Chapter 2
Introduction to C++ Programming

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OBJECTIVES

- To write simple computer programs in C++.
- To write simple input and output statements.
- To use fundamental types.
- Basic computer memory concepts.
- To use arithmetic operators (算术操作符)
- The precedence (优先级) of arithmetic operators.
- To write simple decision-making statements

Topics

- 2.1 Introduction
- 2.2 First Program in C++: Printing a Line of Text
- 2.3 Standard library(标准库)
- 2.4 Modifying Our First C++ Program
- 2.5 Streams(流)
- 2.6 Stream Input(输入流)/ Stream Output(输出流)
- 2.7 Another C++ Program: Adding Integers
- 2.8 Memory Concepts
- 2.9 Arithmetic
- 2.10 Decision Making: Equality and Relational Operators

2.1 Introduction

- 五个C++程序实例（数据输入/输出/关系判断）
- 1-3个例子
  - 如何在屏幕上显示信息?
- 第4个例子
  - 如何进行数学运算?
- 第5个例子
  - 如何使用判断语句?

Topics

- 2.1 Introduction
- **2.2 First Program in C++: Printing a Line of Text**
- 2.3 Standard library(标准库)
- 2.4 Modifying Our First C++ Program
- 2.5 Streams(流)
- 2.6 Stream Input(输入流)/ Stream Output(输出流)
- 2.7 Another C++ Program: Adding Integers
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2.2 First Program in C++: Printing a Line of Text

- Simple program
  - Prints a line of text
  - Illustrates several important features of C++

```
1  // Fig. 2.1: fig02_01.cpp
2  // Text-printing program.
3  #include <iostream> // allows program to output data to the screen
4
5  // function main begins program execution
6  int main()
7  {
8     std::cout << "Welcome to C++!\n"; // display message
9
10    return 0; // indicate that program ended successfully
11
12 } // end function main
```

```
Welcome to C++!
```

2.2 First Program in C++: Printing a Line of Text

```
1  // Fig. 2.1: fig02_01.cpp
2  // Text-printing program.
3  #include <iostream> // allows program to output data to the screen
4
5  // f
6  int
7  {
8     s
9
10    r
11
12 } //
```

Line1-2: Comments (注释)

- // single-line comment (单行注释)
- /* */ (多行注释)
- Used to describe program, 目的、作者、日期和时间等信息
- 注释文字不影响编译和运行

2.2 First Program in C++: Printing a Line of Text

```
1  // Fig. 2.1: fig02_01.cpp
2  // Text-printing program.
3  #include <iostream> // allows program to output data to the screen
4
5  // function main begins program execution
6  int main()
7  {
8     std::c
9
10    return
11
12 } // end
```

去掉，what happens？

- #: 预处理命令(preprocessor directive), 编译之前处理
- include 文件包含
  - <文件名>（标准库） 或者 “文件名”
  - <iostream> (Ch2.5)
  - 功能：数据输入/输出

2.2 First Program in C++: Printing a Line of Text

```
1  // Fig. 2.1: fig02_01.cpp
2  // Text-printing program.
3  #include <iostream> // allows program to output data to the screen
4
5  // function main begins program execution
6  int main()
7  {
8
9
10
11
12 }
```

Line 4: 空行（blank lines）

- 被编译器忽略
- 作用: 增加程序的可读性
  - TAB字符、空格字符起同样作用

2.2 First Program in C++: Printing a Line of Text

```
1  // Fig. 2.1: fig02_01.cpp
2  // Text-printing program.
3  #include <iostream> // allows program to output data to the screen
4
5  // function main begins program execution
6  int main()
7  {
8     std::cout << "Welcome to C++!\n"; // display message
9
10    r
11
12 } // end function main
```

Line 5: // function main begins program execution

- 单行注释

2.2 First Program in C++: Printing a Line of Text

```
1  // Fig. 2.1: fig02_01.cpp
2  // Text-printing program.
3  #include <iostream> // allows program to output data to the screen
4
5  // function main begins program execution
6  int main()
7  {
8     std::cout << "Welcome to C++!\n"; // display message
9
10    return 0; // indicate that program ended successfully
11
12 }
```

