C++ Programming
- Expressions

With Thanks to Dr. Feng Xin

Outline

- Arithmetic expressions
- Relational expressions (conditions)
- Logical expressions (decisions)
- Increment operators
- Bitwise operators

Expressions

- An expression is a sequence of operands (constants or variables) and operators
  - e.g., `a*b-c`, `(m+n)*(x+y)`, `2*3+4`
- An expression is evaluated from left to right using the rule of precedence of operators
  - Precedence
    - Highest priority: `()`
    - High priority: `*, /, %`
    - Low priority: `+, -`
  - What are the results of `x` and `y`
    - `x = 9-12/3+3*2-1;`
    - `y = 9-10/(3+3)*(2-1);`

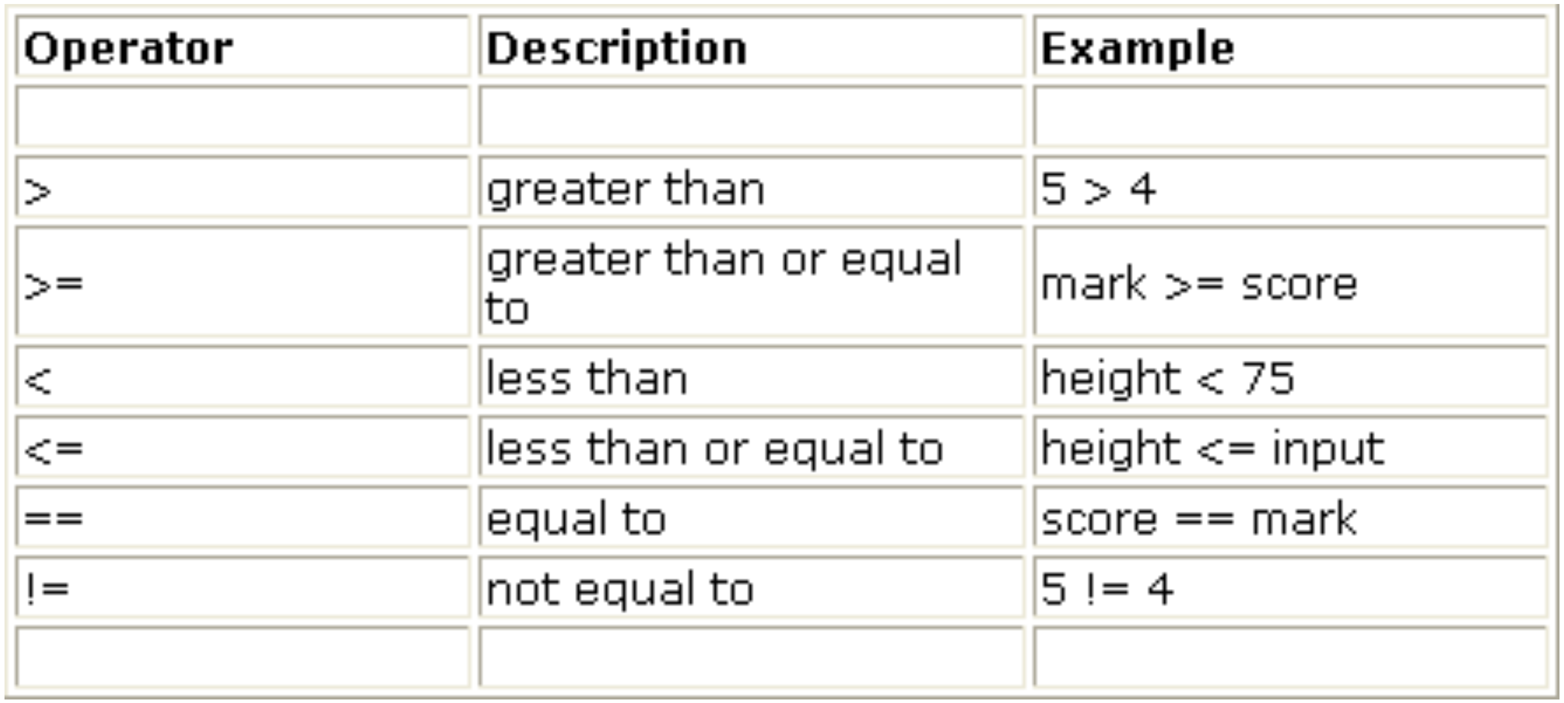
Arithmetic Expressions

- Arithmetic operators
  - Binary operators
    - +, -, *: for all integer and float
      - e.g, `a+b, 10-4, -5, 2.0*10`
    - /:
      - integer: give the `int` quotient. E.g., `10 / 3 = 3`
      - Float: give the `float` quotient.
      - e.g., `10.0/3 = 3.333333`
    - %(modulus): only for integers, give the remainder
      - e.g., `5%3 = 2`

Relational Expressions (Conditions)

- Expressions with relational operators
  - `<, <=, >, >=, ==, !=`
- Compare variables and values
- The result of a relational expression is either `0 (false)` or `1 (true)`
  - `4 < 5: true`
  - `4 > 5: false`
  - `4!=5: true.`
- `x > 10`: unknown, depending on the value of `x`.

