Syntax and Semantics

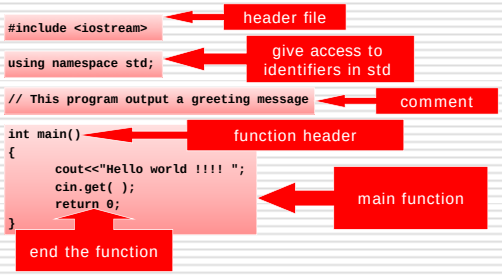
Outline

- C++ Structure
- Data types

Terminology

- A *programming language* is a set of rules, symbols, and special words used to construct a program.
- *Syntax* (grammar) is a set of rules that precisely states how valid instructions to be constructed in C++.
- *Semantics* (meaning) is the correctness of instructions written in C++.

C++ Structure



C++ Program

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

/* This program computes the sum and product of two integers. */

int main(void)
{
  int Number1, Number2, Sum, Product;
  Number1 = -5;
  Number2 = 10;
  Sum = Number1 + Number2;
  Product = Number1 * Number2;
  cout<<"The sum is "<<Sum<<'\n';
  cout<<"The product is "<<Product;
  return 0;
}
```

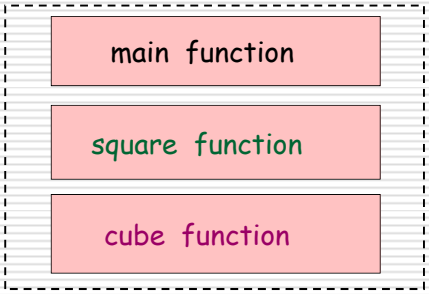

Another C++ Program

```
#include <iostream>

int Square( int );      // declares these two
int Cube( int );          // value-returning functions

using namespace std ;

int main( )
{
    cout << "The square of 27 is " << Square(27) << endl;   // function call
    cout << "The cube of 27 is " << Cube(27) << endl;       // function call
    return 0;
}
int Square( int n )
{
     return n * n;
}

int Cube( int n )
{
    return n * n * n;
}
```


Output of program

```
The square of 27 is 729
The cube of 27 is 19683
```


Program With Several Functions



C++ Structure

- All C++ programs have
  - header file(s)
  - a *function* called *main*.
- *Function* is a subprogram in C++.
- *Begin { and end } markers*: to indicate the beginning and ending of a block of statements to be executed.

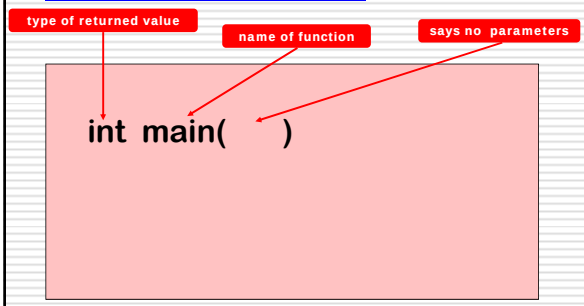
C++ function Structure

```
int main (   )
{

  return 0;
}
```

Function heading

Function body

What is in a heading?



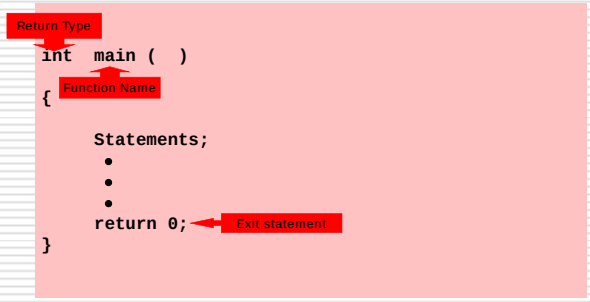
Block(Compound Statement)

- A block is a sequence of zero or more statements enclosed by a pair of curly braces { }

SYNTAX

```
{
  Statement (optional)
                .
                .
                .
}
```

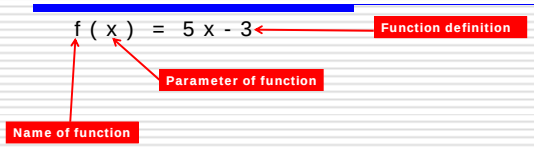
C++ function Structure



Exit status

- The integer value returned by **main** to the operating system when it completes execution
- Exit status of 0 indicate successful completion of the program on most computer systems
- Nonzero value indicates an error

Function Concept in Math



When x = 1, f (x) = 2 is the returned value.
When x = 4, f (x) = 17 is the returned value.
Returned value is determined by the function definition and by the values of any parameters.

Functions

In C++ there are two types of functions, *predefined functions* and *user-defined functions.*

- Predefined or built-in functions come with libraries of C++.
- User-defined functions are created by programmers.

Predefined Functions

Function Name	Type of Arguments	Type of Value Returned	Purpose
sqrt(x)	double	double	square root of x
floor(x)	double	double	largest integer < x
ceil(x)	double	double	smallest integer > x

