# Chapter 2 : Fundamentals of C++

## Basic Programming Elements & 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

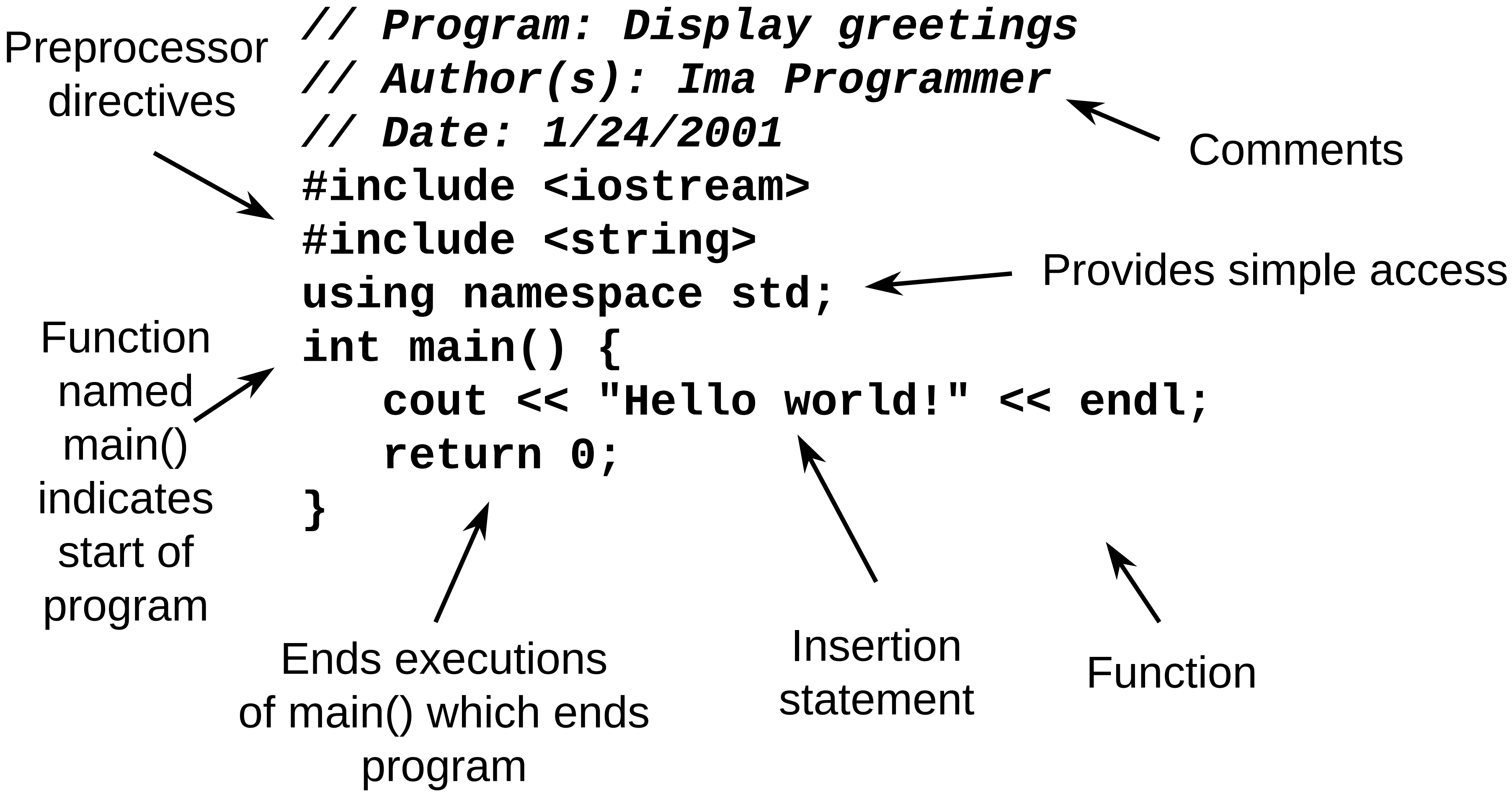
- **Advantages**
  - Structured into small understandable units
  - Complexity is reduced
  - Overall program size decreases