Relational Expressions

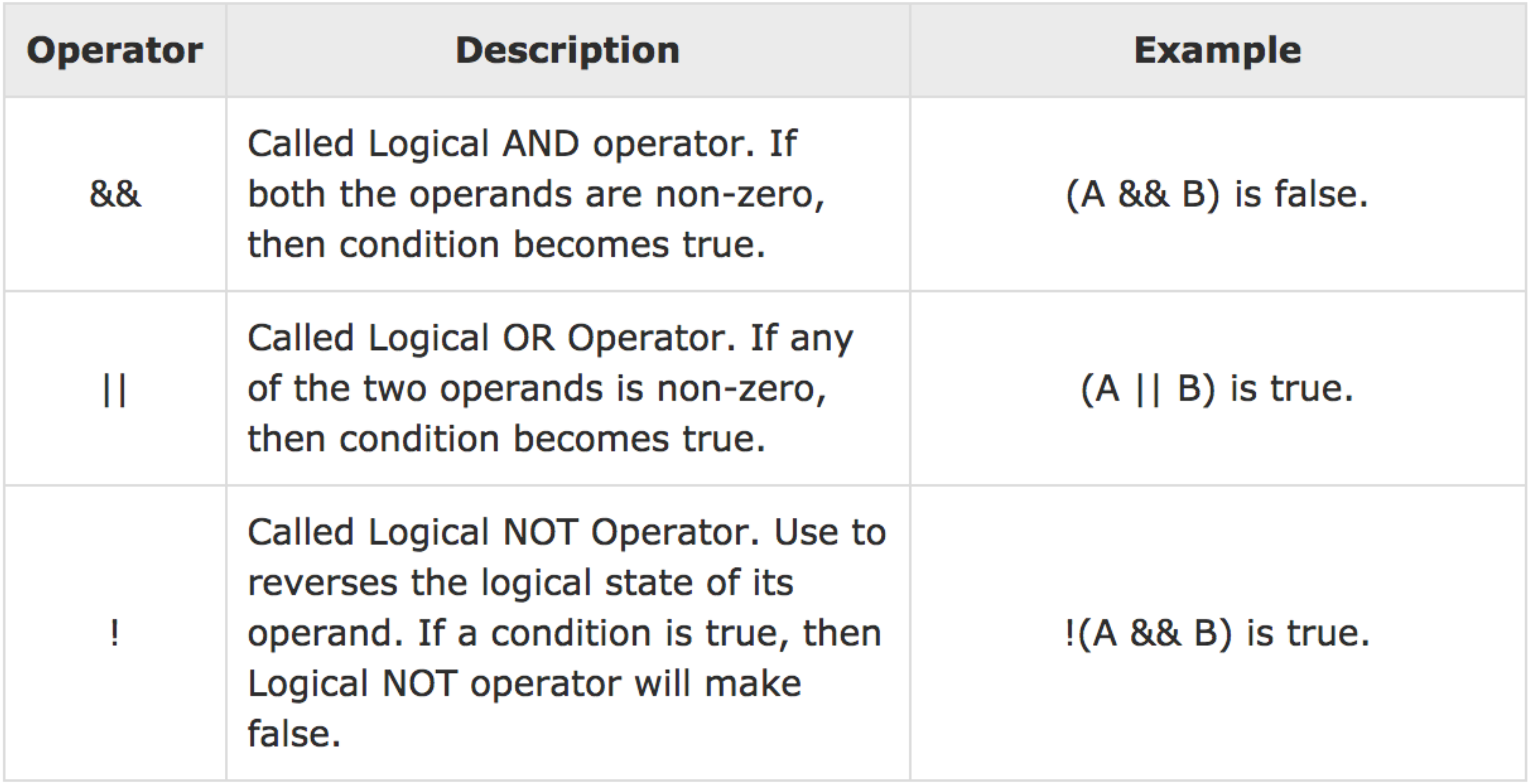


Operator	Description	Example
>	greater than	5 > 4
>=	greater than or equal to	mark >= score
<	less than	height < 75
<=	less than or equal to	height <= input
==	equal to	score == mark
!=	not equal to	5 != 4

Logical Expressions (Decisions)

- Comprise relational expressions (conditions) and logical operators
  - Logical operators
    - `&&` (two ampersands): means *and*.
      - e.g., `(GPA >= 1.7 && GPA <= 1.99)`
    - `||` (two vertical bars): means *or*.
      - e.g., `(spellingErrors > 5 || grammarErrors > 3)`
    - `!` (an exclamation point): means *not*.
      - e.g., `!(score < 80)`
- Allows you to give more than one condition
- A logical expression is also called a decision

Logical Expressions



Operator	Description	Example
&&	Called Logical AND operator. If both the operands are non-zero, then condition becomes true.	(A && B) is false.
||	Called Logical OR Operator. If any of the two operands is non-zero, then condition becomes true.	(A || B) is true.
!	Called Logical NOT Operator. Use to reverses the logical state of its operand. If a condition is true, then Logical NOT operator will make false.	!(A && B) is true.

