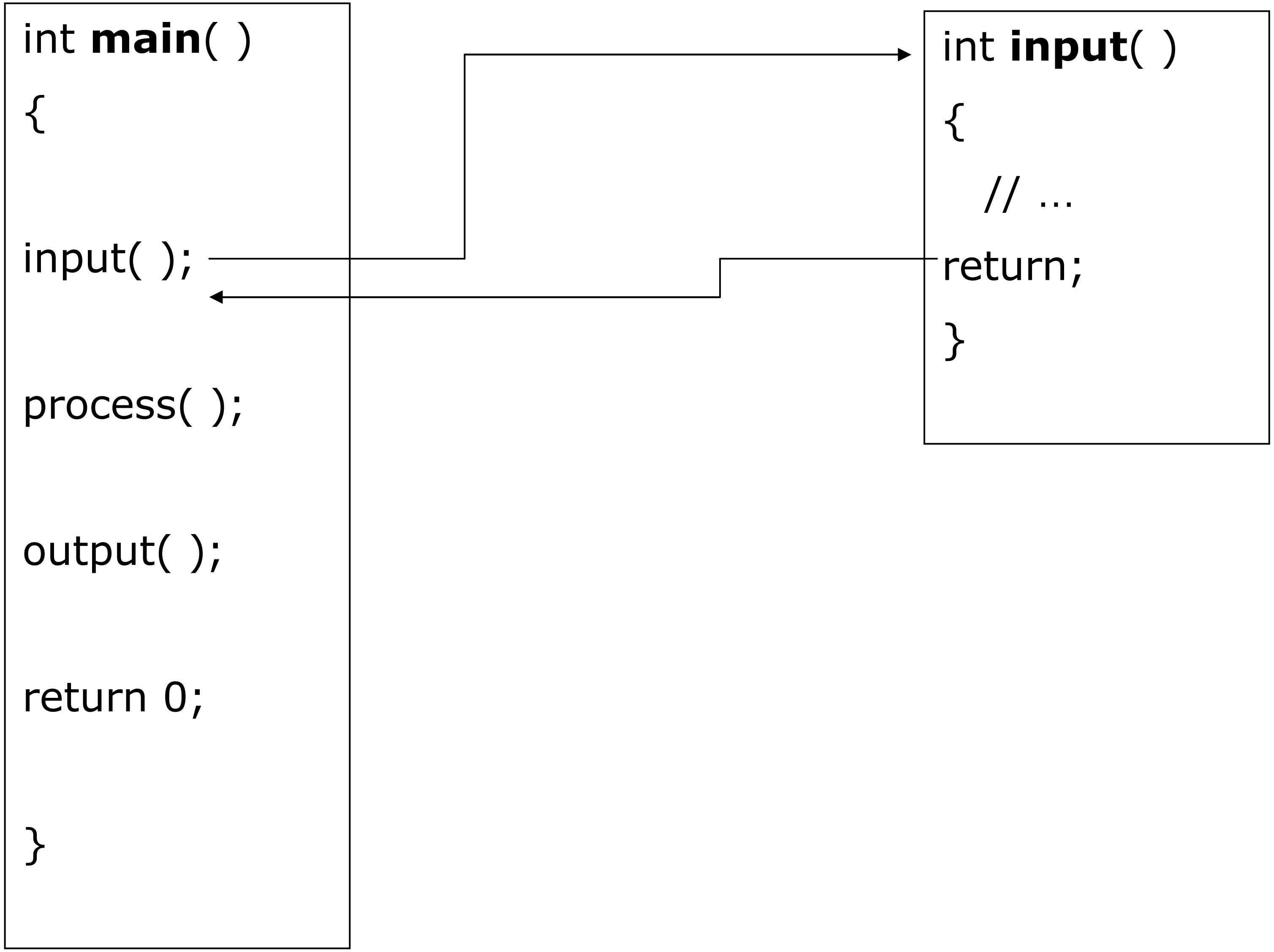
Chapter 2

Data, Variables, and Calculations

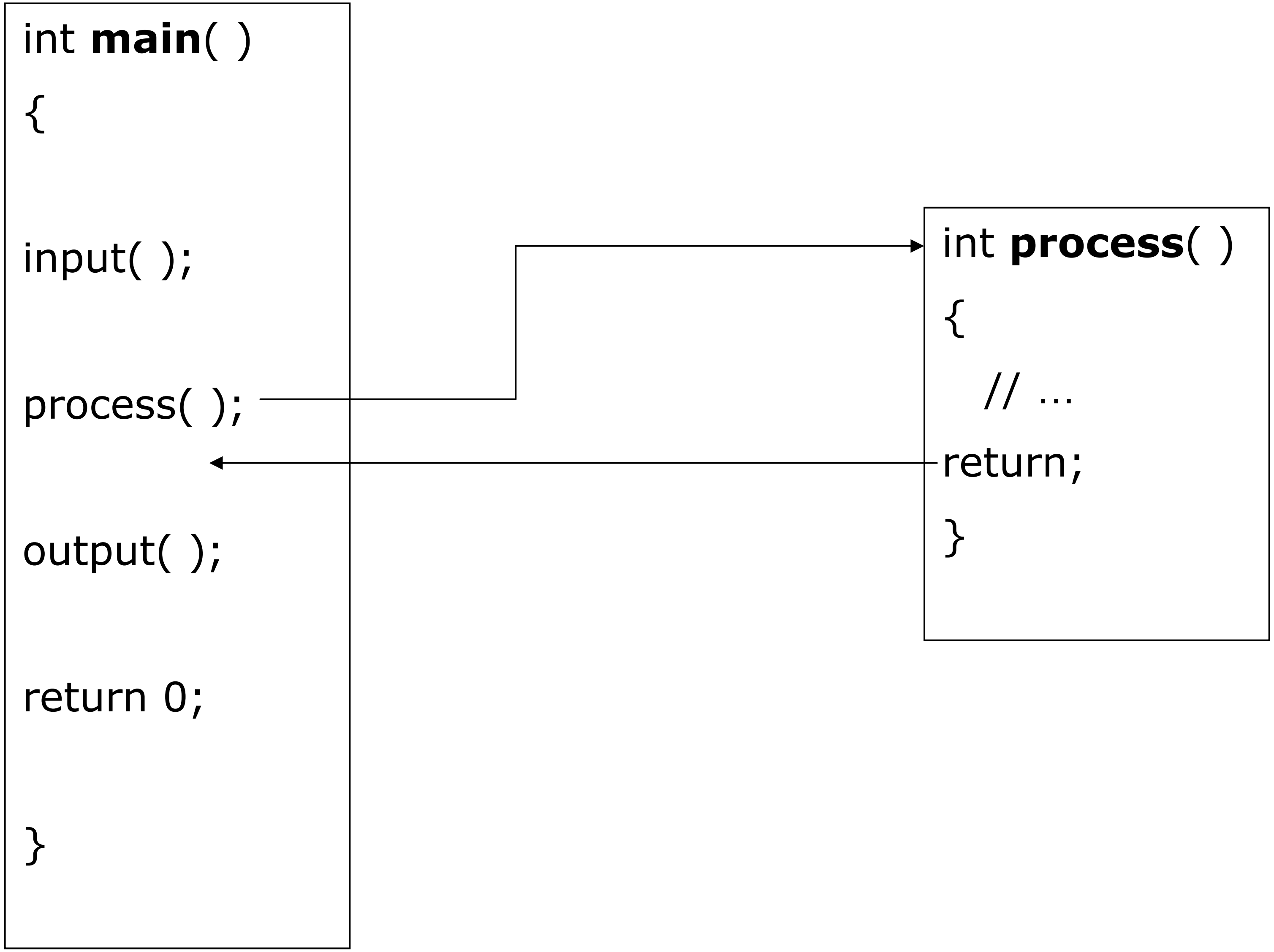
The Structure of a C++ Program



```
int main( )
{

input( );


process( );


output( );


return 0;


}
```

```
int input( )
{
   // …
return;
}
```

