C++ Course 2: C++ Language Basics 1

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C++ history

- 1979-1998 Development
- C++ 98 : First Official Standard
- C++ 11 : New (Big) Standard
  Rvalue references + move semantics
  Lambda expressions + **std::function**
  Concurrency (**thread**, **future**, ...)
  Smart pointers **(shared_ptr**, **unique_ptr**)
  auto + **decltype**
- C++ 14 : Small changes only
- C++ 17 : **filesystem**, **any**, **optional**, ...
- C++ 20: ???

Integer types

Integer types

char (8 bit) , **short** (16 bit), **int** (32 bit), **long** (32/64), **long long** (64 bit), **size_t** (32/64)

Sign modifiers

signed , **unsigned** , **signed** = default (except **char**)

For example:

int	:	−2147483648 .. 2147483647
unsigned int	:	0 .. 4294967295

Fixed-width types (C++ 11):

int8_t, int16_t, int32_t, int64_t

uint8_t, uint16_t, uint32_t, uint64_t

The danger of mixing signed and unsigned numbers

```
int a = -10;
unsigned int b = 1;
cout << "a + b = " << a + b << endl;
```

The danger of mixing signed and unsigned numbers

```
int a = -10;
unsigned int b = 1;
cout << "a + b = " << a + b << endl;
```

Result (OUCH !):

```
a + b = 4294967287
```

int and **unsigned int** have the same size (32 bit)
a+**b** has type **unsigned int**

But **a** + **(int)b** is OK !
The sum is now **int** (signed).

numeric_limits : Example 2_1

Type alias

```
using MyType = long long;
// typedef long long MyType;   // C++ 98
```

numeric_limits<MyType> : Type information

```
cout << boolalpha; // Write bool as true/false
cout << "sizeof(MyType) = " <<  sizeof(MyType) << endl;
cout << "is_signed = " << numeric_limits<MyType>:: is_signed << endl;
cout << "is_integer = " << numeric_limits<MyType>:: is_integer << endl;
cout << "is_exact = " << numeric_limits<MyType>:: is_exact << endl;
cout << "has_infinity = " << numeric_limits<MyType>:: has_infinity << endl;
cout << "has_quiet_NaN = " << numeric_limits<MyType>:: has_quiet_NaN << endl;
cout << "digits = " << numeric_limits<MyType>:: digits << endl;
cout << "digits10 = " << numeric_limits<MyType>:: digits10 << endl;
cout << "lowest() = " << numeric_limits<MyType>:: lowest() << endl;
cout << "min() = " << numeric_limits<MyType>:: min() << endl;
cout << "max() = " << numeric_limits<MyType>:: max() << endl;
```

numeric_limits : Example 2_1

Type alias

```
using MyType = long long;
// typedef long long MyType;    // C++ 98
```

numeric_limits<MyType> : Type information

```
sizeof(MyType) = 8
is_signed = true
is_integer = true
is_exact = true
has_infinity = false
has_quiet_NaN = false
digits = 63
digits10 = 18
lowest() = -9223372036854775808
min() = -9223372036854775808
max() = 9223372036854775807
```

Other types

Boolean:

bool (8 bit) : **false** (1), **true** (0)

Floating point:

float (32 bit), **double** (64 bit), **long double** (128 bit ?)

Always use **double** !

Small difference between 2 large doubles:

```
double a = 1.0e15;
double b = 1.0e15 + 0.1234;
cout << endl << "b - a = " << b-a << endl;
```

Other types

Boolean:

bool (8 bit) : **false** (1), **true** (0)

Floating point

float (32 bit), **double** (64 bit), **long double** (128 bit ?)

Always use **double** !

Small difference between 2 big doubles:

```
double a = 1.0e15;
double b = 1.0e15 + 0.1234;
cout << endl << "b - a = " << b-a << endl;
```

```
b - a = 0.125
```