# 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

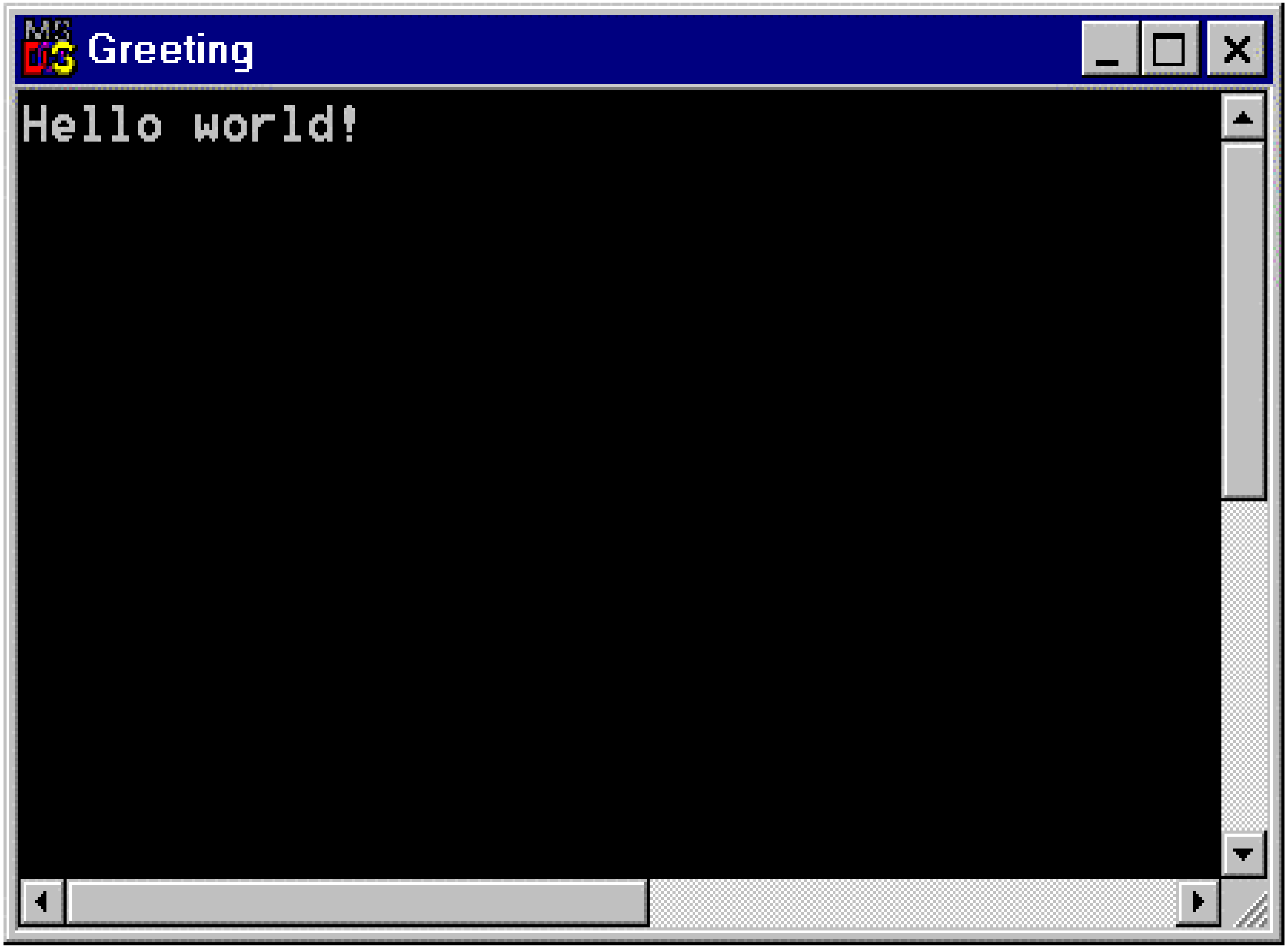
Function named main() indicates start of program

