The Fundamentals of C++

Basic programming elements and concepts

Program Organization

- Program statement
  - Definition
  - Declaration
  - Action
- Executable unit
  - Named set of program statements
  - Different languages refer to executable units by different names
    - Subroutine: Fortran and Basic
    - Procedure: Pascal
    - Function : C++

Program Organization

- C++ program
  - Collection of definitions, declarations and functions
  - Collection can span multiple files
- Advantages
  - Structured into small understandable units
  - Complexity is reduced
  - Overall program size decreases

Object

- Object is a representation of some information
  - Name
  - Values or properties
    - Data members
  - Ability to react to requests (messages)!!
    - Member functions
- When an object receives a message, one of two actions are performed
  - Object is directed to perform an action
  - Object changes one of its properties

A First Program - Greeting.cpp

```
// Program: Display greetings
// Author(s): Ima Programmer
// Date: 1/24/2001
#include <iostream>
#include <string>
using namespace std;
int main() {
   cout << "Hello world!" << endl;
   return 0;
}
```

Preprocessor directives

Comments

Provides simple access

Function named main() indicates start of program

Ends executions of main() which ends program

Insertion statement

Function

Greeting Output

Area.cpp

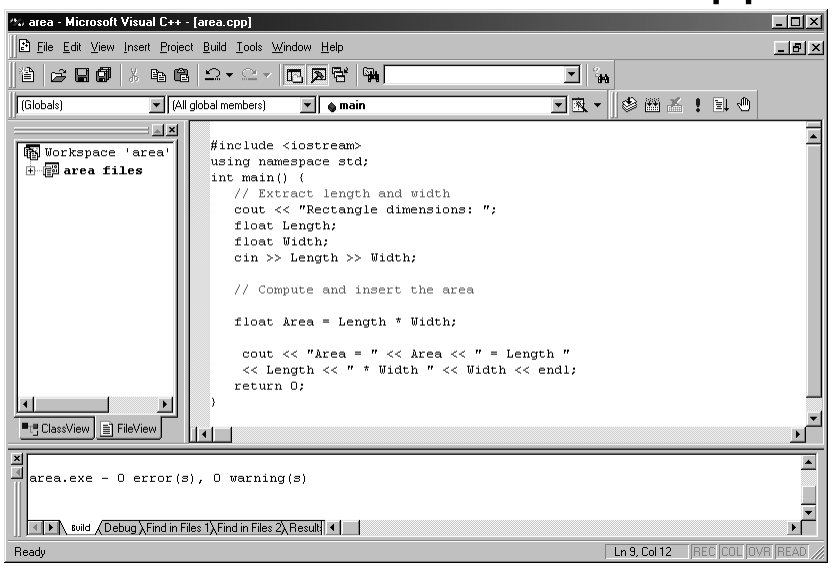
```
#include <iostream>
using namespace std;
int main() {
   // Extract length and width
   cout << "Rectangle dimensions: ";
   float Length;
   float Width;
   cin >> Length >> Width;

   // Compute and insert the area

   float Area = Length * Width;

  cout << "Area = " << Area << " = Length "
    << Length << " * Width " << Width << endl;
   return 0;
}
```

