑ Remark

- A normal variable is used to store value, while *a pointer variable is used to store address (reference) of another variable*
- Pointers are representation of addresses
- We can have a pointer to any variable type


Memory Address of Normal Variable
Memory Address of Pointer Variable
1001
2047
Value of Normal Variable
50
1001
Value of Pointer Variable
var
(normal variable)
ptr
(pointer)

Advantages of using pointer?

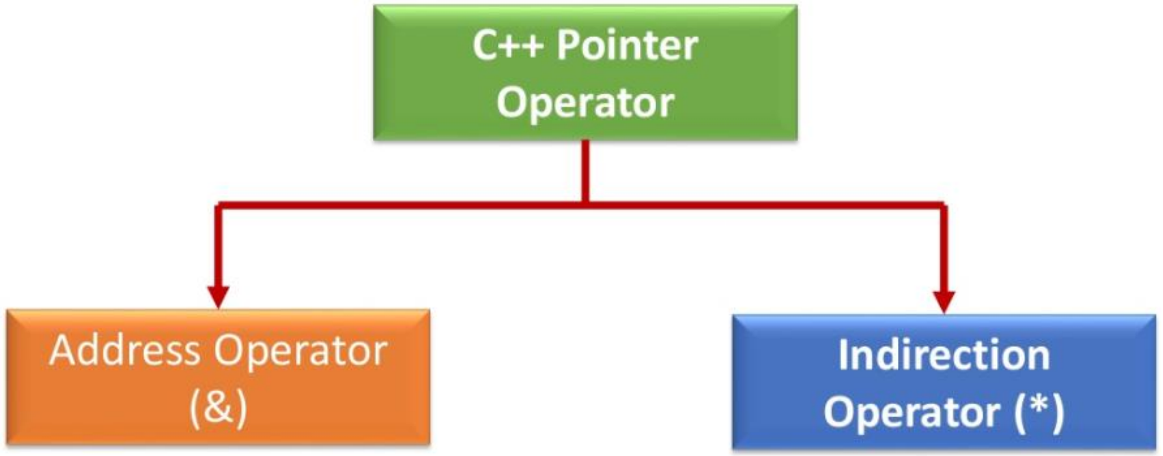
❑ Some main advantages

1. Use less memory
   - Dynamic memory allocation
2. Program runs faster
   - Increase execution speed and reduce execution time
3. Efficient when work with array, structure, list, stack, queue, …
4. Provide another way to access array element
5. Instead of copying data, pointer just point to an existing data
6. A function can return more than one value by passing via function argument

Pointer Operator

❑ What?

- Two operators when work with pointer
  - Address operator (**reference** operator)
    - It uses **&**
    - It returns memory address
  - Indirection operator (**deference** operator or value operator)
    - It uses *****
    - It returns value



Pointer Declaration

❑ Syntax

A pointer is a variable that must be defined by specifying the type of variable pointed, as follows

```
var *nameOfPointer : type
```

The type of variable pointed can be a primary type (such as integer, character ...) or a complex type (such as structured type ...)

```
structure students
          name: string
          age: integer
end structure
```

```
var *a: integer
    *c: character
    *s: string
    *stu: students
```

Pointer Initialization

❑ Syntax

```
var *a: integer
     a ← NULL
```

```
var *c, d: character
     c ← &d
```

Access to Pointer Variable

❑ Syntax

- After (and only after) having declared and initialized a pointer, it is possible to access the contents of the memory address pointed by the pointer by the operator '*'
- Syntax: *nameOfPointer

```
var *a, b: integer
a ← &b
b ← 10
*a ← *a + b
write(*a, b)
```

- a: pointer (stores an address)
- * a: pointer variable (as integer variable or in this case it is equivalent to variable **b**)