Ends executions of main() which ends program

Insertion statement

Function

# Greeting Output



```
Hello world!
```

# Area.cpp

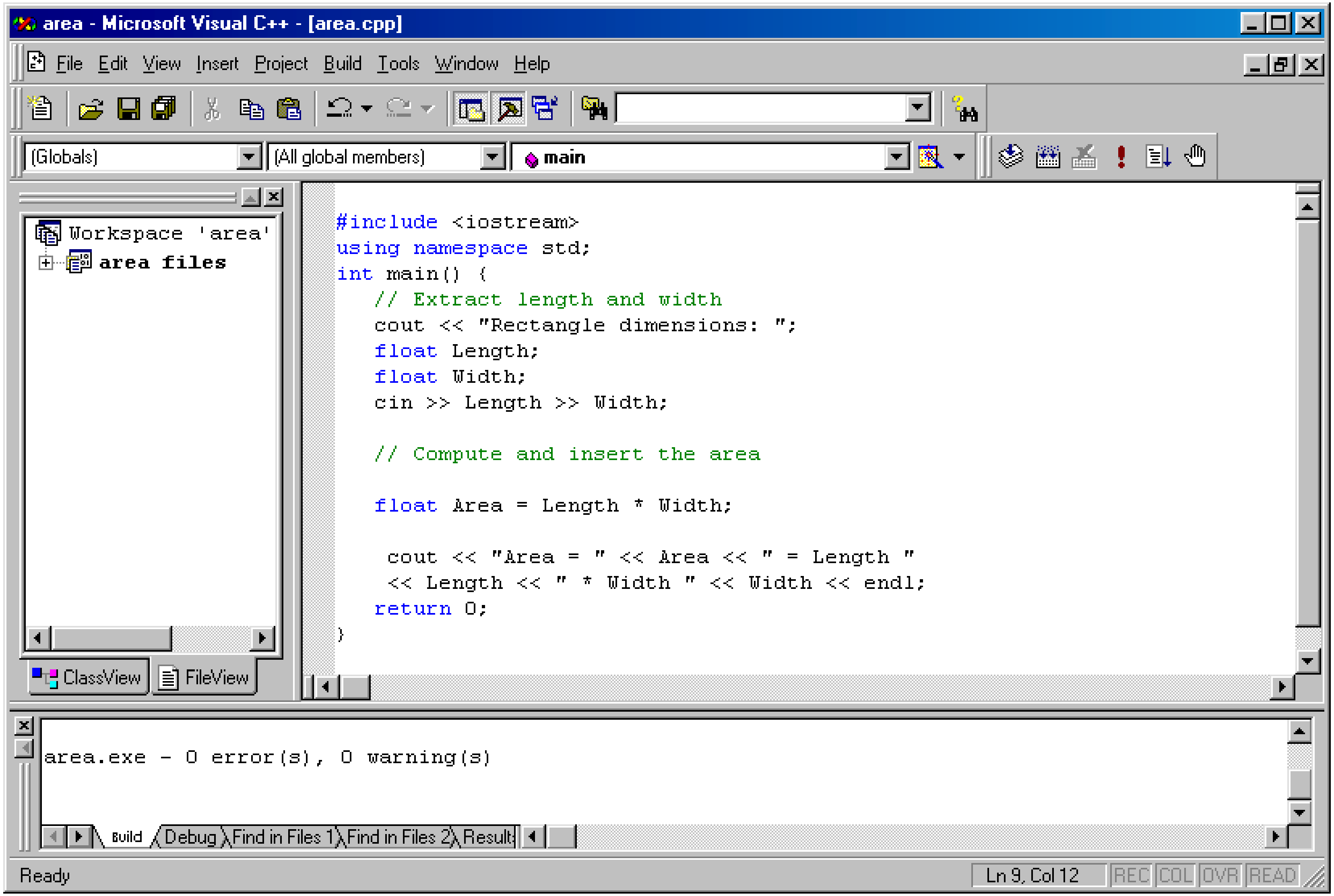
```
#include <iostream>
using namespace std;
int main() {
   // Extract length and width
   cout << "Rectangle dimensions: ";
   float Length;
   float Width;
   cin >> Length >> Width;

   // Compute and insert the area

   float Area = Length * Width;

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

Definitions

Extraction

Definition with initialization

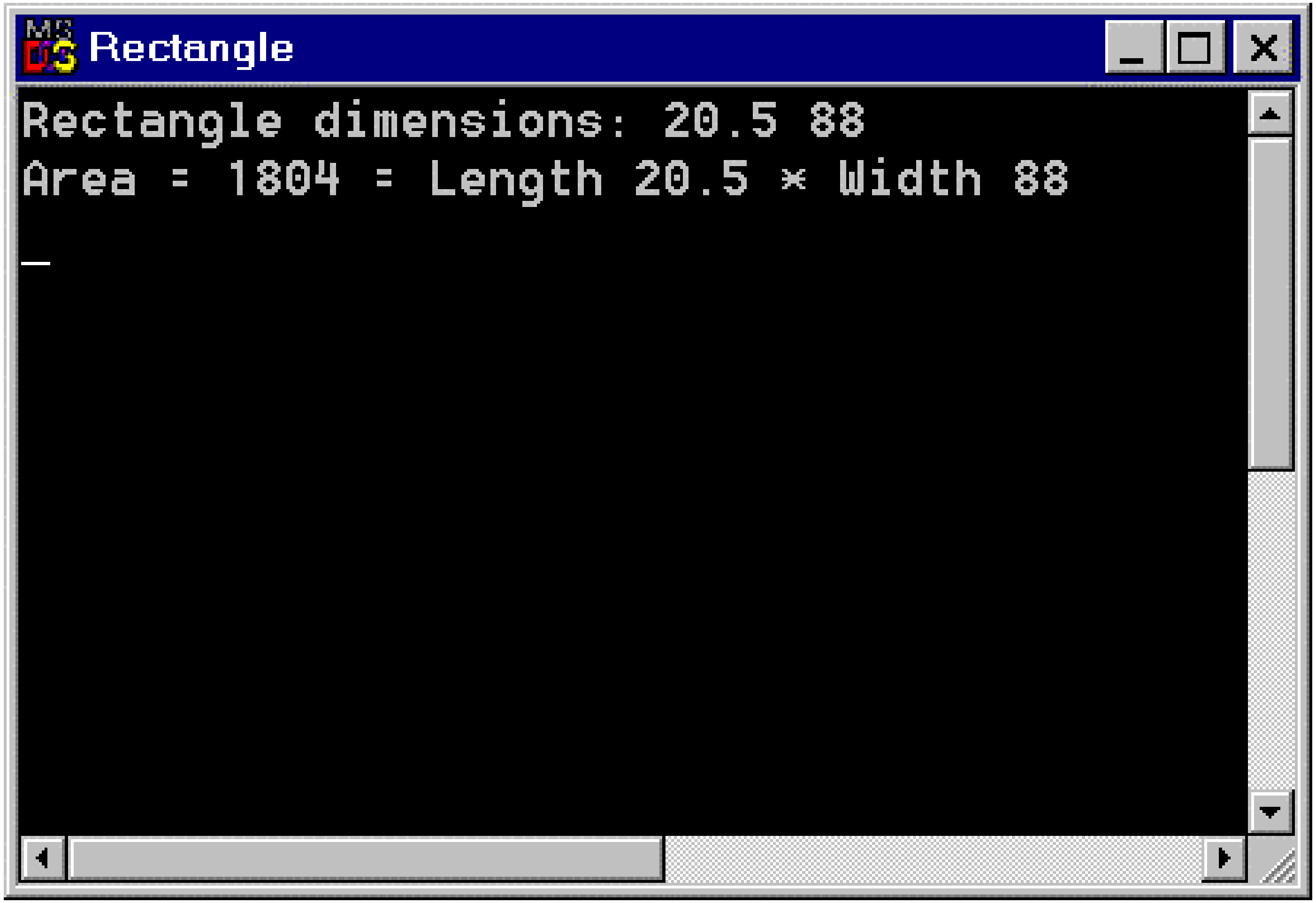
# Visual C++ IDE with Area.cpp



