The C++ Programming Language: A Subset for CMIS 102

Introduction

The goal of CMIS 102 is to teach you some basic concepts about programming that you can take onward to more advanced courses, regardless of the programming language used in the more advanced courses. Of course, it is impossible seriously to learn about programming without learning a programming language at the same time. Conversely, it's not possible to learn your first programming language without learning how to program at the same time. So we have had to choose a language. We have chosen C++. C++ is a major language in its own right, and in syntax and control structures is very similar to Java.

The C++ programming language, defined in ANSI/ISO Standard 14882-2003, is very large and complex. But for CMIS 102 use, within C++ we can find a small subset that is both easy to learn, and has upwards of 80% commonality with Java. This note is an informal but reasonably precise description of this subset.

Bear in mind that C++ compilers recognize the full C++ language. So it is possible for you to write code that goes beyond what we describe here, and still be accepted by the compiler. But if you write code that adheres to the following rules, your program should compile correctly. Whether it does what you want it to do is, of course, another question.

The CMIS 102 Subset of the C++ Programming Language

Comments

You can include comments in your source code in either of two ways:

- On any line of code, anything after // is a comment.
- Anything between `/*` and the next `*/` is a comment. This format allows multi-line comments.

  Examples:
  ```
  x = x + 1; // That was a C++ statement, but this is a comment
  /* Here is the first line of a multi-line comment
     and here is more of  it
     and here is the rest of it.
  */
  ```

Constants

An *integer constant* is a string of one or more digits, optionally preceded by a minus sign.

Examples: `137, -456, 0`

A *float constant* consists of an optional minus sign, a string of one or more digits, a decimal point, and a string of one or more digits.

Examples: `123.456, -12.34, 0.0`

A *boolean constant* is either `true` or `false`.

Examples: `true`, `false`

A *character constant* is either (a) a character other than \, ", or ', enclosed in single quotes, or (b) one of `'\n'`, `'\t'`, `'\\'`, `'\"'`, or `'\''`, indicating newline, tab, backslash, double quote, and single quote, respectively. These forms of character constants are called *escape sequences*.

Examples: `'A'`, `'4'`, `'b'`, `'\n'`, `'\t'`, `'\\'`, `'\"'`, `'\''`,

A *string constant* is a string of characters enclosed in double quotes. The characters may not include \, ", or '; but any of the escape sequences listed above may be included.

Identifiers

An *identifier* is a name given to a variable or function. An identifier can contain only letters, digits, and underscore, and cannot begin with a digit.

Examples: Cat, Dog789, EXIT_SUCCESS, _888Hello

Caution: Identifiers are case sensitive. Cat, CAT, and cat are all different.

Tip: Although it is permitted, you should never begin an identifier with an underscore, or use two underscores is a row. Doing either may create a conflict with a library function.

Reserved Words

Certain identifiers have specified meanings in the language. You may not redefine them. Table 1 lists the 73 reserved words of C++. You will recognize many of them (those in yellow). Others may be rather obscure.

Table 1. C++ Reserved Words

and	and_eq	asm	auto
bitand	bitor	bool	break
case	catch	char	class
const	const_cast	continue	default
delete	do	double	dynamic_cast
else	enum	explicit	export
extern	false	float	for
friend	goto	if	inline
int	long	mutable	namespace
new	not	not_eq	operator
or	or_eq	private	protected
public	register	reinterpret_cast	return
short	signed	sizeof	static
static_cast	struct	switch	template
this	throw	true	try
typedef	typeid	typename	union
unsigned	using	virtual	void
volatile	wchar_t	while	xor
xor_eq			

Primitive Data Types

A *data type* is the set of values that a variable of that type can hold.

A variable of type `int` can hold any integer in the range –2,147,483,648 to + 2,147,483,647.

Note: This statement assumes a word length of 32 bits, which is typical.