```
Total_Weight = floor(Weight);
Total_Amount = ceil(SubTotal1 + SubTotal2);
```


Identifiers

An *identifier* is a name associated with a function or data object (variable, data type).

- Combinations of letters (A…Z, a…z), digits (0…9), and underscore (_)
- Must begin with a letter or underscore
- No special characters such as +, $, , *, ', etc.
- Case sensitive

More About Identifiers

- Some C++ compilers recognize only the first 32 characters of an identifier as significant
- Then these identifiers are considered the same:

```
age_Of_This_Old_Rhinoceros_At_My_Zoo
age_Of_This_Old_Rhinoceros_At_My_Safari
```

- Consider these:

```
Age_Of_This_Old_Rhinoceros_At_My_Zoo
age_Of_This_Old_Rhinoceros_At_My_Zoo
```


Examples

- Valid identifier:
  - Value2, Sum, Integer1, Product, Total_Income
- Invalid Identifier:
  - Number 1, 2Data, First-Initial, Cost_in_$, float

Reserved Words

A *reserved word* is a predefined word with a special meaning in C++ (appendix A-1), e.g., int, if, else, for, switch...

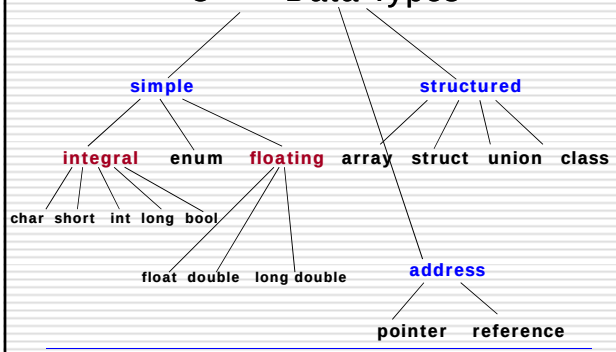
Data and Data Types

- Each data in C++ has a type associated with it.
- A *data type* is a set of data together with a set of operations on the data values, e.g., char, short, int, float, long...

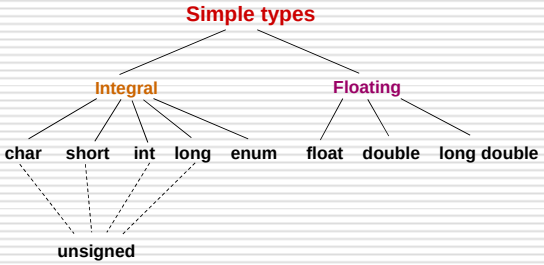
Classifications of Data types

- *Integral type*:
  - An *integral type* is a data type possesses integer values, e.g., char, short, int, and long.
- *floating type*:
  - A *floating type* is a data type with a set of operations on real numbers, e.g., float, double (double precision), and long double.

C++ Data Types



C++ Simple Data Types



Integral Types

- int
  - 123, +123, -123, 22333
- char
  - 'S', 'c', '4', '@'

Integral Types

Type	Size in Bytes	Minimum Value	Maximum
char	1	-128	127
unsigned char	1	0U	255U
short	2	-32,768	32,767
unsigned short	2	0U	65,535U
int	4	-2147483648	2147483647
unsigned int	4	0U	4,294,967,295U
long	8	-9223372036854775808L	9223372036854775807L
unsigned long	8	0UL	18446744073709551616UL

Floating-Point Types

- A real number or a floating number has an integer part and a fractional part, with a decimal point in between e.g., 18.0, 127.54, 0.57, 4., .8, 1.74536E-12, 3.652442E4, 7E20.

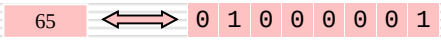
Type	Size in Bytes	Minimum Value	Maximum
float	4	3.4E-38	3.4E+38
double	8	1.7E-308	1.7E+308
long double	10	3.4E-4932	1.1E+4932

Variables

- A *variable* is a location in memory that stores a data value which can be changed and reference by an identifier, e.g.,

Data1

(memory location: 125=1111101)



Declaration

- A statement that associates an identifier with a data object, a function, or a data type is called declaration statement.
- A declaration tells the compiler to allocate enough memory to hold a value of this data type and to associate the identifier with this location

```
data type Identifier, Identifier, …;
```

- int Number1; allocate 4 bytes for Number1
- char FirstInitial; allocate 1 byte for FirstInitial
- float Wages; allocate 4 bytes for Wages

Constants

A *constant variable* a location in memory that we can refer to by an identifier, and in which a **data value that cannot be changed** is stored.