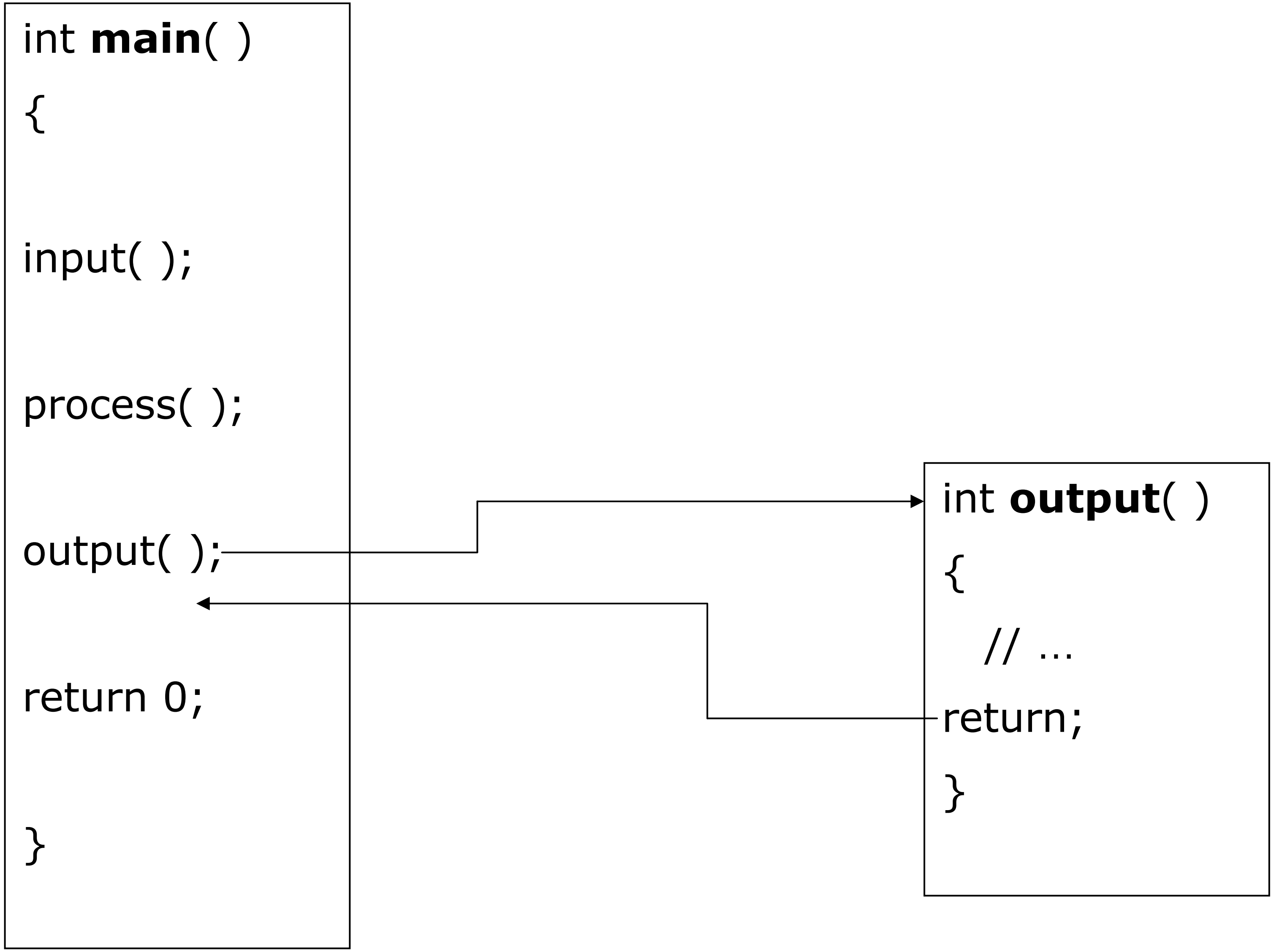
The Structure of a C++ Program



```
int main( )
{

input( );

process( );

output( );

return 0;

}
```

```
int process( )
{
   // …
return;
}
```

The Structure of a C++ Program



```
int main( )
{

input( );

process( );

output( );

return 0;

}
```

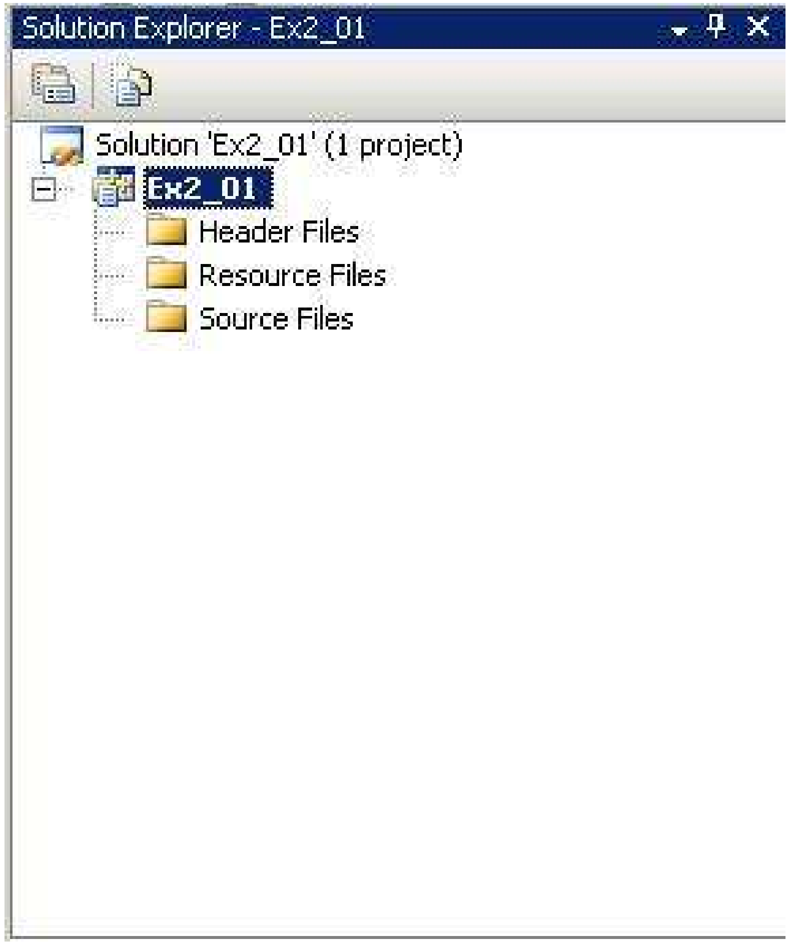
```
int output( )
{
   // …
return;
}
```

main( )