A variable of type `float` can hold any one of about 4,294,967,296 specific rational numbers. The largest positive value of a `float` variable is about 3.388×10^{38}. The smallest positive value of a `float` variable is about 1.413×10^{-45}. A variable of type `double` can hold any one of abut 1.84×10^{19} specific rational numbers. The range of positive `double` values is about 4.9×10^{-324} to 1.7×10^{308}.

> Note: This statement assumes a word length of 32 bits, which is typical.
>
> Disclaimer: The exact number of allowed values actually depends on the technique for representing numbers used in the particular computer. For a computer using the IEEE 754 standard, the number of different `float` values is somewhat less than 4,294,967,296, for technical reasons.

A variable of type `bool` can hold either `true` or `false`. Theoretically, it only takes one bit to hold a value of type `bool`, although most compilers allocate more, such as 8, 16, or 32.

A variable of type `char` can hold an integer in the range 0 to 255. The values in the range 32 to 126 represent printable characters (the so-called ASCII character set.)

Variables and Declarations

A *variable* is a name assigned to a portion of your computer's memory that can hold a value of a specific data type. A declaration is a program statement that asks the compiler to assign a portion of the computer's memory to hold a data item, and to associate with it the name you specify. You must declare every variable you use.

> Examples 1: `int j, numberOfPeople;` requests the allocation of an appropriate amount of memory (usually 32 bits) to hold each of two values of type `int`. These memory locations will be known by the names `j` and `numberOfPeople`.
>
> Example 2: `float myWaterConsumption;` requests the allocation of an appropriate amount of memory (usually 32 bits) to hold a value of type `float`. This memory location will be know by the name `myWaterConsumption`.
>
> Note: Although it is an engineering issue rather than a programming issue, whenever you deal with values of data type `float`, you need to specify the units. For example, myWaterConsumption may be in cubic feet per hour, or liters per day, or whatever.

Operators

Operators are actions that the computer can perform on one or two inputs called *operands*. Each operand must be of some data type. The data type of the result may depend on the data type of the operands. Table 2 lists the C++ operators, their symbols, their input data types, and their result data types. They are listed in equal-precedence groups, in order of decreasing precedence.

Expressions

An expression is a combination of variables, constants, operators, and parentheses, such that if values are assigned to each of the variables, the expression can be evaluated to produce a value of some data type. The precise rules for constructing valid expressions are rather complicated, but they are close enough to the rules for expressions in algebra that you should be able to understand the concept from some examples. The following are all valid expressions:

```
x + 5
(x + 5) -y
(x + 5)/(2*y + 3)
(x + 37 <= 40) || (y != 18)
```

Table 2. C++ Operators

Operator Name	Symbol	Unary or Binary	Input Data Type	Result Data Type
Increment	++	U	int	int
Decrement	--	U	int	int
Unary minus	-	U	int	int
			float	float
Unary plus	+	U	int	int
			float	float
NOT	!	U	bool	bool
Multiplication	*	B	int	int
			float	float
Division	/	B	int	int
			float	float
Remainder	%	B	int	int
Addition	+	B	int	int
			float	float
Subtraction	-	B	int	int
			float	float
Less than	<	B	int	bool
			float	bool
Less than or equal	<=	B	int	bool
			float	bool
Greater than	>	B	int	bool
			float	bool
Greater than or equal	>=	B	int	bool
			float	bool
Equals	==	B	int	bool
			float	bool
			bool	bool
Not equals	!=	B	int	bool
			float	bool
			bool	bool
AND	&&	B	bool	bool
OR	||	B	bool	bool

Assignment Statements

An assignment statement has the form *variable* = *expression*`;` . Execution of an assignment statement consists of evaluating the expression, and then storing the resulting value in the variable. The result of evaluating the expression must be a data type compatible with the variable.