Example 1

❑ Not using pointer

- A function that exchanges the values of two variables (How does it work?)

```
function exchange(v1: integer, v2: integer)
begin
var tmp: integer
    tmp ← v1
    v1 ← v2
    v2 ← tmp
end
```

```
main program
begin
    var a,b: integer
        a ← 1
        b ← 2
        exchange(a,b)
        write(a,b)
end
```

What are the values of **a** and **b** here?

a is 1, b is 2

Example 2:

❑ Using pointer

- A function that exchanges the values of two variables (How does it work?)

```
function exchange(*v1: integer, *v2: integer)
begin
var tmp: integer
    tmp ← *v1
    *v1 ← *v2
    *v2 ← tmp
end
```

```
main program
begin
    var a,b: integer
        a ← 1
        b ← 2
        exchange(&a,&b)
        write(a,b)
end
```

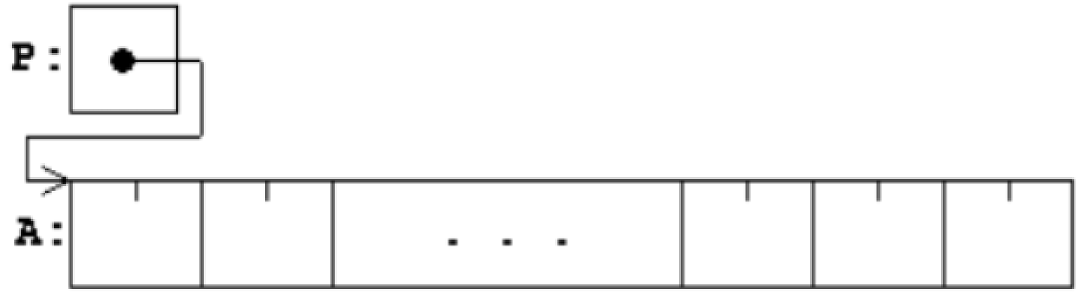
What are the values of **a** and **b** here?

a is 2, b is 1

Pointer and Array

- The name of an array represents the address of its first element **&array [0]**

```
var  A[10],  *P:  integer
          P ← A
```



- If P points to any element of an array, then P + 1 points to the next element
- More generally:

  (P+i) points to the i th element behind P and

  (P-i) point to the i th element before P

Pointer and Array

❑ Remark

- Suppose we have variables
  - `Var arr[10]: integer`
  - `Var *p:integer`

- Array name `arr` represents the address of the first elements of this array `(&arr[0])`
- We can say
  - `p = arr;` // `p` point to the first element `(arr[0])` in the array
- When a pointer points to an array, the value of the pointer is the first array element
  - `write(*p)`

NOTE

❑ Reference (&) Vs. Deference (*) operator

- &: to get address of any variable
- *: to get value at the address that the point stores

Example:

- If an integer variable, say n, is stored in memory address 0xf1bd23, and n contains a value of 5.

Then:

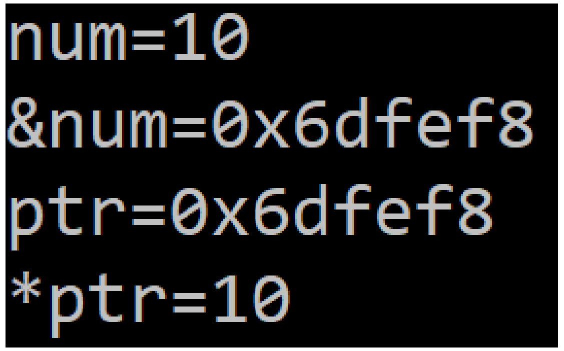
Reference operator **&n** gives the value of 0xf1bd23
Deference operator ***n** gives the value of 5

Q&A

Example 1: Using C++

- Suppose we have program as follows

```
#include<iostream>
using namespace std;
int main(){
        int num=10;
        int *ptr;
        ptr = &num;
        cout<<“num=”<<num<<endl;
        cout<<“&num=”<<&num<<endl;
        cout<<“ptr=”<<ptr<<endl;
        cout<<“*ptr=”<<*ptr<<endl;
}
```