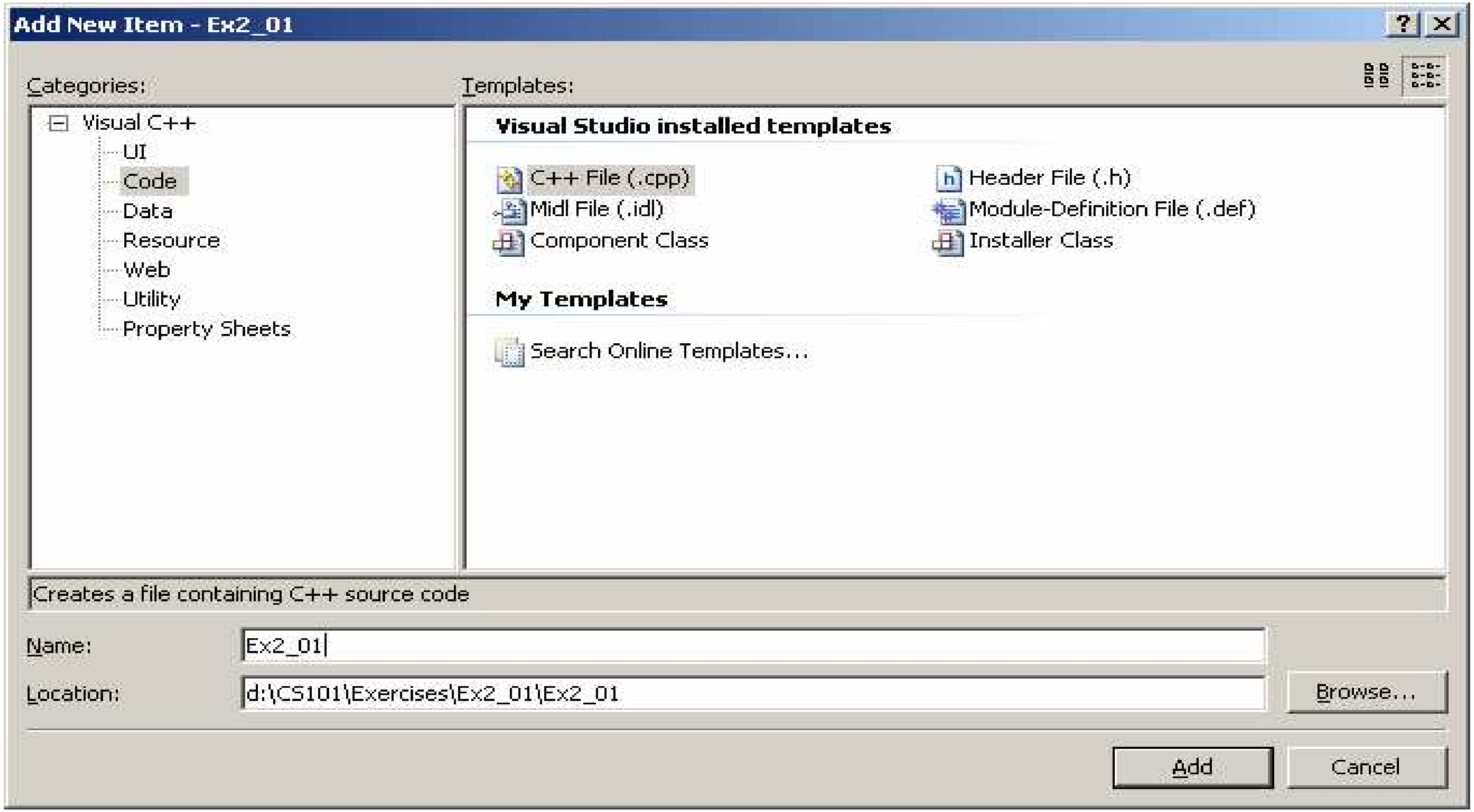
- Every ANSI/ISO standard C++ program contains the function main().
- A Program in C++ consists of one or more functions.
- A function is simple a self-contained block of code with a unique name.
  - You can invoke a function by its name.
- The principal advantage of having a program broken up into functions is that you can write and test each piece separately.
  - Re-use

Ex2_01

- Start a new Win32 Console Project
  - Ctrl+Shift+N
  - Choose Empty project
  - Right-click Source Files and Add > New Item
- Choose category Code and template C++ file (.cpp).