Example 1: Assignments to a some variables of type `float`

```
float x, y, z;
x = 3.0; y = 5.6;
z = (x + y)/(x - y);
```

Example 2: An assignment to a variable of type `bool`

```
bool answer; int x, y;
answer = x < y;
```

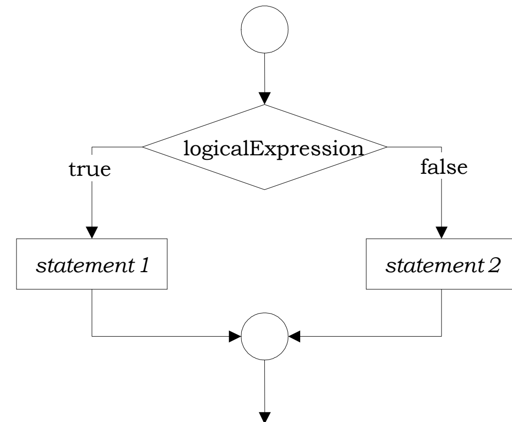
It is possible to combine a declaration statement with an assignment statement. This is called *initialization*.

Examples:

```
float x = 3.4, y = 5.6;
```
is equivalent to
```
float x, y;
x = 3.4; y = 5.6;
```

If…Else Statements

An "if…else" statement is of the form `if (`*logicalExpression*`)` *statement1* `else` *statement2* or, if *statement2* is "do nothing", simply of the form `if (`*logicalExpression*`)` *statement1*. *logicalExpression* must be an expression that evaluates to a value of type `bool`. It operates as shown in the flowchart to the right.



Examples:
```
if (x < y) z = +1; else z = -1;

if (x >= y && y >= z) {
    a = 5; b = 6;
}
```

Note: *statement 1* and *statement 2* are often compound statements. *statement 2* can be empty, in which case the word `else` is omitted. Often, *statement 2* is itself an if…else statement, as in the following example

```
If (g >= 70) then grade = 'A'; else if (g >= 80) then grade = 'B';
```

Switch Statements

A switch statement if of the form

`switch(`*expression*`) {`
`case` *value1*`:`
  sequence of one or more statements
  `break;`
`case` *value2*`:`
  sequence of one or more statements
  `break;`
…
`case` *valueN*`:`
  sequence of one or more statements
  `break;`
`default:`
  sequence of one or more statements
  `break;`
`}`

The following rules apply to switch statements:

- *expression* must evaluate to an integer.
- Each of *value1* through *valueN* must be an integer constant.
- The default clause is optional.

When the switch statement is executed, *expression* is evaluated and compared to *value1* through *valueN*. If a match is found, the statements following the match are executed up to the `break;` statement. If there is no match, the statements following *default:* are executed.

Example:
```
switch (j) {
case 1:
```

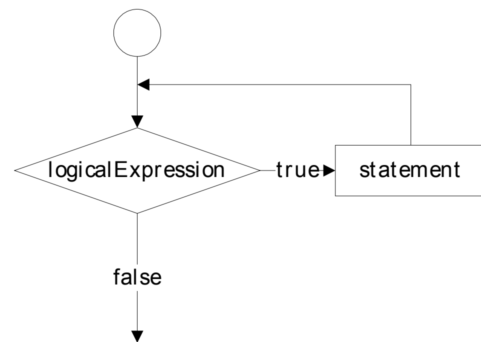
```
        z = x;
        break;
case 2:
        z = x*x;
        break;
default:
        z = 1;
        break;
}
```

Caution: If you omit a `break;`, execution of statements will continue into the next group, which is almost certainly not what you intend.

While Loops

There are two types of "while" loops: pre-test and post-test. In the following, *logicalExpression* must be an expression that evaluates to a value of type `bool`.

