网站：http://www.cplusplus.com/doc/

**一、变量和类型**

**1.1 变量-初始化变量**

|  |  |
| --- | --- |
| // initialization of variables  #include  using namespace std;  int main ()  { int a=5; // initial value: 5  int b(3); // initial value: 3  int c{2}; // initial value: 2  int result; // initial value undetermined   a = a + b;   result = a - c;   cout << result;  return 0; } | 6 |

**1.2 类型推倒（Type deduction）: auto and decltype**

When a new variable is initialized, the compiler can figure out what the type of the variable is automatically by the initializer. For this, it suffices to use auto as the type specifier for the variable:

|  |  |  |
| --- | --- | --- |
| 1 2 | int foo = 0; auto bar = foo; // the same as: int bar = foo; |  |

Here, bar is declared as having an auto type; therefore, the type of bar is the type of the value used to initialize it: in this case it uses the type of foo, which is int.  
  
Variables that are not initialized can also make use of type deduction with the decltype specifier:

|  |  |
| --- | --- |
| 1 2 | int foo = 0; decltype(foo) bar; // the same as: int bar; |

**1.3 初始化字符串**

string mystring = "This is a string";

string mystring ("This is a string");

string mystring {"This is a string"};

**二 、常量**

**2.1 整数**

|  |  |
| --- | --- |
| **Suffix** | **Type modifier** |
| u *or* U | unsigned |
| l *or* L | long |
| ll *or* LL | long long |

75 // int

75u // unsigned int

75l // long

75ul // unsigned long

75lu // unsigned long

**2.2 浮点数**

3.14159 // 3.14159

6.02e23 // 6.02 x 10^23

1.6e-19 // 1.6 x 10^-19

3.0 // 3.0

**三 运算符**

**3.1 递增和递减**

|  |  |
| --- | --- |
| **Example 1** | **Example 2** |
| x = 3; y = ++x; // x contains 4, y contains 4 | x = 3; y = x++; // x contains 4, y contains 3 |

Here there are some examples:

|  |  |  |
| --- | --- | --- |
| 1 2 3 4 5 | (7 == 5) // evaluates to false (5 > 4) // evaluates to true (3 != 2) // evaluates to true (6 >= 6) // evaluates to true (5 < 5) // evaluates to false |  |

Of course, it's not just numeric constants that can be compared, but just any value, including, of course, variables. Suppose that a=2, b=3 and c=6, then:

|  |  |
| --- | --- |
| 1 2 3 4 | (a == 5) // evaluates to false, since a is not equal to 5 (a\*b >= c) // evaluates to true, since (2\*3 >= 6) is true (b+4 > a\*c) // evaluates to false, since (3+4 > 2\*6) is false ((b=2) == a) // evaluates to true |

**3.2逗点运算符（，）**

The comma operator (,) is used to separate two or more expressions that are included where only one expression is expected. When the set of expressions has to be evaluated for a value, only the right-most expression is considered.  
  
For example, the following code:

|  |  |
| --- | --- |
|  | a = (b=3, b+2); |

**结果：**a=5

**3.3 sizeof**

This operator accepts one parameter, which can be either a type or a variable, and returns the size in bytes of that type or object:

|  |  |  |
| --- | --- | --- |
|  | x = sizeof (char); |  |

Here, x is assigned the value 1, because char is a type with a size of one byte.

**四、标准输入\输出**

**4.1输入Standard input (cin)**

The extraction operator can be used on cin to get strings of characters in the same way as with fundamental data types:  
**输入单词，**

|  |  |  |
| --- | --- | --- |
| 1 2 | string mystring;  cin >> mystring; |  |

However, **cin extraction** always considers **spaces (whitespaces, tabs, new-line...) as terminating the value being extracted, and thus extracting a string means to always extract a single word, not a phrase or an** entire sentence.  
  
To get an entire line from cin, there exists a function, called **getline（输入句子）**, that takes the stream (cin) as first argument, and the string variable as second. For example:

|  |  |
| --- | --- |
| // cin with strings  #include <iostream>  #include <string>  using namespace std;  int main ()  { string mystr;   cout << "What's your name? ";   getline (cin, mystr);   cout << "Hello " << mystr << ".\n";   cout << "What is your favorite team? ";   getline (cin, mystr);   cout << "I like " << mystr << " too!\n";  return 0; } | What's your name? Homer Simpson Hello Homer Simpson. What is your favorite team? The Isotopes I like The Isotopes too! |

**五、控制流（while for switch等）**

**http://www.cplusplus.com/doc/tutorial/control/**

**六 函数和返回值**

**6.1 main函数的返回值**

ou may have noticed that the return type of main is int, but most examples in this and earlier chapters did not actually return any value from main.  
  
Well, there is a catch: If the execution of main ends normally without encountering a return statement the compiler assumes the function ends with an implicit return statement:

|  |  |  |
| --- | --- | --- |
|  | return 0; |  |

Note that this only applies to function main for historical reasons. All other functions with a return type shall end with a proper return statement that includes a return value, even if this is never used.  
  
When main returns zero (either implicitly or explicitly), it is interpreted by the environment as that the program ended successfully. Other values may be returned by main, and some environments give access to that value to the caller in some way, although this behavior is not required nor necessarily portable between platforms. The values for main that are guaranteed to be interpreted in the same way on all platforms are:

|  |  |
| --- | --- |
| **value** | **description** |
| 0 | The program was successful |
| [EXIT\_SUCCESS](http://www.cplusplus.com/EXIT_SUCCESS) | The program was successful (same as above). This value is defined in header [<cstdlib>](http://www.cplusplus.com/%3Ccstdlib%3E). |
| [EXIT\_FAILURE](http://www.cplusplus.com/EXIT_FAILURE) | The program failed. This value is defined in header [<cstdlib>](http://www.cplusplus.com/%3Ccstdlib%3E). |

Because the implicit return 0; statement for main is a tricky exception, some authors consider it good practice to explicitly write the statement.