Or, if you take 1.0e+16

```
b - a = 0
```

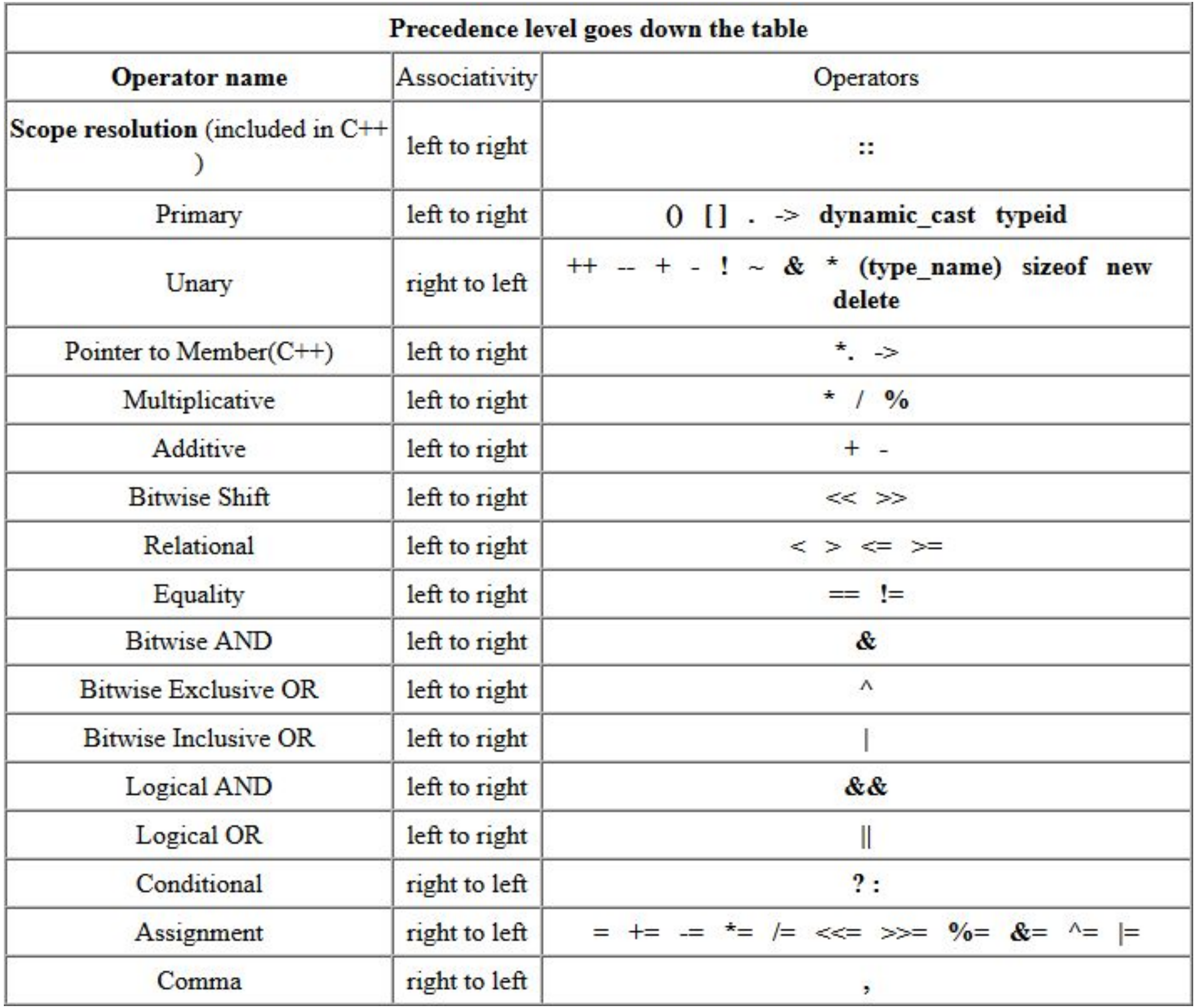
Literals

1234	int
4000000000u	unsigned int
8’000’000’000ll	long long
8000000000ull	unsigned long long
1.23e-4	double
1.23e-4f	float
1.23e-4d	long double
’M’	char
”Dina Meyer”	const char[11] (including ‘\0’, NOT std::string !)
false	bool

Hexadecimal, octal, binary (C++ 14) literals

0xFF	int (HEX) = 255
0100	int (OCTAL) = 64
0b100	int (BIN) = 4

Operators



Precedence level goes down the table		
Operator name	Associativity	Operators
Scope resolution (included in C++)	left to right	**::**
Primary	left to right	**() [ ] . -> dynamic_cast typeid**
Unary	right to left	**++ -- + - ! ~ & * (type_name) sizeof new delete**
Pointer to Member(C++)	left to right	*. ->
Multiplicative	left to right	* / **%**
Additive	left to right	+ -
Bitwise Shift	left to right	<< >>
Relational	left to right	< > <= >=
Equality	left to right	== **!=**
Bitwise AND	left to right	**&**
Bitwise Exclusive OR	left to right	^
Bitwise Inclusive OR	left to right	|
Logical AND	left to right	**&&**
Logical OR	left to right	||
Conditional	right to left	**? :**
Assignment	right to left	= += -= *= /= <<= >>= **%=** **&=** ^= |=
Comma	right to left	,

True story: "negative" bit shift

int a = 12 << -1;   // What is wrong with this ?