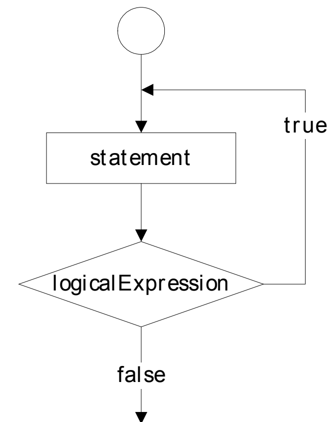
The pre-test "while" has the form `while (`*logicalExpression*`)` *statement*. It operates as shown in this flow chart:



Example:

```
while (n < 137) n = n + 2;
```

The post-test "while" has the form `do` *statement* `while (`*logicalExpression*`);` It operates as shown in this flow chart:



Example:

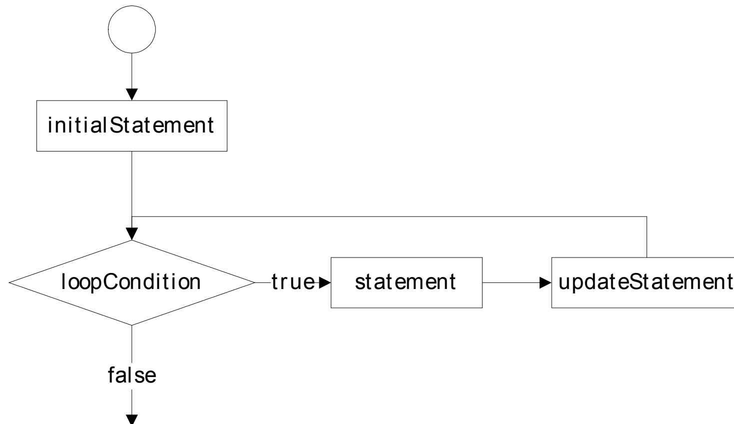
```
do n = n + 2; while (n < 137);
```

For Loops

A "for" loop has the form `for` (*initialStatement*; *loopCondition*; *updateStatement*) *statement*.

<u>*Explanations*</u>:

(Step 1) The"for" loop begins with execution of the *initialStatement*.
(Step 2) If the *loopCondition* is `true`, then *statement* (the body of the loop) is executed.
(Step 3) The *updateStatement* is executed
(Step 4) The cycle is repeated from (Step 2) until the *loopCondition* is `false`.



Example1:

```
for (i = 0; i < 10; i++) x = x + 1;
```

In this example, the statement `x = x + 1;` is executed ten times, with the variable `i` ranging from 0 to 9.

Example 2:

```
for (j = 3; j <= 10; j = j + 2) x = x + 1;
```

In this example, the statement `x = x + 1;` is executed four times, with the variable `i` taking on the values 3, 5, 7, and 9.

Input and Output Statements

The statement to write output to the console has the form

`cout <<` *item1* `<<` *item2* `<<` … `<<` *itemN*`;`

where each of *item1*, …, *itemN* is either

- an integer, float, character, or string constant, or
- an expression that evaluates to an integer or float value, or
- `endl` (indicating newline).

Examples:

```
cout << "Hello";
cout << "The answer is " << x - y << " cubic yards." << endl;
```

The statement to obtain one or more `int` or `float` values from the user has the form

`cin >>` *variable1* >> *variable2* >> ... >> *variableN*;

where each of *variable1* through *variableN* is of type `int` or `float`.

Examples:

```
int i; float x;
cout << "\nPlease enter a value for i: ";
cin >> i;
cout << "\nPlease enter values for x and y: ";
cin >> x >> y;
```

Warning: `cin` does no data validation. If you enter data that is not a valid integer or float, as applicable, a nonsense value may be assigned to *variable*; or, the computer may go into an infinite loop, forcing you to shut down the program.

Compound Statements

A *compound statement* is a sequence of one or more statements enclosed in braces. The format of a compound statement is { *statement1 statement2 … statementN* }.

```
Example: {x = 1; y = 2; if (x < y) {z = 1; w = 2;}}
```

Note: This example shows a compound statement inside an "if" statement which is in turn inside a compound statement. This is called *nesting*.