**6.2传引用和传值**

|  |  |
| --- | --- |
| // passing parameters by reference  #include <iostream>  using namespace std;  void duplicate (int& a, int& b, int& c)  { a\*=2; b\*=2; c\*=2; }  int main ()  { int x=1, y=3, z=7;   duplicate (x, y, z);   cout << "x=" << x << ", y=" << y << ", z=" << z;   return 0; } | x=2, y=6, z=14 |

**6.3 默认值**

|  |  |
| --- | --- |
| // default values in functions  #include <iostream>  using namespace std;  int divide (int a, int b=2)   { int r; r=a/b; return (r); }  int main ()  { cout << divide (12) << '\n';   cout << divide (20,4) << '\n';   return 0;   } | 6 5 |

**七 重载和模板**

**7.1 重载（overloads）**

In C++, two different functions can have the same name if their parameters are different; either because they have a different number of parameters, or because any of their parameters are of a different type. For example:

|  |  |  |
| --- | --- | --- |
| 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 | // overloading functions  #include <iostream>  using namespace std;  int operate (int a, int b)  { return (a\*b); }  double operate (double a, double b)  { return (a/b); }  int main ()  { int x=5,y=2;   double n=5.0,m=2.0;   cout << operate (x,y) << '\n';   cout << operate (n,m) << '\n';  return 0; } | 10 2.5 |

**7.2 模板**

|  |  |  |  |
| --- | --- | --- | --- |
| 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 | // overloaded functions  #include <iostream>  using namespace std;  int sum (int a, int b)  {  return a+b;  }  double sum (double a, double b)  {  return a+b;  }  int main ()  {  cout << sum (10,20) << '\n';  cout << sum (1.0,1.5) << '\n';  return 0;  } | 30  2.5 | [Edit & Run](http://www.cplusplus.com/doc/tutorial/functions2/) |

Here, sum is overloaded with different parameter types, but with the exact same body.  
  
The function sum could be overloaded for a lot of types, and it could make sense for all of them to have the same body. For cases such as this, C++ has the ability to define functions with generic types, known as *function templates*. Defining a function template follows the same syntax than a regular function, except that it is preceded by the template keyword and a series of template parameters enclosed in angle-brackets <>:  
  
template <template-parameters> function-declaration   
The template parameters are a series of parameters separated by commas. These parameters can be generic template types by specifying either the class or typename keyword followed by an identifier. This identifier can then be used in the function declaration as if it was a regular type. For example, a generic sum function could be defined as:

|  |  |
| --- | --- |
| 1 2 3 4 5 | template <class SomeType>  SomeType sum (SomeType a, SomeType b)  {  return a+b;  } |

**实际例子1：**

|  |  |
| --- | --- |
| // function template  #include <iostream>  using namespace std;  template <class T>  T sum (T a, T b)  {  T result;  result = a + b;  return result;  }  int main () {  int i=5, j=6, k;  double f=2.0, g=0.5, h;  k=sum<int>(i,j);  h=sum<double>(f,g);  cout << k << '\n';  cout << h << '\n';  return 0;  } | 11  2.5 |

**实际例子2：**

|  |  |  |
| --- | --- | --- |
| // function templates  #include <iostream>  using namespace std;  template <class T, class U>  bool are\_equal (T a, U b)  {  return (a==b);  }  int main ()  {  if (are\_equal(10,10.0))  cout << "x and y are equal\n";  else  cout << "x and y are not equal\n";  return 0;  } | x and y are equal | [Edit & Run](http://www.cplusplus.com/doc/tutorial/functions2/) |

**7.3 Non-type template arguments**

|  |  |  |  |
| --- | --- | --- | --- |
| 2 3 4 5 6 7 8 9 10 11 12 13 14 | // template arguments  #include <iostream>  using namespace std;  template <class T, int N>  T fixed\_multiply (T val)  {  return val \* N;  }  int main() {  std::cout << fixed\_multiply<int,2>(10) << '\n';  std::cout << fixed\_multiply<int,3>(10) << '\n';  } | 20  30 | [Edit & Run](http://www.cplusplus.com/doc/tutorial/functions2/) |

**8 Name Visible**

[**http://www.cplusplus.com/doc/tutorial/namespaces/**](http://www.cplusplus.com/doc/tutorial/namespaces/)

// using

#include <iostream>

using namespace std;

namespace first

{

int x = 5;

int y = 10;

}

namespace second

{

double x = 3.1416;

double y = 2.7183;

}

int main () {

using namespace first;

cout << x << '\n';

cout << y << '\n';

cout << second::x << '\n';

cout << second::y << '\n';

return 0;

}

**9数组**

**9.1 数组作为参数**

**/**/ arrays as parameters

#include <iostream>

using namespace std;

void printarray (int arg[], int length) {

for (int n=0; n<length; ++n)

cout << arg[n] << ' ';

cout << '\n';

}

int main ()

{

int firstarray[] = {5, 10, 15};

int secondarray[] = {2, 4, 6, 8, 10};

printarray (firstarray,3);

printarray (secondarray,5);

**9.2 Library Arrays**

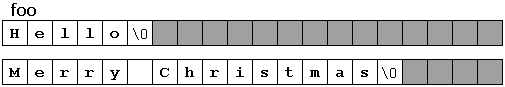
|  |  |
| --- | --- |
| **language built-in array** | **container library array** |
| #include <iostream>  using namespace std;  int main()  {  int myarray[3] = {10,20,30};  for (int i=0; i<3; ++i)  ++myarray[i];  for (int elem : myarray)  cout << elem << '\n';  } | #include <iostream>  #include <array>  using namespace std;  int main()  {  array<int,3> myarray {10,20,30};  for (int i=0; i<myarray.size(); ++i)  ++myarray[i];  for (int elem : myarray)  cout << elem << '\n';  } |