Definitions

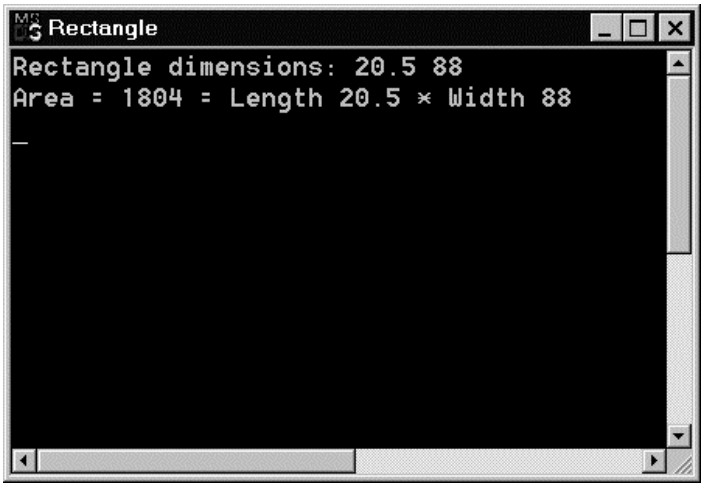
Extraction

Definition with initialization

Visual C++ IDE with Area.cpp



Area.cpp Output

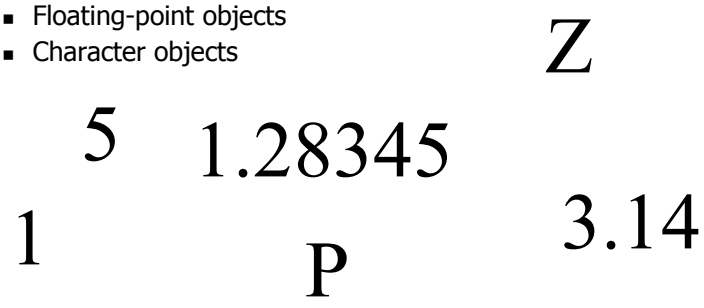


Comments

- Allow prose or commentary to be included in program
- Importance
  - Programs are read far more often than they are written
  - Programs need to be understood so that they can be maintained
- C++ has two conventions for comments
  - `//` single line comment (preferred)
  - `/*` long comment `*/` (save for debugging)
- Typical uses
  - Identify program and who wrote it
  - Record when program was written
  - Add descriptions of modifications

Fundamental C++ Objects

- C++ has a large number of fundamental or built-in object types
- The fundamental object types fall into one of three categories
  - Integer objects
  - Floating-point objects
  - Character objects



Integer Object Types

- The basic integer object type is **`int`**
  - The size of an **`int`** depends on the machine and the compiler
    - On PCs it is normally 16 or 32 bits
- Other integers object types
  - **`short`**: typically uses less bits
  - **`long`**: typically uses more bits
- Different types allow programmers to use resources more efficiently
- Standard arithmetic and relational operations are available for these types

Integer Constants

- Integer constants are positive or negative whole numbers
- Integer constant forms
  - Decimal
  - Octal (base 8)
    - Digits 0, 1, 2, 3, 4, 5, 6, 7
  - Hexadecimal (base 16)
    - Digits 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, a , b, c, d, e, f, A, B, C, D, E, F
- Consider
  - 31 oct and 25 dec

Decimal Constants

- Examples
  - 97
  - 40000L
  - 50000
  - 23a (illegal)

L or l indicates long integer

- The type of the constant depends on its size, unless the type specifier is used

Character Object Types

- Character type **`char`** is related to the integer types
- Characters are encoded using a scheme where an integer represents a particular character
- ASCII is the dominant encoding scheme
  - Examples
    - `' '` encoded as 32
    - `'A'` encoded as 65
    - `'a'` encoded as 97
    - `'+'` encoded as 43
    - `'Z'` encoded as 90
    - `'z'` encoded as 122
  - Appendix A gives the complete ASCII character set

Character Operations

- Arithmetic and relational operations are defined for characters types
  - `'a' < 'b'` is true
  - `'4' > '3'` is true
  - `'6' <= '2'` is false

Character Constants

- Explicit (literal) characters within single quotes
  - `'a','D','*'`
- Special characters - delineated by a backslash \
  - Two character sequences (escape codes)
  - Some important special escape codes
    - `\t` denotes a tab
    - `\\` denotes a backslash quote
    - `\"` denotes a double quote
    - `\n` denotes a new line
    - `\'` denotes a single
  - `'\t'` is the explicit tab character, `'\n'` is the explicit new line character, and so on

Literal String Constants

- A literal string constant is a sequence of zero or more characters enclosed in double quotes
  - `"We are even loonier than you think"`
  - `"Rust never sleeps\n"`
  - `"Nilla is a Labrador Retriever"`
- Not a fundamental type