Add New Item



Creates a file containing C++ source code

Name: Ex2_01

Location: d:\CS101\Exercises\Ex2_01\Ex2_01

Syntax of C Language

```
// Ex2_01.cpp
// Simple calculation
#include <iostream>

using std::cout;
using std::endl;

int main()
{
    int a, b, c;

    a = 10;
    b = 20;
    c = a + b;

    cout << "The summation a + b = ";
    cout << c;
    cout << endl;

}
```

Comments begin with //

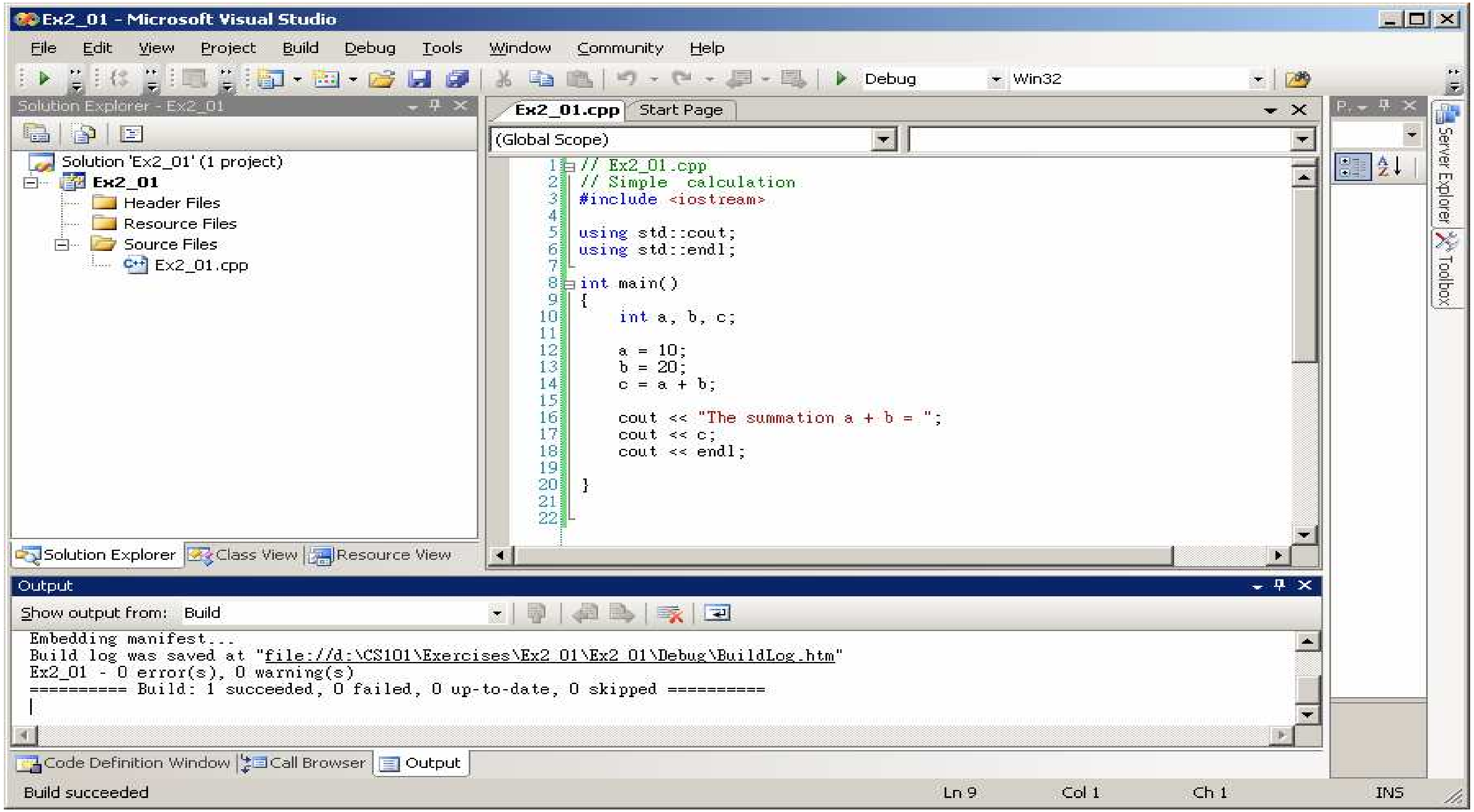
A statement block is enclosed by braces.

Whitespace

Each statement ends with a semicolon.