**10 字符序列（Character sequences）**

For example, the following array:

|  |  |  |
| --- | --- | --- |
|  | char foo [20]; |  |

is an array that can store up to 20 elements of type char. It can be represented as:  
  
http://www.cplusplus.com/doc/tutorial/ntcs/c_strings1.png

In this case, the array of 20 elements of type char called foo can be represented storing the character sequences"Hello" and "Merry Christmas" as:  
  


**10.1 空中止符字符串的初始化（Initialization of null-terminated character sequences）**

**效果相同**

|  |  |  |
| --- | --- | --- |
| 2 | char myword[] = { 'H', 'e', 'l', 'l', 'o', '\0' };  char myword[] = "Hello"; |  |

In both cases, the array of characters myword is declared with a size of 6 elements of type char: the 5 characters that compose the word "Hello", plus a final null character ('\0')

Expressions (once *myword* has already been declared as above), such as:  
一旦被初始化，下面的声明就无效

|  |  |
| --- | --- |
| 1 2 | myword = "Bye";  myword[] = "Bye"; |

would **not** be valid, like neither would be:

|  |  |  |
| --- | --- | --- |
|  | myword = { 'B', 'y', 'e', '\0' }; |  |

This is because arrays cannot be assigned values. Note, though, that each of its elements can be assigned a value individually. For example, this would be correct:

|  |  |  |
| --- | --- | --- |
| 1 2 3 4 | myword[0] = 'B';  myword[1] = 'y';  myword[2] = 'e';  myword[3] = '\0'; |  |

**10.2Strings and null-terminated character sequences**

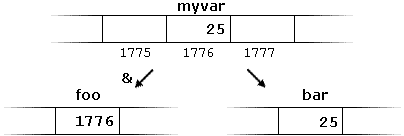
|  |  |  |
| --- | --- | --- |
| strings and NTCS:  #include <iostream>  #include <string>  using namespace std;  int main ()  {  char question1[] = "What is your name? ";  string question2 = "Where do you live? ";  char answer1 [80];  string answer2;  cout << question1;  cin >> answer1;  cout << question2;  cin >> answer2;  cout << "Hello, " << answer1;  cout << " from " << answer2 << "!\n";  return 0;  } | What is your name? Homer  Where do you live? Greece  Hello, Homer from Greece! | [Edit & Run](http://www.cplusplus.com/doc/tutorial/ntcs/) |

**11 指针（Pointer）**

**11.1 操作符地址（&）**

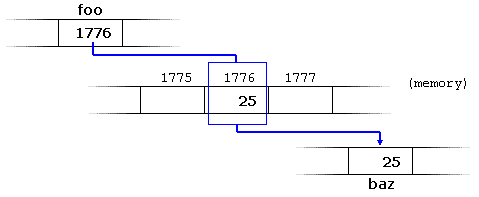
In this case, consider the following code fragment:

|  |  |  |
| --- | --- | --- |
| 1 2 3 | myvar = 25;  foo = &myvar;  bar = myvar; |  |

The values contained in each variable after the execution of this are shown in the following diagram:   
  


11.2 间接引用操作符（\*）Dereference operator (\*)

baz = \*foo;

his could be read as: "baz equal to value pointed to by foo", and the statement would actually assign the value 25to baz, since foo is 1776, and the value pointed to by 1776 (following the example above) would be 25.  
  


baz = foo; // baz equal to foo (1776)

baz = \*foo; // baz equal to value pointed to by foo (25)

The reference and dereference operators are thus complementary:

& is the *address-of operator*, and can be read simply as "address of"

\* is the *dereference operator*, and can be read as "value pointed to by"

**11.3 指针声明**

**例子1**

|  |  |
| --- | --- |
| // my first pointer  #include <iostream>  using namespace std;  int main ()  {  int firstvalue, secondvalue;  int \* mypointer;  mypointer = &firstvalue;  \*mypointer = 10;  mypointer = &secondvalue;  \*mypointer = 20;  cout << "firstvalue is " << firstvalue << '\n';  cout << "secondvalue is " << secondvalue << '\n';  return 0;  } | firstvalue is 10  secondvalue is 20 |

**例子2**

|  |  |
| --- | --- |
| // more pointers  #include <iostream>  using namespace std;  int main ()  {  int firstvalue = 5, secondvalue = 15;  int \* p1, \* p2;  p1 = &firstvalue; // p1 = address of firstvalue  p2 = &secondvalue; // p2 = address of secondvalue  \*p1 = 10; // value pointed to by p1 = 10  \*p2 = \*p1; // value pointed to by p2 = value pointed by p1  p1 = p2; // p1 = p2 (value of pointer is copied)  \*p1 = 20; // value pointed by p1 = 20    cout << "firstvalue is " << firstvalue << '\n';  cout << "secondvalue is " << secondvalue << '\n';  return 0;  } | firstvalue is 10  secondvalue is 20 |

**11.4 指针和数组（Pointer and Arrays）**

|  |  |
| --- | --- |
| // more pointers  #include <iostream>  using namespace std;  int main ()  {  int numbers[5];  int \* p;  p = numbers; \*p = 10;  p++; \*p = 20;  p = &numbers[2]; \*p = 30;  p = numbers + 3; \*p = 40;  p = numbers; \*(p+4) = 50;  for (int n=0; n<5; n++)  cout << numbers[n] << ", ";  return 0;  } | 10, 20, 30, 40, 50, |