The compiler gives a WARNING :

warning: left shift count is negative

Negative shift is NOT ALLOWED !!!

In particular **12 << -1** is NOT the same as **12 >> 1** !!!

The behavior is UNDEFINED !

- People copypasted some bad code from the internet
- IGNORED the warnings
- Gave the code to Android developers
- Algorithm developers : "My code works !"
- Android developers : "Nothing works !"
- The results are different on different platforms! BAD!
- Took a *long time* to fix this.

Make this code work on platform XXX !

Suppose some algorithm "works on my computer" but not on Android!

The correct question is "WHY are the results different ???"
C++ code should work the same everywhere! This is called standard!

Does the code conform to C++ standard (e.g. C++ 14)?

YES:
Than it should work on every compiler (if not it is a compiler/library bug)

NO:
The code relies on *undefined* or *compiler-specific* behavior.
Then this is a BAD code and BAD algorithm and I am responsible.
"Works on my computer" is not a good argument.

Operators 1

&a Address of a variable **a** (This is NOT a reference declaration !)

***b** Pointer **b** dereferencing (This is NOT a pointer declaration !)

```
int a = 17;
int *b = &a;   // &a = address of a
cout << *b;   // Prints 17
```

a.c Member access operator

b->c Member access operator (pointer), equivalent to (*b).c

ns::c Scope resolution (namespace members and static class members)

```
std::string a = ”Mary had a little lamb”;
std::string *b = &a;
std::cout << a.length() << std::endl;
std::cout << b->length() << std::endl;
```

Operators 2

condition ? value1 : value2   Conditional (a.k.a. ternary) operator

```
cout <<  (a > 0 ? a : -a);
```

a = b Assignment operator

```
a = b = (c = d + 13)*2;
```

, Comma operator (Evaluates all expressions, returns the last one)

```
int a = 13;
int b = (a++, ++a, a+1);
```

All operators can be overloaded in C++ (except for **a.b** and **a::b** !)

Variable declaration and initialization : Example 2_2

```
int i1(17);    // This does not work for class fields !
int i2 = 17;  // Forbidden with an explicit constructor
int i3 = int(17);  // No copy/move here!
int i4{17};        // List initialization
int i5 = {17};   // Forbidden with an explicit constructor
```

All this declarations call constructor **once**, no assignment/copy/move !

Does not exist in C++ !

~~**Warrior w{**~~
~~**name: ”Karin Koenig”,**~~
~~**weapon: ”Rapier”,**~~
~~**age: 25**~~
~~**};**~~

auto, decltype, decltype(auto)

auto = Automatic type inference

```
int a = 13;
auto b = a;   // b is int = 13
```

decltype(a) = Type of variable **a**

```
decltype(a)  c = 14;  // c is int = 14
```

decltype(auto) = A version of **auto** following **decltype** rules (C++ 14)

```
int & d = a; // d is a reference to a
auto e = d;  // e is int = 13, ref is ignored
decltype(auto)  f = d;  // f is a ref to a
```

And now we try to change variable **a** ...

```
a = 22;
```

What are the values of **a, b, c, d, e, f** ?

auto, decltype, decltype(auto)

auto = Automatic type inference

```
int a = 13;
auto b = a;   // b is int = 13
```

decltype(a) = Type of variable **a**

```
decltype(a)  c = 14;  // c is int = 14
```

decltype(auto) = A version of **auto** following **decltype** rules (C++ 14)

```
int & d = a; // d is a reference to a
auto e = d;  // e is int = 13, ref is ignored
decltype(auto)  f = d;  // f is a ref to a
```

And now we try to change variable **a** ...

```
a = 22;
```

a==**22**, b==13, c==14, d==**22**, e==13, f==**22**

Move and swap operations

std::move = Move an object (No copying)

```
string s1("Brianna");
string s2 = move(s1);
```

std::swap = Swap two objects (No copying)

```
string s3("Mira");
string s4("Visas");
swap(s3, s4);
```

What are the values of **s1**, **s2**, **s3**, **s4** ?