End-of-Line

<F7> to Build



```
// Ex2_01.cpp
// Simple  calculation
#include <iostream>

using std::cout;
using std::endl;

int main()
{
    int a, b, c;

    a = 10;
    b = 20;
    c = a + b;

    cout << "The summation a + b = ";
    cout << c;
    cout << endl;

}

```

```
Embedding manifest...
Build log was saved at "file://d:\CS101\Exercises\Ex2_01\Ex2_01\Debug\BuildLog.htm"
Ex2_01 - 0 error(s), 0 warning(s)
========== Build: 1 succeeded, 0 failed, 0 up-to-date, 0 skipped ==========
```

Naming Variables

- Variable names can include the letters A-Z, a-z, the digits 0-9, and the underscore character (_).
  - Variable names cannot begin with digits.
  - Avoid naming a variable name to begin with an underscore (_this, _that), because it may conflict with standard system variables.
- Variable names are case-sensitive.
- Convention in C++
  - Classes names begin with a capital letter.
  - Variable names begin with a lowercase letter.

Naming Variables (2)

- In Visual C++ 2005, variable names can be up to 2048 characters long.
  - number_of_students
  - strips_per_roll
- However, not all compilers support such long names.
  - It's a good idea to limit names to a maximum of 31 characters.
- Illegal variable names:
  - 8_Ball, 7UP
  - Hash!, Mary-Ann

Declaring Variables

- `int value;`
  - This declares a variable with the name `value` that can store integers.
- `int i, j, k;`
  - A single declaration can specify the names of several variables.
  - However, it is better to declare each variable in a single line. (Why?)
- `int value = 10;`
  - When you declare a variable, you can also assign an initial value to it.

Integer Types & Character Types

- Integer Types
  - int // 4 bytes
  - short // 2 bytes
  - long // 4 bytes,
    - the same as int in Visual C++ 2005
- Character Data Types
  - char letter = ‘A’; // 1 byte
    - Single quote, not double quote (“)
    - The ASCII code of the character is stored in that byte.
    - Therefore, it is equivalent to `char letter = 65;`

Integer Type Modifier

- Examples:
  - signed int;   // equivalent to int
  - signed short;   // equivalent to short
    - Range: -32768 ~ 32767
  - unsigned short;
    - Range: 0 ~ 65535
  - signed char;
    - Range: -128 ~ 127
  - unsigned char;
    - Range: 0 ~ 255

Boolean Type

- Examples:
  - `bool testResult;`
  - `bool colorIsRed = true;`
- In old C language, there is no `bool` data type.
  - Variables of type `int` were used to represent logical values.
    - Zero for false; non-zero for true.
    - Symbols TRUE and FALSE are defined for this purpose.
    - Note that TRUE and FALSE are not C++ keywords.
    - Don't confuse `true` with TRUE.

Floating-Point Type

- A floating-point constant contains a decimal point, or an exponent, or both.
  - 112.5
  - 1.125E2 (1.125×10^2)
- Examples:
  - double inch_to_cm = 2.54;
    - 8 bytes
    - Ref. Chapter 3 of Forouzan:
      - 1 bit sign
      - 11 bit exponent
      - 52 bit mantissa
  - float pi = 3.14159f;
    - 4 bytes

Enumeration

- Declare an enumeration type `Week`, and the variable `thisWeek;`
  - `enum Week {Sun, Mon, Tue, Wed, Thu, Fri, Sat} thisWeek;`
- You may then assign one enumeration constant as the value to the variable `thisWeek:`
  - `thisWeek = Thu;`
- Actually, the first name in the list, `Sun`, will have the value 0, `Mon` will be 1, and so on.

The const Modifier

- `const float inch_to_cm = 2.54;`
  - If you accidentally wrote an incorrect statement which altered the value of `inch_to_cm`, the compiler will fail and complain.
  - Avoid using magic numbers like 2.54 in your program when the meaning is not obvious. Declare a constant for it.
- All the above data types can have const modifiers.
- Constant Expressions
  - `const float foot_to_cm = 12 * inch_to_cm;`

Basic Input/Output Operations

- Input from the keyboard
  - `cin >> num1 >> num2;`
- Output to the command Line
  - `cout << num1 << num2;`
  - `cout << num1 << ‘ ‘ << num2;`
  - `cout << setw(6) << num1 << setw(6) << num2;`
    - `#include <iomanip>`
    - Causes the next output value to have width of 6 spaces.