**11.4 指针初始化**

Pointers can be initialized to point to specific locations at the very moment they are defined:

|  |  |  |
| --- | --- | --- |
| 1 2 | int myvar;  int \* myptr = &myvar; |  |

The resulting state of variables after this code is the same as after:

|  |  |
| --- | --- |
| 1 2 3 | int myvar;  int \* myptr;  myptr = &myvar |

When pointers are initialized, what is initialized is the address they point to (i.e., myptr), never the value being pointed (i.e., \*myptr). Therefore, the code above shall not be confused with:

**下面是不对的：**

|  |  |
| --- | --- |
| 1 2 3 | int myvar;  int \* myptr;  \*myptr = &myvar; |

11.5 指针运算Pointer arithmetics

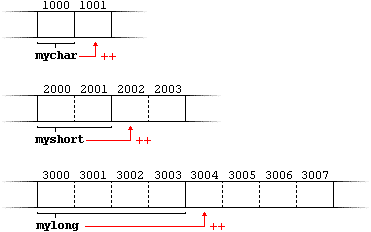
. For example, let's **imagine** that in a given system, **char takes 1 byte, short takes 2 bytes, and long takes 4**.Suppose now that we define three pointers in this compiler: 

|  |  |  |
| --- | --- | --- |
| 1 2 3 | char \*mychar;  short \*myshort;  long \*mylong; |  |

and that we know that they point to the memory locations 1000, 2000, and 3000, respectively.   
  
Therefore, if we write:

|  |  |  |
| --- | --- | --- |
| 1 2 3 | ++mychar; 地址加1  ++myshort; 地址加2  ++mylong; 地址加4 |  |

mychar, as one would expect, would contain the value 1001. But not so obviously, myshort would contain the value 2002, and mylong would contain 3004, even though they have each been incremented only once



**++操作符的优先级高于\*，所以\*p++相当于（\*（p++））。实际结果先取p指向的内容，指针p再+1（指向下一个位置）.**

**例子1**

|  |  |
| --- | --- |
| 1 2 3 4 | \*p++ // same as \*(p++): increment pointer, and dereference unincremented address  \*++p // same as \*(++p): increment pointer, and dereference incremented address  ++\*p // same as ++(\*p): dereference pointer, and increment the value it points to  (\*p)++ // dereference pointer, and post-increment the value it points to |

**例子2 ：**

\*p++ = \*q++ 相当于

\*p = \*q;

++p;

++q;

11.6 指针和const（Pointers and const）

**11.6.1**

int x;

int y = 10;

const int \* p = &y;

x = \*p; // ok: reading p

\*p = x; // error: modifying p, which is const-qualified

**11.6.2**

|  |  |
| --- | --- |
| // pointers as arguments:  #include <iostream>  using namespace std;  void increment\_all (int\* start, int\* stop)  {  int \* current = start;  while (current != stop) {  ++(\*current); // increment value pointed  ++current; // increment pointer  }  }  void print\_all (const int\* start, const int\* stop)  {  const int \* current = start;  while (current != stop) {  cout << \*current << '\n';  ++current; // increment pointer  }  }  int main ()  {  int numbers[] = {10,20,30};  increment\_all (numbers,numbers+3);  print\_all (numbers,numbers+3);  return 0;  } | 11  21  31 |

**11.6.3**

int x;

int \* p1 = &x; // non-const pointer to non-const int

const int \* p2 = &x; // non-const pointer to const int

int \* const p3 = &x; // const pointer to non-const int

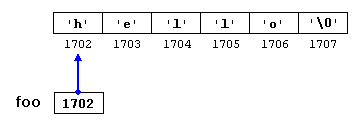
const int \* const p4 = &x; // const pointer to const int

const int \* p2a = &x; // non-const pointer to const int

int const \* p2b = &x; // also non-const pointer to const int

11.7 Pointers and string literals

|  |  |
| --- | --- |
| const char \* foo = "hello"; |  |

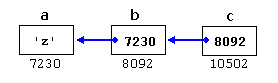
This declares an array with the literal representation for "hello", and then a pointer to its first element is assigned to foo. If we imagine that "hello" is stored at the memory locations that start at address 1702, we can represent the previous declaration as:  
   
Note that here foo is a pointer and contains the value 1702, and not 'h', nor "hello", although 1702 indeed is the address of both of these.  
  
The pointer foo points to a sequence of characters. And because pointers and arrays behave essentially in the same way in expressions, foo can be used to access the characters in the same way arrays of null-terminated character sequences are. For example:

|  |  |  |
| --- | --- | --- |
| 1 2 | \*(foo+4)  foo[4] |  |

Both expressions have a value of 'o' (the fifth element of the array).

11.8 指向指针的指针（Pointers to pointers）

|  |  |
| --- | --- |
| char a;  char \* b;  char \*\* c;  a = 'z';  b = &a;  c = &b; |  |

This, assuming the randomly chosen memory locations for each variable of 7230, 8092, and 10502, could be represented as:  
  


11.9 无类型指针（void pointer）

The void type of pointer is a special type of pointer. In C++, void represents the absence of type. Therefore, voidpointers are pointers that point to a value that has no type (and thus also an undetermined length and undetermined dereferencing properties).

|  |  |
| --- | --- |
| // increaser  #include <iostream>  using namespace std;  void increase (void\* data, int psize)  {  if ( psize == sizeof(char) )  { char\* pchar; pchar=(char\*)data; ++(\*pchar); }  else if (psize == sizeof(int) )  { int\* pint; pint=(int\*)data; ++(\*pint); }  }  int main ()  {  char a = 'x';  int b = 1602;  increase (&a,sizeof(a));  increase (&b,sizeof(b));  cout << a << ", " << b << '\n';  return 0;  } | y, 1603 |