```
const data type identifier = literal value
```

- `const float PI = 3.14159;`
- `const int MaxHours = 40;`
- `const char Blank = ' ';`
- `Const string STARS = "****";`

C++ Data Type String

- a string is a sequence of characters enclosed in double quotes
- string sample values

  "Hello"

  "Year 2000"

  "1234"

  "Joe Nobody"
- the empty string (null string) contains no characters and is written as ""

Strings

- A value of type char is limited to a single character
- A string is a sequence of characters enclosed in double quotes, e.g.,
  - `"Problem Solving"`
  - `"C++"`
  - `"Programming and "`
  - `" . "`
- A string must be typed entirely on one line. The following string is invalid:

```
"This string is invalid because it
is typed on more than one line."
```


More About Type String

- string is not a built-in (standard) type
  - it is a programmer-defined data type
  - it is provided in the C++ standard library
- string operations include
  - comparing 2 string values
  - searching a string for a particular character
  - joining one string to another

What is an Expression in C++?

- An *expression* is a valid arrangement of variables, constants, and operators
- In C++ each expression can be evaluated to compute a value of a given type.
- The value of the expression

  9 + 5 is 14

Mathematical Operations

+	**Unary plus**
-	**Unary minus**
+	**Addition**
-	**Subtraction**
*	**Multiplication**
/	**Division**
%	**Modulus**

A *unary operator* is an operator with one operand.
A *binary operator* is an operator with two operands.

Precedence of C++ Operators

- / % *
- + –

Examples

```
Sum = Num1+ Num2;
Average = (Num1+ Num2)/2;
W = X * Y / X + Y;
Delta = B * B – 4 * A * C;
Quotient = X / Y;
Remainder = X % Y;
```


Type of Arithmetic Expressions

combining float with either integer or float
⇒ float
combining integers or floats with /
⇒ integer or float
combining integers with either +, –, *
⇒ integer
% can be used with only integer

Division Operator

```
11/4      = 2
11.0/4.0  = 2.75
11/4.0    = 2.75
```

Modulus %

- The modulus operator % yields the *integer remainder* of the result of dividing its first operand by its second.
- If either one of the operands is negative, the sign of the result is machine-dependent.

Examples

```
 14 %  3 =  2
-14 %  3 = -2
 14 % -3 =  2
-14 % -3 = -2
```


Increment and Decrement Operators

++ Increment

-- decrement

Examples:

`Num + + or + + Num ⇔ Num = Num + 1`

Assignment Statement

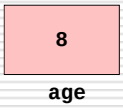
- An *assignment statement* is a statement that assigns the value of an expression into a variable.

```
Variable = Expression;
```

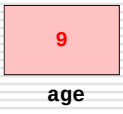
- *Expression is* an arithmetic expression, another identifier or a literal value
- first, Expression on right is evaluated
- then the resulting value is stored in the memory location of Variable on left
- An automatic type coercion occurs after evaluation but before the value is stored if the types differ for Expression and Variable

Example

- `int age;`
- `age = 8;`

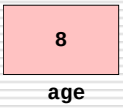


- `age = age + 1;`

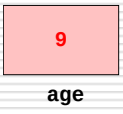


PREFIX FORM Increment Operator

- `int age;`
- `age = 8;`

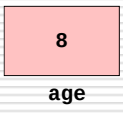


- `++age;`

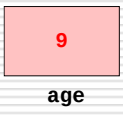


POSTFIX FORM Increment Operator

- `int age;`
- `age = 8;`

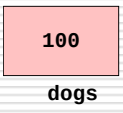


- `age++;`



Decrement Operator

- `int dogs;`
- `dogs = 100;`



- `dogs--;`

Which Form to Use

- when the increment (or decrement) operator is used in a "stand alone" statement solely to add one (or subtract one) from a variable's value, it can be used in either prefix or postfix form

dogs-- ; **--dogs ;**

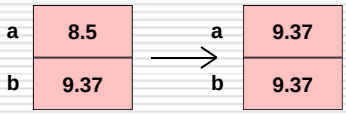
BUT…

- when the increment (or decrement) operator is used in a statement with other operators, the prefix and postfix forms can yield ***different*** results

WE'LL SEE HOW LATER . . .

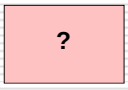
What value is stored?

```
float  a;
float  b;

a = 8.5;
b = 9.37;
a = b;
```



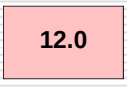
What is stored?

```
float  someFloat;
```



someFloat

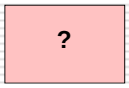
```
someFloat = 12; //causes implicit type conversion
```



someFloat

What is stored?

```
int  someInt;
```



someInt

```
someInt = 4.8; //causes implicit type conversion
```

someInt

Type Casting is Explicit Conversion of Type

```
int(4.8)     = 4

float(5)     = 5.0

float(7/4) = 1.0

float(7)/float(4)    = 1.75
```


Some Expressions

```
int  age;
   EXAMPLE                  VALUE
   age = 8                    8
   - age                     -8
   5 + 8                     13
   5 / 8                      0
   6.0 / 5.0                1.2
   float ( 4 / 8 )          0.0
   float ( 4 ) / 8          0.5
```


What values are stored?