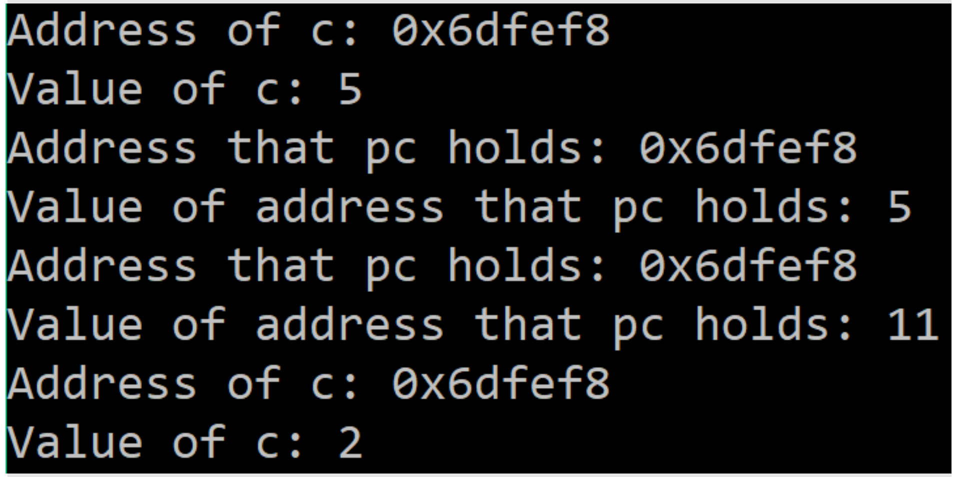
```
num=10
&num=0x6dfef8
ptr=0x6dfef8
*ptr=10
```

Example 2: Using C++

```
#include<iostream>
using namespace std;
int main(){
         int *pc, c;
         c=5;

         cout<<“Address of c: ”<<&c<<endl;
         cout<<“Value of c: ”<<c<<endl;
         pc = &c;
         cout<<“Address that pc holds: ”<<pc<<endl;
         cout<<“Value of address that pc holds: ”<<*pc<<endl;
         c = 11;
         cout<<“Address that pc holds: ”<<pc<<endl;
         cout<<“Value of address that pc holds: ”<<*pc<<endl;
         *pc = 2;
         cout<<“Address of c: ”<<&c<<endl;
         cout<<“Value of c: ”<<c<<endl;
}
```