11.10 无效指针和空指针（Invalid pointers and null pointers）

无效指针

int \* p; // uninitialized pointer (local variable)

int myarray[10];

int \* q = myarray+20; // element out of bounds

空指针

|  |  |  |
| --- | --- | --- |
| 1 2 | int \* p = 0;  int \* q = nullptr; |  |

Here, both p and q are *null pointers*, meaning that they explicitly point to nowhere, and

[**http://www.cplusplus.com/doc/tutorial/pointers/**](http://www.cplusplus.com/doc/tutorial/pointers/)

**11.11 函数指针（pointers to function）**

|  |  |  |
| --- | --- | --- |
| 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 | // pointer to functions  #include <iostream>  using namespace std;  int addition (int a, int b)  { return (a+b); }  int subtraction (int a, int b)  { return (a-b); }  int operation (int x, int y, int (\*functocall)(int,int))  {  int g;  g = (\*functocall)(x,y);  return (g);  }  int main ()  {  int m,n;  int (\*minus)(int,int) = subtraction;  m = operation (7, 5, addition);  n = operation (20, m, minus);  cout <<n;  return 0;  } | 8 |

**12 数据结构（Structure）**

**例子1**

|  |  |
| --- | --- |
| // example about structures  #include <iostream>  #include <string>  #include <sstream>  using namespace std;  struct movies\_t {  string title;  int year;  } mine, yours;  void printmovie (movies\_t movie);  int main ()  {  string mystr;  mine.title = "2001 A Space Odyssey";  mine.year = 1968;  cout << "Enter title: ";  getline (cin,yours.title);  cout << "Enter year: ";  getline (cin,mystr);  stringstream(mystr) >> yours.year;  cout << "My favorite movie is:\n ";  printmovie (mine);  cout << "And yours is:\n ";  printmovie (yours);  return 0;  }  void printmovie (movies\_t movie)  {  cout << movie.title;  cout << " (" << movie.year << ")\n";  } | Enter title: Alien  Enter year: 1979  My favorite movie is:  2001 A Space Odyssey (1968)  And yours is:  Alien (1979) |

12.1 数据结构指针Pointers to structures

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| / pointers to structures  #include <iostream>  #include <string>  #include <sstream>  using namespace std;  struct movies\_t {  string title;  int year;  };  int main ()  {  string mystr;  movies\_t amovie;  movies\_t \* pmovie;  pmovie = &amovie;  cout << "Enter title: ";  getline (cin, pmovie->title);  cout << "Enter year: ";  getline (cin, mystr);  (stringstream) mystr >> pmovie->year;  cout << "\nYou have entered:\n";  cout << pmovie->title;  cout << " (" << pmovie->year << ")\n";  return 0;  } | | | | Enter title: Invasion of the body snatchers  Enter year: 1978    You have entered:  Invasion of the body snatchers (1978) | |
| **Expression** | **What is evaluated** | **Equivalent** | |
| a.b | Member b of object a |  | |
| a->b | Member b of object pointed to by a | (\*a).b | |
| \*a.b | Value pointed to by member b of object a | \*(a.b) | |

12.2 嵌套结构（Nesting structures）

|  |  |
| --- | --- |
| 2 3 4 5 6 7 8 9 10 11 12 | struct movies\_t {  string title;  int year;  };  struct friends\_t {  string name;  string email;  movies\_t favorite\_movie;  } charlie, maria;  friends\_t \* pfriends = &charlie; |

**13 其他数据类型**

13. 1 Type aliases (typedef / using)

For example:

|  |  |  |
| --- | --- | --- |
| 1 2 3 4 | typedef char C;  typedef unsigned int WORD;  typedef char \* pChar;  typedef char field [50]; |  |

This defines four type aliases: C, WORD, pChar, and field as char, unsigned int, char\* and char[50], respectively. Once these aliases are defined, they can be used in any declaration just like any other valid type:

|  |  |
| --- | --- |
| 1 2 3 4 | C mychar, anotherchar, \*ptc1;  WORD myword;  pChar ptc2;  field name; |

**13.2 unions**

Unions allow one portion of memory to be accessed as different data types. Its declaration and use is similar to the one of structures, but its functionality is totally different:

|  |
| --- |
| union type\_name {  member\_type1 member\_name1;  member\_type2 member\_name2;  member\_type3 member\_name3;  .  .  } object\_names; |

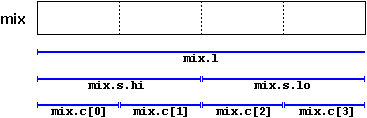
declares an object (mytypes) with three members:

|  |  |  |
| --- | --- | --- |
| 1 2 3 | mytypes.c  mytypes.i  mytypes.f |  |

Each of these members is of a different data type. **But since all of them are referring to the same location in memory, the modification of one of the members will affect the value of all of them**. It is not possible to store different values in them in a way that each is independent of the others.