Floating-Point Object Types

- Floating-point object types represent real numbers
  - Integer part
  - Fractional part
- The number 108.1517 breaks down into the following parts
  - 108 - integer part
  - 1517 - fractional part
- C++ provides three floating-point object types
  - **`float`**
  - **`double`**
  - **`long double`**

Floating-Point Constants

- Standard decimal notation

  134.123
  0.15F ← F or f indicates single precision floating point value

- Standard scientific notation

  1.45E6
  0.979e-3L ← L or l indicates long double floating point value

- When not specified, floating-point constants are of type **`double`**

Names

- Used to denote program values or components
- A valid name is a sequence of
  - Letters (upper and lowercase)
  - Digits
    - A name cannot start with a digit
  - Underscores
    - A name should not normally start with an underscore
- Names are case sensitive
  - MyObject is a different name than MYOBJECT
- There are two kinds of names
  - Keywords
  - Identifiers

Keywords

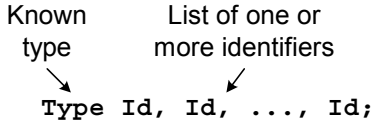
- Keywords are words reserved as part of the language
  - `int`, `return`, `float`, `double`
- They cannot be used by the programmer to name things
- They consist of lowercase letters only
- They have special meaning to the compiler

Identifiers

- Identifiers should be
  - Short enough to be reasonable to type (single word is norm)
    - Standard abbreviations are fine (but only standard abbreviations)
  - Long enough to be understandable
    - When using multiple word identifiers capitalize the first letter of each word
- Examples
  - `Min`
  - `Temperature`
  - `CameraAngle`
  - `CurrentNbrPoints`

Definitions

- All objects that are used in a program must be defined
- An object definition specifies
  - Type
  - Name
- General definition form



  - Our convention is one definition per statement!

Examples

```
char Response;
int MinElement;
float Score;
float Temperature;
int i;
int n;
char c;
float x;
```

Objects are uninitialized with this definition form

(Value of a object is whatever is in its assigned memory location)

Arithmetic Operators

- Common
  - Addition +
  - Subtraction -
  - Multiplication *
  - Division /
  - Mod %

Write `m*x + b`
not `mx + b`

- Note
  - No exponentiation operator
  - Single division operator
  - Operators are overloaded to work with more than one type of object

Integer Division

- Integer division produces an integer result
  - Truncates the result
- Examples
  - `3 / 2` evaluates to 1
  - `4 / 6` evaluates to 0
  - `10 / 3` evaluates to 3

Mod

- Produces the remainder of the division
- Examples
  - `5 % 2` evaluates to 1
  - `12 % 4` evaluates to 0
  - `4 % 5` evaluates to 4

Operators and Precedence

- Consider *mx + b*
- Consider `m*x + b` which of the following is it equivalent to
  - `(m * x) + b`
  - `m * (x + b)`
- Operator precedence tells how to evaluate expressions
- Standard precedence order
  - () Evaluate first, if nested innermost done first
  - * / % Evaluate second. If there are several, then evaluate from left-to-right
  - + - Evaluate third. If there are several, then evaluate from left-to-right

Operator Precedence

- Examples

```
20 -  4 / 5  * 2   +   3 * 5  % 4

      (4 / 5)
     ((4 / 5) * 2)
     ((4 / 5) * 2)      (3 * 5)
     ((4 / 5) * 2)    ((3 * 5) % 4)
(20 -((4 / 5) * 2))   ((3 * 5) % 4)
(20 -((4 / 5) * 2)) + ((3 * 5) % 4)
```

Defining and Initializing

- When an object is defined using the basic form, the memory allotted to it contains random information
- Better idea to specify its desired value at the same time
  - Exception is when the next statement is an extraction for the object
- Remember our convention of one definition per statement!

Examples

```
int FahrenheitFreezing = 32;
char FinalGrade = 'A';
cout << "Slope of line: ";
float m;
cin >> m;
cout << "Intercept: ";
float b;
cin >> b;
cout << "X value of interest: ";
float x;
cin >> x;
float y = (m * x) + b;
```