```
#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;
}
```

```
area.exe - 0 error(s), 0 warning(s)
```

# Area.cpp Output



```
Rectangle dimensions: 20.5 88
Area = 1804 = Length 20.5 * Width 88

_
```

# 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

# Comments (cont.)

- **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

5

Z

1.28345

3.14

1

P

# 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

# 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<br>
`'4' > '3'` is true<br>
`'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

    `\"` denotes a double quote

    `\n` denotes a new line

    `\'` denotes a single quote

  - `'\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

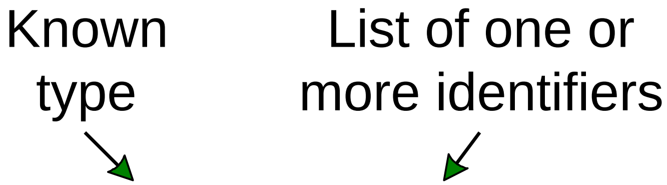
- **Identifiers should be**
  - Short enough to be reasonable to type (single word is norm)
    - Standard abbreviations are fine (but only standard abbreviations)
  - Long enough to be understandable
    - When using multiple word identifiers capitalize the first letter of each word
- **Examples**
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



Known type

List of one or more identifiers

```
Type Id, Id, ..., Id;
```

  - 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`<br>
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;
```