One of the uses of a union is to be able to access a value either in its entirety or as an array or structure of smaller elements. For example: 

|  |  |  |
| --- | --- | --- |
| 1 2 3 4 5 6 7 8 | union mix\_t {  int l;  struct {  short hi;  short lo;  } s;  char c[4];  } mix; |  |

If we assume that the system where this program runs has an int type with a size of 4 bytes, and a short type of 2 bytes, the union defined above allows the access to the same group of 4 bytes: mix.l, mix.s and mix.c, and which we can use according to how we want to access these bytes: as if they were a single value of type int, or as if they were two values of type short, or as an array of char elements, respectively. The example mixes types, arrays, and structures in the union to demonstrate different ways to access the data. For a little-endian system, this union could be represented as:  
  


13.2 匿名（Anonymous unions**）**

When unions are members of a class (or structure), they can be declared with no name. In this case, they become*anonymous unions*, and its members are directly accessible from objects by their member names. For example, see the differences between these two structure declarations:

|  |  |
| --- | --- |
| **structure with regular union** | **structure with anonymous union** |
| struct book1\_t {  char title[50];  char author[50];  union {  float dollars;  int yen;  } price;  } book1; | struct book2\_t {  char title[50];  char author[50];  union {  float dollars;  int yen;  };  } book2; |

The only difference between the two types is that in the first one, the member union has a name (price), while in the second it has not. This affects the way to access members dollars and yen of an object of this type. For an object of the first type (with a regular union), it would be:

|  |  |  |
| --- | --- | --- |
| 1 2 | book1.price.dollars  book1.price.yen |  |

whereas for an object of the second type (which has an anonymous union), it would be:

|  |  |  |
| --- | --- | --- |
| 1 2 | book2.dollars  book2.yen |  |

Again, remember that because it is a member union (not a member structure), the members dollars and yen actually share the same memory location, so they cannot be used to store two different values simultaneously. The pricecan be set in dollars or in yen, but not in both simultaneously.  
  
**13.3 Enumerated types (enum)**

*Enumerated types* are types that are defined with a set of custom identifiers, known as *enumerators*, as possible values. Objects of these *enumerated types* can take any of these enumerators as value.  
  
Their syntax is:

|  |
| --- |
| enum type\_name {  value1,  value2,  value3,  .  .  } object\_names; |

This creates the type type\_name, which can take any of value1, value2, value3, ... as value. Objects (variables) of this type can directly be instantiated as object\_names.  
  
For example, a new type of variable called colors\_t could be defined to store colors with the following declaration:

|  |  |  |
| --- | --- | --- |
|  | enum colors\_t {black, blue, green, cyan, red, purple, yellow, white}; |  |

Notice that this declaration includes no other type, neither fundamental nor compound, in its definition. To say it another way, somehow, this creates a whole new data type from scratch without basing it on any other existing type. The possible values that variables of this new type color\_t may take are the enumerators listed within braces. For example, once the colors\_t enumerated type is declared, the following expressions will be valid:

|  |  |  |
| --- | --- | --- |
| 1 2 3 4 | colors\_t mycolor;    mycolor = blue;  if (mycolor == green) mycolor = red; |  |

Values of *enumerated types* declared with enum are implicitly convertible to the integer type int, and vice versa. In fact, the elements of such an enum are always assigned an integer numerical equivalent internally, of which they become an alias. If it is not specified otherwise, the integer value equivalent to the first possible value is 0, the equivalent to the second is 1, to the third is 2, and so on... Therefore, in the data type colors\_t defined above, blackwould be equivalent to 0, blue would be equivalent to 1, green to 2, and so on...  
  
A specific integer value can be specified for any of the possible values in the enumerated type. And if the constant value that follows it is itself not given its own value, it is automatically assumed to be the same value plus one. For example:

|  |  |  |
| --- | --- | --- |
| 1 2 3 | enum months\_t { january=1, february, march, april,  may, june, july, august,  september, october, november, december} y2k; |  |

In this case, the variable y2k of the enumerated type months\_t can contain any of the 12 possible values that go from january to december and that are equivalent to the values between 1 and 12 (not between 0 and 11, since januaryhas been made equal to 1).  
  
Because enumerated types declared with enum are implicitly convertible to int, and each of the enumerator values is actually of type int, there is no way to distinguish 1 from january - they are the exact same value of the same type. The reasons for this are historical and are inheritance of the C language.

**13.4 Enumerated types with enum class**

But, in C++, it is possible to create real enum types that are neither implicitly convertible to int and that neither have enumerator values of type int, but of the enum type itself, thus preserving type safety. They are declared with enum class (or enum struct) instead of just enum:

|  |  |  |
| --- | --- | --- |
|  | enum class Colors {black, blue, green, cyan, red, purple, yellow, white}; |  |

Each of the enumerator values of an enum class type needs to be scoped into its type (this is actually also possible with enum types, but it is only optional). For example:

|  |  |  |
| --- | --- | --- |
| 1 2 3 4 | Colors mycolor;    mycolor = Colors::blue;  if (mycolor == Colors::green) mycolor = Colors::red; |  |

Enumerated types declared with enum class also have more control over their underlying type; it may be any integral data type, such as char, short or unsigned int, which essentially serves to determine the size of the type. This is specified by a colon and the underlying type following the enumerated type. For example:

|  |  |  |
| --- | --- | --- |
|  | enum class EyeColor : char {blue, green, brown}; |  |

Here, Eyecolor is a distinct type with the same size of a char (1 byte).

**14 类（class）**

**14.1 访问控制符**

* private members of a class are accessible only from within other members of the same class (or from their*"friends"*).
* protected members are accessible from other members of the same class (or from their *"friends"*), but also from members of their derived classes.
* Finally, public members are accessible from anywhere where the object is visible.

|  |  |
| --- | --- |
| 1 2 3 4 5 6 | class Rectangle {  int width, height;  public:  void set\_values (int,int);  int area (void);  } rect; |

|  |  |
| --- | --- |
| // classes example  #include <iostream>  using namespace std;  class Rectangle {  int width, height;  public:  void set\_values (int,int);  int area() {return width\*height;}  };  void Rectangle::set\_values (int x, int y) {  width = x;  height = y;  }  int main () {  Rectangle rect;  rect.set\_values (3,4);  cout << "area: " << rect.area();  return 0;  } | area: 12 |