Arrays

An *array* is a sequence of values of the same type, stored in consecutive locations in the computer's memory. If the number of elements in the array is N, then the values are numbered 0, 1, 2, …, N-1.

The form of an array declaration is

element-type array-name[*array-size*];

where

element-type is a valid type, such as `int`, `float`, or `char`;
`array-name` is an identifier
`array-size` is a positive integer constant

Example: `float myArray[20];`

An array element reference has the form

array-name[*subscriptExpression*]

where

array-name is the name of the array, and
subscriptExpresssion is an expression that evaluates to an integer in the range 0 through N –1 (where N is the size of the array).

An array element reference can be used in an expression, or it can be the target of an assignment.

Example:

```
myArray[0] = 2*myArray[1] + 3*myArray[2];
```

Function Declaration and Invocation

A function declaration is of the form

return-type function-name(*parameter-type-1 paramater-name-1*,
 …, *parameter-type-N paramater-name-N*)
{
 your statements
}

The rules are:

- *return-type* is the type of value to be returned: either `int`, `float`, or `char;` or `void` if no value is to be returned.
- *function-name* is an identifier to be used as the name of the function.
- *parameter-type-1* through *parameter-type-N* are the types of the formal parameters: `int`, `float`, or `char`.
- *parameter-name-1* through *parameter-name-N* are identifiers by which the parameter values will be referred to within this function.
- If the return type is other than `void`, there must be a `return` statement in the body of the function.

A function you have defined is invoked by writing

function-name (*actual-parameter-1*, …, *actual-parameter-N*)

The rules are:

- *actual-parameter-1* through *actual-parameter-N* are expressions whose types are *parameter-type-1* through *parameter-type-N* respectively.
- You can use a function invocation as a statement, by putting a semicolon after it; or
- If the function returns a value, you can use it in an expression just as you would use a variable.
- If the function returns a value, you must have a return statement in the body of the function.

Example:

```
int biggerPlusOne(int x, int y) {
      if (x > y) return x + 1; else return y + 1;

}

. . .
int x, y, z;
. . .
z = 2*biggerPlusOne(x, y) + 5;
```

Return Statement

The format of a return statement is `return` *value*`;` where *value* is an expression that evaluates to a value of the return-type of the function. See the example above.

Class Method Invocation

A *class* is a programmer-defined data type. A class is usually provided with a set of operations, called *methods*, that can be performed on values, or *objects*, having that data type. Invoking a method is similar to invoking a function, except that the name of the method is preceded by the variable name and a period.

Example:

Assume that the class MyClass has a method getHeight that returns a `float`. Then we can write

```
float x;
MyClass xyz;
x = xyz.getHeight();
```

Compiler Directives

Compiler directives provide information to the compiler that the compiler needs to process your source code. Compiler directives are NOT statements in the C++ programming language, so C++ syntax rules do not apply to them.

Caution: compiler directives do NOT end in semicolons.

`#include` directives tell the compiler to read C++ statements from some file. There are two forms, as shown in the examples.

Example 1: `#include <iostream>` tells the compiler to read information from the iostream file, which is to be found in a folder of similar files provided with the C++ compiler system.

Example 2: `#include "SStream.h"` tells the compiler to read information from the SStream.h file, which is in the user's own folder.

`#define` directives tell the compiler to replace every occurrence of an identifier in the program with a specific constant, as though the programmer had written the constant herself.

Example 1: `#define EXIT_SUCCESS 0`

Example 2: `#define PI 3.1415926535`

Program Structure

The structure of a simple C++ program is illustrated by the following example. Some remarks are included as comments.

```
#include <cstdlib>
#include <iostream>
// Here insert any other #include statements needed.
// Also insert here any #define statements you would like.

using namespace std;

// Here insert any functions that you have written yourself.

int main(int argc, char *argv[])
{
    // Your declarations and executable statements here…

    system("PAUSE");  // Needed only for Dev-C++ compiler
    return EXIT_SUCCESS;
}
```