Move and swap operations

std::move = Move object (No copying)

```
string s1("Brianna");
string s2 = move(s1);
```

std::swap = Swap two objects (No copying)

```
string s3("Mira");
string s4("Visas");
swap(s3, s4);
```

s1 == “”

s2 == “Brianna”

s3 == “Visas”

S4 = “Mira”

Simplest cmake projects

My first CMake project (**CMakeLists.txt**)

```
add_executable(hello hello.cpp)
```

My second CMake project

```
# This is a comment
cmake_minimum_required(VERSION 3.1)

project(hello)

set(CMAKE_CXX_STANDARD 14)

set(SRCS
#   somefile.h somefile.cpp
    hello.cpp
)

add_executable(${PROJECT_NAME} ${SRCS})
```

How to build a CMake project ?

```
mkdir build
cd build
cmake ..
cmake --build .
```

Rebuild after you have edited some source files ...

```
cmake --build .
```

Using *generators* (Example: Windows, MinGW)

```
mkdir build
cd build
cmake -G ”MinGW Makefiles” ..
cmake --build .
```

CMake does not call the C++ compiler directly.
Generators use low-level build systems (**make**, **nmake**, **ninja, ...**)
and IDEs (Visual Studio, Code.Blocks, xcode)

if statement : Example 2_3

```
if (a > 0)
      cout << ”a is positive” << endl;
else if (0 == a)  {
      cout << ”a is equal to zero” << endl;
} else
      cout << ”a is negative” << endl;
```

{...} is a *block*

```
{
      statement1;
      statement2;
      statement3;
}
```

Switch statement

```
    switch (m) {
    case 1:
        cout << "January" << endl;
        break;
    case 2:
        cout << "February" << endl;
        break;
    case 3:
        cout << "March" << endl;
        break;
...
    default:
        cout << "Wrong Month !" << endl;
    }
```

switch works only for integer and **enum** types !

Don’t forget **break** !

Loops

```
for (int i=0;  i<10; ++i)
    cout << i << endl;


int j=0;
while (j < 10)
    cout << j++ << endl;


int k=0;
// This runs at least once !
do
    cout << k++ << endl;
while (k < 10);


for (char c: string("Tower"))
    cout << c;
```

Loops: bad style

```
int i;
cout << "Enter a number (0 = exit) :" << endl;
cin >> i;
while (i != 0) {
    cout << i << " * 2 = " << i*2 << endl;

    cout << "Enter a number (0 = exit) :" << endl;
    cin >> i;
}
```

Loops: bad style

```
int i;
cout << "Enter a number (0 = exit) :" << endl;
cin >> i;
while (i != 0) {
    cout << i << " * 2 = " << i*2 << endl;

    cout << "Enter a number (0 = exit) :" << endl;
    cin >> i;
}
```

A piece of code is repeated 2 times = BAD

Loops: good style

```
int i;
for (;;) {
    cout << "Enter a number (0 = exit) :" << endl;
    cin >> i;
    if (0 == i)
        break;
    cout << i << " * 2 = " << i*2 << endl;
}
```

"Infinite loop", which runs until

break exits the loop

Library of the day : OpenCV : Example 2_4

```
#include <iostream>
#include <opencv2/opencv.hpp>

int main(){
     using namespace std;
     cv::VideoCapture cam(cv::CAP_ANY); // Open the camera
     if (!cam.isOpened())
          throw runtime_error("Cannot open camera");

     for (;;) {
          cv::Mat img;
          cam.read(img); // Read frame
          // Select the central roi and apply photo negative
          int w = img.cols, h = img.rows;
          cv::Mat m(img, cv::Rect(w/3, h/3, w/3, h/3));
          cv::bitwise_not(m, m);
          // Show frame
          cv::imshow("img", img);
          if (27 == cv::waitKey(1))
               break;
     }
     return 0;
}
```

Library of the day : OpenCV : Example 2_4

```
cmake_minimum_required(VERSION 3.1)
project(e2_4)
set(CMAKE_CXX_STANDARD 14)
# Find package OpenCV
find_package(OpenCV REQUIRED)
# Add opencv include dirs
include_directories( ${OpenCV_INCLUDE_DIRS} )
message("OpenCV_INCLUDE_DIRS = ${OpenCV_INCLUDE_DIRS}")
message("OpenCV_LIBS = ${OpenCV_LIBS}")
set(SRCS
     main.cpp
)
add_executable(${PROJECT_NAME} ${SRCS})
target_link_libraries(${PROJECT_NAME} ${OpenCV_LIBS})
```

Sometimes you need to specify OpenCV directory:

cmake -DOpenCV_DIR=/home/seymour/opencv/411/lib/cmake/opencv4 ..

This must be the directory with *.cmake files !

Alternatively you can specify CMake package search path:

cmake -DCMAKE_PREFIX_PATH=/home/seymour/opencv/411 ..

Thank you for your attention !