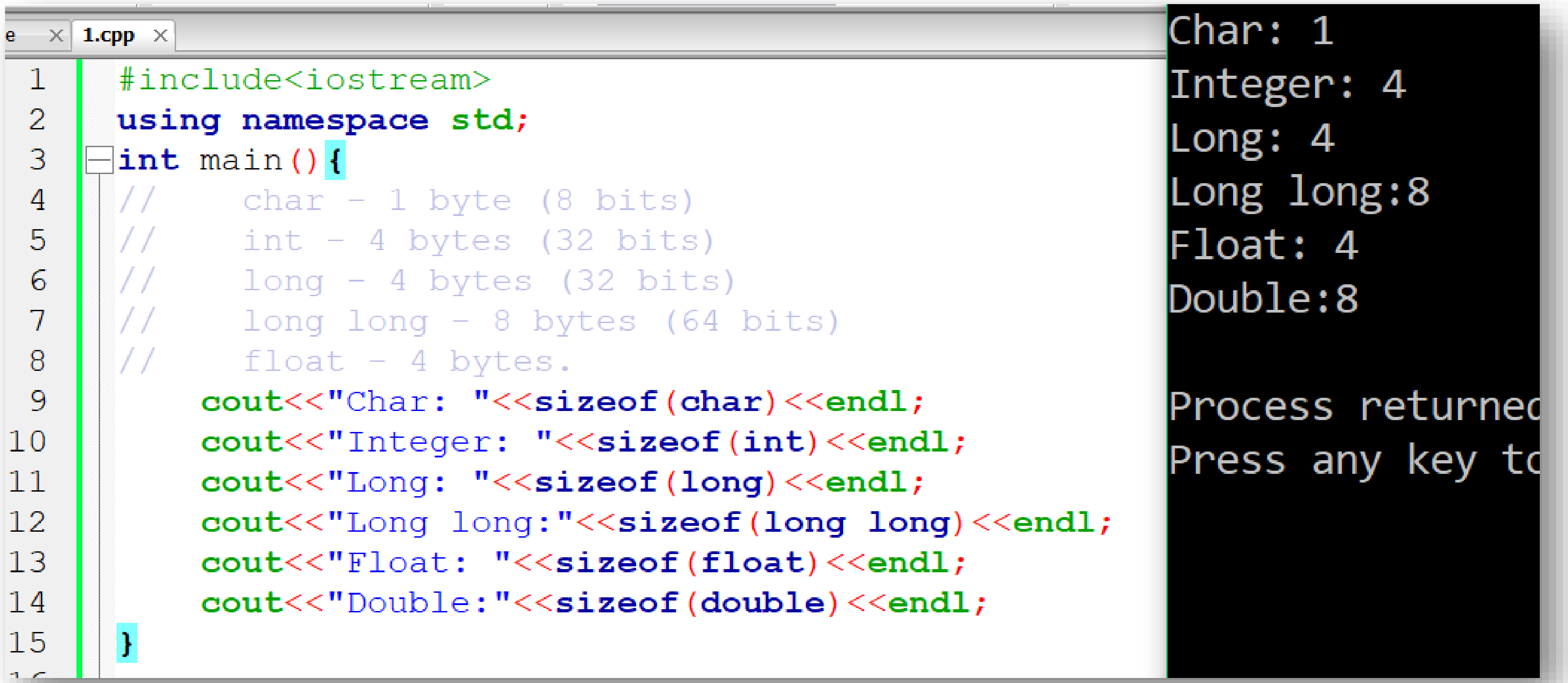
Output



```
Address of c: 0x6dfef8
Value of c: 5
Address that pc holds: 0x6dfef8
Value of address that pc holds: 5
Address that pc holds: 0x6dfef8
Value of address that pc holds: 11
Address of c: 0x6dfef8
Value of c: 2
```

Size of Data Type

- Display size of variable using **sizeof**



```cpp
#include<iostream>
using namespace std;
int main(){
//    char - 1 byte (8 bits)
//    int - 4 bytes (32 bits)
//    long - 4 bytes (32 bits)
//    long long - 8 bytes (64 bits)
//    float - 4 bytes.
    cout<<"Char: "<<sizeof(char)<<endl;
    cout<<"Integer: "<<sizeof(int)<<endl;
    cout<<"Long: "<<sizeof(long)<<endl;
    cout<<"Long long:"<<sizeof(long long)<<endl;
    cout<<"Float: "<<sizeof(float)<<endl;
    cout<<"Double:"<<sizeof(double)<<endl;
}
```

```
Char: 1
Integer: 4
Long: 4
Long long:8
Float: 4
Double:8

Process returned
Press any key to
```

C++ program

Q&A

Practice

❑ Exercises

1. Write a C++ program that declares and initializes any values to a variable of type float, integer and string. The program then display the value and address (in hexadecimal form) for each variable.

2. Write a C++ program to get two integer numbers from a user then swap the values of those two variables and display them on screen.

3. Create a subprogram to swap the values of the four parameters. The first two parameters exchange each other. The last two parameters exchange each other.

4. Create a function to solve quadratic equation. The function takes 6 parameters. The functions solve roots then store in parameters. Prototype of this function is defined as below:

   ```
   void solveEquation(float a, float b, float c, float *x1, float *x2, float *delta)
   ```