Operators

Once we know of the existence of variables and constants, we can begin to operate with them. For that purpose, C++ integrates operators. Unlike other languages whose operators are mainly keywords, operators in C++ are mostly made of signs that are not part of the alphabet but are available in all keyboards. This makes C++ code shorter and more international, since it relies less on English words, but requires a little of learning effort in the beginning.

You do not have to memorize all the content of this page. Most details are only provided to serve as a later reference in case you need it.

Assignment (=)

The assignment operator assigns a value to a variable.

```
a = 5;
```

This statement assigns the integer value 5 to the variable a. The part at the left of the assignment operator (=) is known as the *lvalue* (left value) and the right one as the *rvalue* (right value). The lvalue has to be a variable whereas the rvalue can be either a constant, a variable, the result of an operation or any combination of these.
The most important rule when assigning is the *right-to-left* rule: The assignment operation always takes place from right to left, and never the other way:

```
a = b;
```

This statement assigns to variable a (the lvalue) the value contained in variable b (the rvalue). The value that was stored until this moment in a is not considered at all in this operation, and in fact that value is lost.

Consider also that we are only assigning the value of b to a at the moment of the assignment operation. Therefore a later change of b will not affect the new value of a.

For example, let us have a look at the following code - I have included the evolution of the content stored in the variables as comments:

```
// assignment operator                    a:4 b:7

#include <iostream>
using namespace std;

int main ()
{
int a, b;               // a:?,  b:?
a = 10;                 // a:10, b:?
b = 4;                  // a:10, b:4
a = b;                  // a:4,  b:4
b = 7;                  // a:4,  b:7

cout << "a:";
cout << a;
cout << " b:";
cout << b;

return 0;
}
```

This code will give us as result that the value contained in a is 4 and the one contained in b is 7. Notice how a was not affected by the final modification of b, even though we declared a = b earlier (that is because of the *right-to-left rule*).

A property that C++ has over other programming languages is that the assignment operation can be used as the rvalue (or part of an rvalue) for another assignment operation. For example:

```
a = 2 + (b = 5);
```

is equivalent to :

```
b = 5;
a = 2 + b;
```

that means: first assign 5 to variable b and then assign to a the value 2 plus the result of the previous assignment of b (i.e. 5), leaving a with a final value of 7.

The following expression is also valid in C++:

```
a = b = c = 5;
```

It assigns 5 to the all three variables: a, b and c.

Arithmetic operators (+, -, *, /, %)

The five arithmetical operations supported by the C++ language are:

+	Addition
-	Subtraction
*	Multiplication
/	Division
%	Modulo

Operations of addition, subtraction, multiplication and division literally correspond with their respective mathematical operators. The only one that you might not be so used to see is *modulo*; whose operator is the percentage sign (%). Modulo is the operation that gives the remainder of a division of two values. For example, if we write:

```
a = 11 % 3;
```

the variable a will contain the value 2, since 2 is the remainder from dividing 11 between 3.

Compound assignment (+=, -=, *=, /=, %=, >>=, <<=, &=, ^=, |=)

When we want to modify the value of a variable by performing an operation on the value currently stored in that variable we can use compound assignment operators:

Expression	is Equavalent to
value += increase;	value = value + increase;
a -= 5;	a = a - 5;
a /= b;	a = a / b;
price *= units + 1;	price = price * (units + 1);

and the same for all other operators. For example:

```
// compound assignment operators                    5

#include <iostream>
using namespace std;

int main ()
{
int a, b=3;
a = b;
a+=2;                    // equivalent to a=a+2
cout << a;
return 0;
}
```

Increase and decrease (++, --)

Shortening even more some expressions, the increase operator (++) and the decrease operator (--) increase or reduce by one the value stored in a variable. They are equivalent to +=1 and to -=1, respectively. Thus:

```
c++;
c+=1;
c=c+1;
```

are all equivalent in its functionality: the three of them increase by one the value of c.

In the early C compilers, the three previous expressions probably produced different executable code depending on which one was used. Nowadays, this type of code optimization is generally done automatically by the compiler, thus the three expressions should produce exactly the same executable code.