Class Exercises

- Translate the following English questions into C/C++ decisions.
  - The height is not equal to zero
  - The temperature (variable: temp) is greater than `32.0` and less than `212.0`
  - The absolute value of pos is greater than `5.0`

Increment and decrement expressions

- **++** (increment), **--** (decrement)
  - Has only one operand. Only applicable to integer
  - e.g.,
    - » `x++` is equivalent to `x=x+1`
    - » `++x` is equivalent to `x=x+1`
    - » `x--` is equivalent to `x=x-1`
    - » `--x` is equivalent to `x=x-1`

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)
```

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

Rules for ++ and --

- postfix ++ (or --)
  - the expression is evaluated first using the original value of the variable
  - then the variable is incremented (or decremented) by one
- prefix ++ (or --)
  - the variable is incremented (or decremented) by one first
  - then the expression is evaluated using the new value of the variable

Class Exercises

```
m   =   5;
y   =   ++m;


x   =   m++;
```

What are the final values of `x`, `y`, and `m`?

Conditional ternary expression

- Format
  - `exp1 ? exp2 : exp3`
  - If `exp1` is true,
    - The result of `exp1 ? exp2 : exp3` is `exp2` (`exp3` is not evaluated)
  - If `exp1` is false,
    - The result of `exp1 ? exp2 : exp3` is `exp3` (`exp2` is not evaluated)

Examples

Example 1

```
x = 4;
y = 5;
z = (x > y) ? x : y;
```

Example 2

```
x = 5;
y = 4;
z = (x > y) ? x : y;
```

The value of `z` is ?

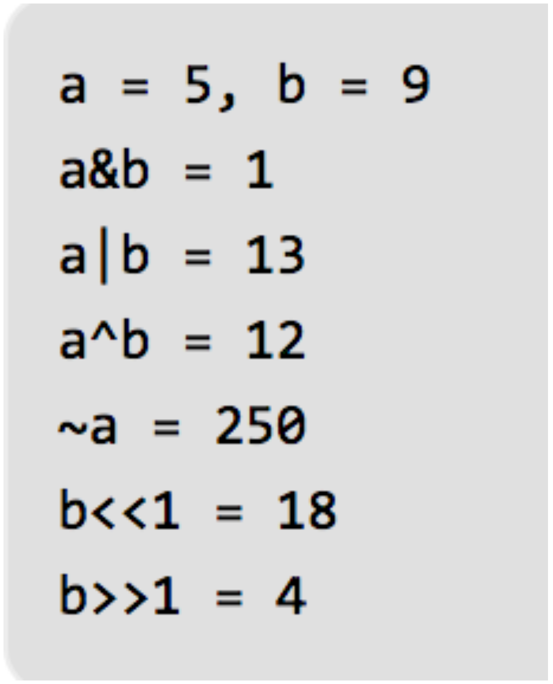
Bitwise Operators

- Work on binary system of all integer types

Operator	Meaning
&	bitwise AND
|	bitwise OR
^	bitwise Exclusive OR
~	bitwise complement
<<	shift left
>>	shift right

Example

a = 5 (00000101)
b = 9 (00001001)



```
a = 5, b = 9
a&b = 1
a|b = 13
a^b = 12
~a = 250
b<<1 = 18
b>>1 = 4
```

Shift, Multiplication and Division

- `14: 0000 1110` $(2^3+2^2+2^1)$
- `14<<1` (shift one bit left: `0001 1100`) $(2^4+2^3+2^2 = 28)$
- `14>>1` (shift one bit right: `0000 0111`) $(2^2+2^1+2^0 = 7)$

Shift, Multiplication and Division

- Multiplication and division are often slower than shift.
- Multiplying 2 can be replaced by shifting 1 bit to the left.

```
n = 10;
m = n << 1;
cout << n*2 << ‘=‘ << m;
m = n << 2;
cout << n*4 << ‘=‘ << m;
```

- Division by 2 can be replaced by shifting 1 bit to the right.

```
n = 10
m = n >> 1;
cout << n/2 << ‘=‘ << m;
```

Comma Operator

- An expression can be composed of multiple sub-expressions separated by commas.
  - Sub-expressions are evaluated left to right.
  - The entire expression evaluates to the value of the rightmost sub-expression.

Operator Precedence

	Operator	Precedence level
–	( )	1
–	~, ++, --, unary -	2
–	*, /, %	3
–	+, -	4
–	<<, >>	5
–	<, <=, >, >=	6
–	==, !=	7
–	&	8
–	^	9
–	|	10
–	&&	11
–	||	12
–	=, +=, -=, etc.	14
–	,	15