Escape Sequences

- An escape sequence starts with a backslash character, \.
  - `cout << endl << “This is a book.”;`
  - `cout << endl << “\tThis is a book.”;`
- Some useful escape sequences:

\a	alert with a beep
\n	newline
\b	backspace
\t	tab
\’	single quote
\”	double quote
\\	backslash

Assignment Statement

- *variable* = *expression* ;
  - `c = a + b;`
  - `q = 27 / 4;  // the quotient is an integer`
  - `r = 27 % 4;  // remainder`
- Repeated assignment
  - `a = b = 2;`
- Modifying a variable
  - `d = a + b / c;           // d = a + (b / c)`
  - `count = count + 5;`
  - `count += 5;        // shorthand notation`
  - `count *= 5;        // count = count * 5`
  - `a /= b + c;        // a = a / (b + c)`

Increment Operators

- Frequently used in C++
- The following statements have exactly the same effect:

```
count = count + 1;
count +=1;                    // shorthand
++count;                      // unary operator
```

- Prefix form: increment before the value is used.

```
int total, count = 1;
total = ++count + 6;          // count=2; total = 8
```

- Postfix form: increment after the value is used.

```
total = count++ + 6;          // total = 7; count=2
total = 6 + count++;
```

Decrement Operators

- Unary operator to decrease the integer variable by 1.
  - `total = --count + 6;`
  - `total = 6 + count--;`

- Both increment and decrement operators are useful in **loops**, as we shall see in Chapter 3.

Comma Operator

- Specify several expressions in an assignment
  - `int num1;`
  - `int num2;`
  - `int num3;`
  - `int num4;`
  - `num4 = (num1=10, num2=20, num3=30);`
- Operator Precedence (see P.77)
- It is a good idea to insert parentheses to make sure.

Casting

- The conversion of a value from one type to another
  - Implicit cast
    - `int n;`
    - `float a = 7.0;`
    - `float b = 2.0;`
    - `float c = a / b;`
    - `n = c;`
      - The floating-point value will be rounded down to the nearest integer (3)
      - The compiler will issue a warning.
  - Explicit cast
    - `n = static_cast<int> ( c );`
      - The compiler assumes you know what you are doing and will not issue a warning.
  - Old-style cast (not recommended)
    - `n = (int) c ;`

Bitwise Operators

- The bitwise operators are useful in programming hardware devices.
  - Review Chapter 4 of Forouzan.

&	AND
|	OR
^	exclusive OR
~	NOT
>>	shift right
<<	shift left

- You may pack a set of on-off flags into a single variable.

Examples of Bitwise Operators

- Bitwise AND
  - `char letter = 0x41;`
  - `char mask = 0x0F;`
  - `letter = letter & mask;`
- Bitwise Shift Operators
  - `char j = 2;// 0000 0010`
  - `j <<= 1;   // 0000 0100`
  - `j >>= 2;   // 0000 0001`
  - `J = -104;  // 1001 1000`
  - `J >>= 2;   // 1110 0110   (=?)`

Storage Duration and Scope

- Duration
  - Automatic storage duration
  - Static storage duration
  - Dynamic storage duration (Chapter 4)
- Scope
  - The part of your program over which the variable name is valid.

Automatic Variables

- Automatic variables have **local scope** (**block scope**).
  - Every time the block of statements containing a declaration for an automatic variable is executed, the variable is created anew.
  - If you specified an initial value for the automatic variable, it will be reinitialized each time it is created.
  - When an automatic variable dies, its memory on the stack will be freed for used by other automatic variables.

Ex2_07.cpp in P.89

- From the viewpoint of the outer block, the inner block just behaves like a single statement.
- The inner block also declares a variable named `count1`, so the variable `count1` declared in the outer block becomes hidden now.
- Other variables (`count3`) declared at the beginning of the outer scope are accessible from within the inner scope.
- After the brace ending the inner scope, `count2` and the inner `count1` cease to exist.
- Try to uncomment the line

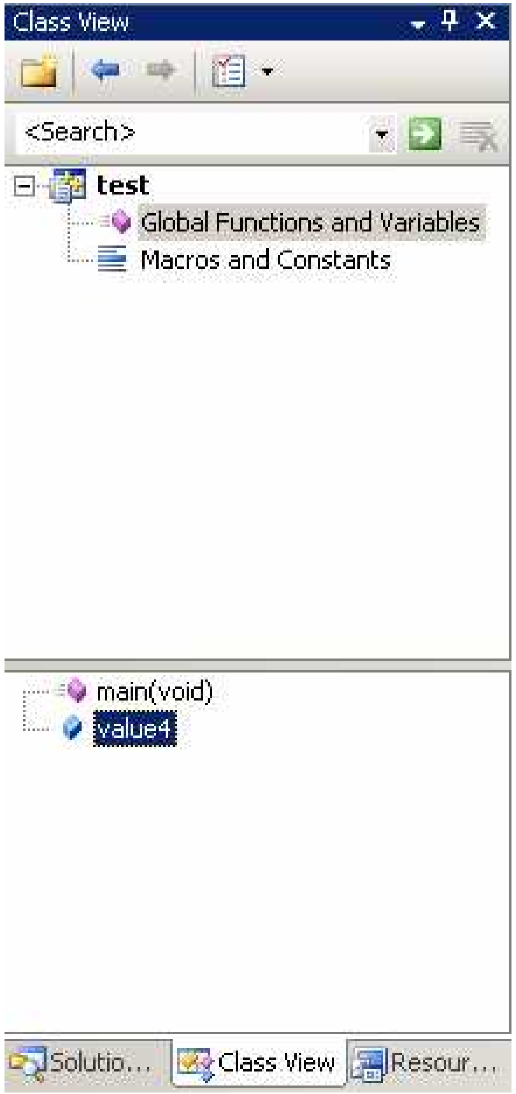
  ```
  // cout << count2 << endl;
  ```