在类中定义方法和在类外面定义方法的区别：

The only difference between defining a member function completely within the class definition or to just include its declaration in the function and define it later outside the class, is that in the first case the function is automatically considered an *inline* member function by the compiler, while in the second it is a normal (not-inline) class member function. This causes no differences in behavior, b**ut only on possible compiler optimization**

**C++类中默认访问修饰符是**private    结构体默认是pulic

### 14.2 Uniform initialization

|  |  |
| --- | --- |
| // classes and uniform initialization  #include <iostream>  using namespace std;  class Circle {  double radius;  public:  Circle(double r) { radius = r; }  double circum() {return 2\*radius\*3.14159265;}  };  int main () {  Circle foo (10.0); // functional form  Circle bar = 20.0; // assignment init.  Circle baz {30.0}; // uniform init.  Circle qux = {40.0}; // POD-like  cout << "foo's circumference: " << foo.circum() << '\n';  return 0;  } | foo's circumference: 62.8319 |

### 15 Class（2）

**15.1 重载操作符。**

|  |  |
| --- | --- |
| // overloading operators example  #include <iostream>  using namespace std;  class CVector {  public:  int x,y;  CVector () {};  CVector (int a,int b) : x(a), y(b) {}  CVector operator + (const CVector&);  };  CVector CVector::operator+ (const CVector& param) {  CVector temp;  temp.x = x + param.x;  temp.y = y + param.y;  return temp;  }  int main () {  CVector foo (3,1);  CVector bar (1,2);  CVector result;  result = foo + bar;  cout << result.x << ',' << result.y << '\n';  return 0;  } | 4,3 |

**15.2 关键字this**

|  |  |
| --- | --- |
| // example on this  #include <iostream>  using namespace std;  class Dummy {  public:  bool isitme (Dummy& param);  };  bool Dummy::isitme (Dummy& param)  {  if (&param == this) return true;  else return false;  }  int main () {  Dummy a;  Dummy\* b = &a;  if ( b->isitme(a) )  cout << "yes, &a is b\n";  return 0;  } | yes, &a is b |

**15.3 常量成员函数**

|  |  |
| --- | --- |
| // constructor on const object  #include <iostream>  using namespace std;  class MyClass {  public:  int x;  MyClass(int val) : x(val) {}  int get() {return x;}  };  int main() {  const MyClass foo(10);  // foo.x = 20; // not valid: x cannot be modified  cout << foo.x << '\n'; // ok: data member x can be read  return 0;  } | 10 |

**T**he access to its data members from outside the class is restricted to read-only

|  |  |  |  |
| --- | --- | --- | --- |
| 1 2 3 | int get() const {return x;} // const member function  const int& get() {return x;} // member function returning a const&  const int& get() const {return x;} // const member function returning a const& | | |
| 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 | | // overloading members on constness  #include <iostream>  using namespace std;  class MyClass {  int x;  public:  MyClass(int val) : x(val) {}  const int& get() const {return x;}  int& get() {return x;}  };  int main() {  MyClass foo (10);  const MyClass bar (20);  foo.get() = 15; // ok: get() returns int&  // bar.get() = 25; // not valid: get() returns const int&  cout << foo.get() << '\n';  cout << bar.get() << '\n';  return 0;  } | 15  20 | |

### 15.4 类模板（class template）

**模板特化（template specification）**

For example, let's suppose that we have a very simple class called mycontainer that can store one element of any type and that has just one member function called increase, which increases its value. But we find that when it stores an element of type char it would be more convenient to have a completely different implementation with a function member uppercase, so we decide to declare a class template specialization for that type:

|  |  |
| --- | --- |
| // template specialization  #include <iostream>  using namespace std;  // class template:  template <class T>  class mycontainer {  T element;  public:  mycontainer (T arg) {element=arg;}  T increase () {return ++element;}  };  // class template specialization:  template <>  class mycontainer <char> {  char element;  public:  mycontainer (char arg) {element=arg;}  char uppercase ()  {  if ((element>='a')&&(element<='z'))  element+='A'-'a';  return element;  }  };  int main () {  mycontainer<int> myint (7);  mycontainer<char> mychar ('j');  cout << myint.increase() << endl;  cout << mychar.uppercase() << endl;  return 0;  } | 8  J |

**16 特别成员**

|  |  |
| --- | --- |
| **Member function** | **typical form for class C:** |
| [Default constructor](http://www.cplusplus.com/doc/tutorial/classes2/#default_constructor) | C::C(); |
| [Destructor](http://www.cplusplus.com/doc/tutorial/classes2/#destructor) | C::~C(); |
| [Copy constructor](http://www.cplusplus.com/doc/tutorial/classes2/#copy_constructor) | C::C (const C&); |
| [Copy assignment](http://www.cplusplus.com/doc/tutorial/classes2/#copy_assignment) | C& operator= (const C&); |
| [Move constructor](http://www.cplusplus.com/doc/tutorial/classes2/#move) | C::C (C&&); |
| [Move assignment](http://www.cplusplus.com/doc/tutorial/classes2/#move) | C& operator= (C&&); |

**16.1 默认构造函数（default constructor）**

But as soon as a class has some constructor taking any number of parameters explicitly declared, the compiler no longer provides an implicit default constructor, and no longer allows the declaration of new objects of that class without arguments. For example, the following class:

|  |  |  |
| --- | --- | --- |
| 1 2 3 4 5 6 | class Example2 {  public:  int total;  Example2 (int initial\_value) : total(initial\_value) { };  void accumulate (int x) { total += x; };  }; |  |

Here, we have declared a constructor with a parameter of type int. Therefore the following object declaration would be correct:

|  |  |  |
| --- | --- | --- |
|  | Example2 ex (100); // ok: calls constructor |  |

But the following:

|  |  |
| --- | --- |
|  | Example2 ex; // not valid: no default constructor |

### 16.2（Copy constructor）

Copy Constructor 是一个特殊的构造函数，一般只有一个参数，这个参数一般是用const修饰的，对自己类的一个引用(reference)。什么时候会用到Copy Constructor?