A characteristic of this operator is that it can be used both as a prefix and as a suffix. That means that it can be written either before the variable identifier (++a) or after it (a++). Although in simple expressions like a++ or ++a both have exactly the same meaning, in other expressions in which the result of the increase or decrease operation is evaluated as a value in an outer expression they may have an important difference in their meaning: In the case that the increase operator is used as a prefix (++a) the value is increased **before** the result of the expression is evaluated and therefore the increased value is considered in the outer expression; in case that it is used as a suffix (a++) the value stored in a is increased after being evaluated and therefore the value stored before the increase operation is evaluated in the outer expression. Notice the difference:

Example1	Example2
B=3;	B=3;
A=++B;	A=B++;
// A contains 4, B contains 4	// A contains 3, B contains 4

In Example 1, B is increased before its value is copied to A. While in Example 2, the value of B is copied to A and then B is increased.

Relational and equality operators (==, !=, >, <, >=, <=)

In order to evaluate a comparison between two expressions we can use the relational and equality operators. The result of a relational operation is a Boolean value that can only be true or false, according to its Boolean result.
We may want to compare two expressions, for example, to know if they are equal or if one is greater than the other is. Here is a list of the relational and equality operators that can be used in C++:

==	Equal to
!=	Not equal to
>	Greater than
<	Less than
>=	Greater than or equal to
<=	Less than or equal to

Here there are some examples:

```
(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, instead of using only numeric constants, we can use any valid expression, including variables. Suppose that a=2, b=3 and c=6,

```
(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.
```

Be careful! The operator = (one equal sign) is not the same as the operator == (two equal signs), the first one is an assignment operator (assigns the value at its right to the variable at its left) and the other one (==) is the

equality operator that compares whether both expressions in the two sides of it are equal to each other. Thus, in the last expression ((b=2) == a), we first assigned the value 2 to b and then we compared it to a, that also stores the value 2, so the result of the operation is true.

Logical operators (!, &&, ||)

The Operator ! is the C++ operator to perform the Boolean operation NOT, it has only one operand, located at its right, and the only thing that it does is to inverse the value of it, producing false if its operand is true and true if its operand is false. Basically, it returns the opposite Boolean value of evaluating its operand. For example:

```
!(5 == 5)   // evaluates to false because the expression at its right (5 == 5) is true.
!(6 <= 4)   // evaluates to true because (6 <= 4) would be false.
!true       // evaluates to false.
!false      // evaluates to true.
```

The logical operators && and || are used when evaluating two expressions to obtain a single relational result. The operator && corresponds with Boolean logical operation AND. This operation results true if both its two operands are true, and false otherwise. The following panel shows the result of operator && evaluating the expression a && b:

&& OPERATOR

a	b	a&&b
True	True	True
True	False	False
False	True	False
False	False	False

The operator || corresponds with Boolean logical operation OR. This operation results true if either one of its two operands is true, thus being false only when both operands are false themselves. Here are the possible results of a || b:

|| OPERATOR

a	b	a || b
True	True	True
True	False	False
False	True	False
False	False	False

For example:

```
( (5 == 5) && (3 > 6) )  // evaluates to false ( true && false ).
( (5 == 5) || (3 > 6) )  // evaluates to true ( true || false ).
```

Conditional operator (?)

The conditional operator evaluates an expression returning a value if that expression is true and a different one if the expression is evaluated as false. Its format is:

condition ? result1 : result2

If condition is true the expression will return result1, if it is not it will return result2.

```
7==5 ? 4 : 3     // returns 3, since 7 is not equal to 5.
7==5+2 ? 4 : 3   // returns 4, since 7 is equal to 5+2.
5>3 ? a : b      // returns the value of a, since 5 is greater than 3.
a>b ? a : b      // returns whichever is greater, a or b.
```

```
// conditional operator                                    7

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

```
int main ()
{
int a,b,c;

a=2;
b=7;
c = (a>b) ? a : b;

cout << c;

return 0;
}
```

In this example a was 2 and b was 7, so the expression being evaluated (a>b) was not true, thus the first value specified after the question mark was discarded in favor of the second value (the one after the colon) which was b, with a value of 7.