  to get an error.

Global Variables

- Variables declared outside of all blocks are called global variables and have **global namespace scope**.
- Global variables have **static storage duration** by default. It will exist from the start of execution of the program, until execution of the program ends.
  - If you do not specify an initial value for a global variable, it will be initialized with 0 by default.
  - On the contrary, automatic variables will not be initialized by default.
- Figure 2-12 shows an example that the lifetime and scope may be different (`value4`).

Class View Pane of IDE Window



- Do NOT declare all variables global!
- For a large program, there are many variables:
  - Accidental erroneous modification of a variable
  - Difficult to name all the variables consistently and uniquely
  - Memory occupied for the duration of program execution

Namespaces

- Namespace is a mechanism to prevent accidental naming clash.
  - The libraries supporting the CLR and Windows Forms use namespaces extensively.
  - The ANSI C++ standard library does, too.
- Every non-local variable or function must be qualified.

```
// Ex2_09.cpp
#include <iostream>

  int value = 0;

int main()
{
   std::cout << "enter an integer: ";
   std::cin  >> value;
   std::cout << "\nYou enterd " << value
        << std::endl;
   return 0;
}
```

global namespace scope

Note the absence of using declarations for cout and endl

using Directive

- `using namespace std;`
  - This imports **all** the names from the std namespace
  - so that you don't need to qualifying the name with prefix `std::` in your program.
  - However, this negates the reason for using a namespace.
  - Only introduce the names that you use with "using declaration":
    - `using std::cout;`
    - `using std::endl;`

Declaring a Namespace

```
// Ex2_10.cpp
// Declaring a namespace
#include <iostream>

namespace myStuff
{
   int value = 0;
}

int main()
{
   std::cout << "enter an integer: ";
   std::cin  >> myStuff::value;
   std::cout << "\nYou entered " << myStuff::value
                  << std::endl;
   return 0;
}
```

using Directive

```
// Ex2_11.cpp
// using  a using directive
#include <iostream>

namespace myStuff
{
   int value = 0;
}

using namespace myStuff;

int main()
{
   std::cout << "enter an integer: ";
   std::cin  >> value;
   std::cout << "\nYou entered " << value
        << std::endl;
   return 0;
}
```

using Declaration

```
// Ex2_11a.cpp
// using  a using declaration
#include <iostream>

namespace myStuff
{
   int value = 0;
}

using myStuff::value;  // only important the variables you need

int main()
{
   std::cout << "enter an integer: ";
   std::cin  >> value;
   std::cout << "\nYou entered " << value
        << std::endl;
   return 0;
}
```

CLI Specific

- Fundamental Data Types
  - `long long` 8bytes
  - `unsigned long long` 8bytes
    - `long int` only occupis 4 bytes
- Use `safe_cast` and not `static_cast` in your C++/CLI code.
- Each ANSI fundamental type name maps to a **value class type** in the `System` namespace.
  - See P.100
- It is suggested to write
  - int count = 10;
  - double value = 2.5;
- instead of
  - System::Int32 count = 10;
  - System::Double value=2.5;

C++/CLI Output to the Command Line

- Console – a class in the System namespace
  - Write()
  - WriteLine
    - `Console::WriteLine(L”\n Orange”);`
  - Formatting the Output:
    - `Console::WriteLine(L"Sum of {0} and {1} = {2}", i, j, i+j);`
    - `Console::WriteLine(L"{2} = {0} + {1}", i, j, i+j);`

C++/CLI Input from the Keyboard

- `String^ line = Console:: Readline();`
- `char ch = Console::Read();`
- `ConsoleKeyInfo keyPress = Console::ReadKey(true);`
  - true – hide the character
  - false – display the character
- When you press the button ‘a’ without Caps Lock:
  - `keyPress.KeyChar = ‘a’`
  - `keyPress.Key = A`
- When you press the button ‘1’ on the NumPad:
  - `keyPress.KeyChar = ‘1’`
  - `keyPress.Key = NumPad1`