当我们定义一个对象时，它是由另外一个对象来初始化的时候就用到Copy Constructor了。还有就是在一个方法以值作为参数传进去或者一个方法中以值作为返回。

A *copy constructor* is a constructor whose first parameter is of type *reference to the class* itself (possibly constqualified) and which can be invoked with a single argument of this type. For example, for a class MyClass, the *copy constructor* may have the following signature:

|  |  |  |
| --- | --- | --- |
|  | MyClass::MyClass (const MyClass&); |  |

If a class has no custom *copy* nor *move* constructors (or assignments) defined, an implicit *copy constructor* is provided. This copy constructor simply performs a copy of its own members. For example, for a class such as:

|  |  |  |
| --- | --- | --- |
| 1 2 3 4 | class MyClass {  public:  int a, b; string c;  }; |  |

An implicit *copy constructor* is automatically defined. The definition assumed for this function performs a *shallow copy*, roughly equivalent to:

|  |  |
| --- | --- |
|  | MyClass::MyClass(const MyClass& x) : a(x.a), b(x.b), c(x.c) {} |

|  |  |
| --- | --- |
| / copy constructor: deep copy  #include <iostream>  #include <string>  using namespace std;  class Example5 {  string\* ptr;  public:  Example5 (const string& str) : ptr(new string(str)) {}  ~Example5 () {delete ptr;}  // copy constructor:  Example5 (const Example5& x) : ptr(new string(x.content())) {}  // access content:  const string& content() const {return \*ptr;}  };  int main () {  Example5 foo ("Example");  Example5 bar = foo;  cout << "bar's content: " << bar.content() << '\n';  return 0;  } | bar's content: Example |

### 16.3Copy assignment

|  |  |
| --- | --- |
| 1 2 3 4 | MyClass foo;  MyClass bar (foo); // object initialization: copy constructor called  MyClass baz = foo; // object initialization: copy constructor called  foo = bar; // object already initialized: copy assignment called |

### 16.4 Move constructor and assignment

|  |  |
| --- | --- |
| 1 2 3 4 5 6 | MyClass fn(); // function returning a MyClass object  MyClass foo; // default constructor  MyClass bar = foo; // copy constructor  MyClass baz = fn(); // move constructor  foo = bar; // copy assignment  baz = MyClass(); // move assignment |

|  |  |  |
| --- | --- | --- |
| **Member function** | **implicitly defined:** | **default definition:** |
| [Default constructor](http://www.cplusplus.com/doc/tutorial/classes2/#default_constructor) | if no other constructors | does nothing |
| [Destructor](http://www.cplusplus.com/doc/tutorial/classes2/#destructor) | if no destructor | does nothing |
| [Copy constructor](http://www.cplusplus.com/doc/tutorial/classes2/#copy_constructor) | if no move constructor and no move assignment | copies all members |
| [Copy assignment](http://www.cplusplus.com/doc/tutorial/classes2/#copy_assignment) | if no move constructor and no move assignment | copies all members |
| [Move constructor](http://www.cplusplus.com/doc/tutorial/classes2/#move) | if no destructor, no copy constructor and no copy nor move assignment | moves all members |
| [Move assignment](http://www.cplusplus.com/doc/tutorial/classes2/#move) | if no destructor, no copy constructor and no copy nor move assignment | moves all members |

Notice how not all *special member functions* are implicitly defined in the same cases. This is mostly due to

**17 虚成员（virtual members）**

properties through references. The syntax for a function to become virtual is to precede its declaration with thevirtual keyword:

|  |  |  |  |
| --- | --- | --- | --- |
| 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 | // virtual members  #include <iostream>  using namespace std;  class Polygon {  protected:  int width, height;  public:  void set\_values (int a, int b)  { width=a; height=b; }  virtual int area ()  { return 0; }  };  class Rectangle: public Polygon {  public:  int area ()  { return width \* height; }  };  class Triangle: public Polygon {  public:  int area ()  { return (width \* height / 2); }  };  int main () {  Rectangle rect;  Triangle trgl;  Polygon poly;  Polygon \* ppoly1 = &rect;  Polygon \* ppoly2 = &trgl;  Polygon \* ppoly3 = &poly;  ppoly1->set\_values (4,5);  ppoly2->set\_values (4,5);  ppoly3->set\_values (4,5);  cout << ppoly1->area() << '\n';  cout << ppoly2->area() << '\n';  cout << ppoly3->area() << '\n';  return 0;  } | 20  10  0 | [Edit & Run](http://www.cplusplus.com/doc/tutorial/polymorphism/) |

### abstract base classes

An abstract base Polygon class could look like this:

|  |  |  |
| --- | --- | --- |
| 1 2 3 4 5 6 7 8 9 | // abstract class CPolygon  class Polygon {  protected:  int width, height;  public:  void set\_values (int a, int b)  { width=a; height=b; }  virtual int area () =0;  }; |  |

Notice that area has no definition; this has been replaced by =0, which makes it a *pure virtual function*. Classes that contain at least one *pure virtual function* are known as *abstract base classes*.

class A  
{  
public:  
 void function(int a)=0; **//必须写上=0，含有这样的函数的类叫做抽象类**  
}

Abstract base classes cannot be used to instantiate objects. Therefore, this last abstract base class version ofPolygon could not be used to declare objects like:

|  |  |
| --- | --- |
|  | Polygon mypolygon; // not working if Polygon is abstract base class |

# Polymorphism

**d**

**d**

**d**