Comma operator (,)

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 rightmost expression is considered.

For example, the following code:

```
a = (b=3, b+2);
```

Would first assign the value 3 to b, and then assign b+2 to variable a. So, at the end, variable a would contain the value 5 while variable b would contain value 3.

Bitwise Operators (&, |, ^, ~, <<, >>)

Bitwise operators modify variables considering the bit patterns that represent the values they store.

Operator	ASM Equivalent	Description
&	AND	Bitwise AND
|	OR	Bitwise Inclusive OR
^	XOR	Bitwise Exclusive OR
~	NOT	Unary Complement(Inversion)
<<	SHL	Shift Left
>>	SHR	Shift Right

Explicit type casting operator

Type casting operators allow you to convert a datum of a given type to another. There are several ways to do this in C++. The simplest one, which has been inherited from the C language, is to precede the expression to be converted by the new type enclosed between parentheses (()):

```
int i;
float f = 3.14;
i = (int) f;
```

The previous code converts the float number 3.14 to an integer value (3), the remainder is lost. Here, the typecasting operator was (int). Another way to do the same thing in C++ is using the functional notation: preceding the expression to be converted by the type and enclosing the expression between parentheses:

```
i = int ( f );
```

Both ways of type casting are valid in C++.

sizeof()

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

```
a = sizeof (char);
```
This will assign the value 1 to a because char is a one-byte long type.
The value returned by sizeof is a constant, so it is always determined before program execution.

Other operators

Later in these tutorials, we will see a few more operators, like the ones referring to pointers or the specifics for object-oriented programming. Each one is treated in its respective section.

Precedence of operators

When writing complex expressions with several operands, we may have some doubts about which operand is evaluated first and which later. For example, in this expression:
```
a = 5 + 7 % 2
```
we may doubt if it really means:
```
a = 5 + (7 % 2)    // with a result of 6, or
a = (5 + 7) % 2    // with a result of 0
```
The correct answer is the first of the two expressions, with a result of 6. There is an established order with the priority of each operator, and not only the arithmetic ones (those whose preference come from mathematics) but for all the operators which can appear in C++. From greatest to lowest priority, the priority order is as follows:

Levels	20.Operator21.	Description	Grouping
1.	: :	Scope	Left to Right
2.	() [] . -> ++ -- dynamic_cast static_cast reinterpret_cast const_cast typeid	Postfix	Left to Right
3.	++ -- ~ ! sizeof new delete	unary (prefix)	Right to Left
	* &	indirection and reference (pointers)	
	+ -	unary sign operator	
4.	(type)	type casting	Right-to-left
5.	.* ->*	pointer-to-member	Left to Right
6.	* / %	Multiplicative	Left to Right
7.	+ -	Addictive	Left to Right
8.	<< >>	Shift	Left to Right
9.	< > <= >=	Relational	Left to Right
10.	= = !=	Equality	Left to Right
11.	&	Bitwise AND	Left to Right
12.	^	Bitwise XOR	Left to Right
13.	|	Bitwise OR	Left to Right
14.	&&	Logical AND	Left to Right
15.	||	Logical OR	Left to Right
16.	?:	Conditional	Right to Left
17.	= *= /= %= += -= >>= <<= &= ^= |=	Assignment	Right to Left
18.	,	Comma	Left to Right

Grouping defines the precedence order in which operators are evaluated in the case that there are several operators of the same level in an expression.

All these precedence levels for operators can be manipulated or become more legible by removing possible ambiguities using parentheses signs (and), as in this example:
```
a = 5 + 7 % 2;
```
might be written either as:
```
a = 5 + (7 % 2);
```
Or
```
a = (5 + 7) % 2;
```
depending on the operation that we want to perform.

So if you want to write complicated expressions and you are not completely sure of the precedence levels, always include parentheses. It will also make your code easier to read.