```
float  loCost;
float  hiCost;

loCost = 12.342;
hiCost = 12.348;

loCost = float(int(loCost*100.0+0.5))/100.0;

hiCost = float(int(hiCost*100.0+0.5))/100.0;
```

loCost hiCost

Examples

- `Count = 153;`
- `Count = Count1;`
- `Num1 = Num2*Num3/Num4;`
- `MidInit = 'A';`

More Examples

```
{
   ...
   int Number1;
   char FirstInitial;
   const float HourRate = 5.65;
   float Wages;
   int Hours;

   Number1 = 65;
   FirstInitial = 'a';
   Wages = HourRate*Hours;
   ...
}
```


String Concatenation (+)

- concatenation is a binary operation that uses the + operator
- at least one of the operands must be a string variable or named constant--the other operand can be string type or char type

Concatenation Example

```
const   string  WHEN = “Tomorrow” ;
const   char    EXCLAMATION = ‘!’ ;
string  Message1 ;
string  Message2 ;

Message1 = “Yesterday “ ;
Message2 = “and “ ;
Message1 = Message1 + Message2 +
               WHEN + EXCLAMATION ;
```

Insertion Operator <<

- variable cout is predefined to denote an output stream that goes to the standard output device (display screen)
- the insertion operator << called "put to" takes 2 operands
- the left operand is a stream expression, such as cout. The right operand is an expression of simple type or a string constant

Output Statements

Syntax

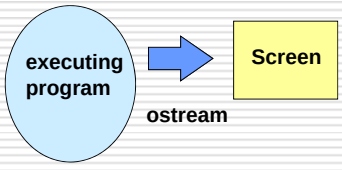
```
cout << Expression << Expression <<...;
```

These examples yield the same output:

```
cout << "The answer is ";
cout << 3 * 4 ;
cout << "The answer is " << 3 * 4;
```


No I/O is built into C++

- Instead, a library provides an output stream



Is compilation the first step?

- No. Before your source program is compiled, it is first examined by the preprocessor to
  - remove all comments from source code
  - handle all preprocessor directives--they begin with the # character such as #include <iostream>
  - tells preprocessor to look in the standard include directory for the header file called iostream and insert its contents into your source code

Using Libraries

- A library has 2 parts
  - Interface (stored in a header file) tells what items are in the library and how to use them.
  - Implementation (stored in another file) contains the definitions of the items in the library.
- `#include <iostream>`
  - Refers to the header file for the `iostream` library needed for use of `cout` and `endl`.

C++ Preprocessor

Numerous libraries of functions are included as part of any C++ programming package. The actual code for these libraries has been already compiled and to be added to the program during the compiling phase of program construction. We use *compiler directive* **`#include`** to inform the compiler which libraries are needed or to be included in the source program.

Examples

```
#include <iostream>
#include <iomanip>
#include <iomanip>
#include <cmath>
#include <string>
```

`iostream` is called a *header file* whose contents are inserted in place of the **`#include`** line during compilation. These header files can be found in *c:\Program Files\Microsoft Visual Studio\Vc98\Include*

Namespace

- A **`namespace`** contains identifiers that used or declared in header files.
- The namespace for identifiers in these header files is called *`std`*
- The purpose of a **`namespace`** is to provide a mechanism that minimizes the possibility of accidentally duplicating names in various parts of a program.

Namespace directive

`using namespace std;`

`using` directive in the line indicates that there are identifiers in the **`namespace`** called **`std`** will be used in the program.

Another way to reference identifiers in the namespace **`std`** is by using a *qualified* name

`std :: cout`

C++ Program

```
// ***************************************************
//  PrintName program
//  This program prints a name in two different formats
// ***************************************************

#include <iostream>                    // for cout and endl
#include <string>                      // for data type string

using namespace std;

const  string  FIRST = "Herman";  // Person's first name
const  string  LAST =  "Smith";   // Person's last name
const  char    MIDDLE = 'G';      // Person's middle initial

int  main( )
{
     string    firstLast;    //  Name in first-last format
     string    lastFirst;    //  Name in last-first format

     firstLast = FIRST + " " + LAST ;
     cout  << "Name in first-last format is "  << endl
           << firstLast  <<  endl;

     lastFirst = LAST + ", " + FIRST + ' ' ;
     cout  << "Name in first-last format is "  << endl
           << lastFirst  <<  MIDDLE  <<  '.'  <<  endl;

     return  0;
}
```


Output of Program

```
Name in first-last format is
Herman Smith
Name in last-first-initial format is
Smith, Herman G.
```