Line 6: int main()

Line 7: {

- ( )表示main
- 关键字int

关键字(Keyword)：关键字是预留的标识符, 每个关键字都有特殊的含义. 我们不能在C++程序中使用与关键字同名的标识符, 例如: int, main等等(Fig. 4.3)

- C++程序可包含多个函数, 但只能有一个main函数;
- 一般, main函数是程序执行的入口, 可执行程序必须有;
- 左花括号{ 应放在每个函数体(Body)开头, 对应的右花括号} 应在函数体结尾出现

2.2 First Program in C++: Printing a Line of Text

```
1  // Fig. 2.1: fig02_01.cpp
2  // Text-printing program.
3  #include <iostream> // allows program to output data to the screen
4
5  // function main begins program execution
6  int main()
7  {
8     std::cout << "Welcome to C++!\n"; // display message
9
10    return 0; // indicate that program ended successfully
```

Line 8: std::cout << "Welcome to C++!\n"; // display message

- C++程序的语句 (Statement);
- std::cout: std名空间, 输出流对象 (Output stream object);
- <<: 流插入操作符 (stream insertion operator);
- “Welcome to C++!\n”: 输出到std::cout (标准输出流) 的字符串;
- \ : Escape character (转义字符), 不打印在屏幕上, 意味着一个特殊的字符将被打印;
- \n : Escape sequence (转义序列)（见下页）;
- ; : semicolon (分号), C++语句结束.

2.2 First Program in C++: Printing a Line of Text

Escape sequence (转义序列)	Description
\n	Newline(换行符) Position the screen cursor to the beginning of the next line.
\t	Horizontal tab(水平制表符) Move the screen cursor to the next tab stop.
\r	Carriage return(回车符) Position the screen cursor to the beginning of the current line; do not advance to the next line.
\a	Alert(警告). Sound the system bell.
\\	Backslash(反斜杠) Used to print a backslash character.
\'	Single quote(单引号) Use to print a single quote character.
\"	Double quote(双引号) Used to print a double quote character.

2.2 First Program in C++: Printing a Line of Text

```
1  // Fig. 2.1: fig02_01.cpp
2  // Text-printing program.
3  #include <iostream> // allows program to output data to the screen
4
5  // function main begins program execution
6  int main()
7  {
8     std::cout << "Welcome to C++!\n"; // display message
9
10    return 0; // indicate that program ended successfully
11
12 } // end function main
```

Line 10: return 0; // indicate that program ended successfully
Line 12: }

- 关键字return是退出函数的几种方式之一
- 数值0表示程序执行顺利结束
- 目前只要记住在每个程序的main函数中都要包括这个语句, 后面将介绍包括这个语句的原因.

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- 2.4 Modifying Our First C++ Program
- 2.5 Streams(流)
- 2.6 Stream Input(输入流)/ Stream Output(输出流)
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2.3 Standard library(标准库)

- 由编译器厂商提供, 与系统平台、厂商和编译器版本无关
- 1. 标准函数库
  - 从C语言中继承下来
  - C格式的输入输出函数、字符与字符串处理函数、数学函数、时间日期函数、动态分配函数以及一些实用函数
- 2. 标准类库
  - 标准C++的I/O流类、字符串类、数字类、异常处理和杂项类以及STL (Standard Template Library, 标准模板库)容器类

2.3 Standard library(标准库)

- 包含(include)相应的头文件
- C++的头文件来源：
  - 标准C语言库函数的头文件，带有.h后缀；

    #include <string.h>
  - 标准C++语言类库的头文件，不带.h后缀；

    #include <iostream>
  - 由标准C语言库函数头文件包装成的标准C++的头文件，把原有标准C语言库函数头文件去掉.h后缀而加上c前缀。

    #include <cstring>

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2.4 Modifying Our First C++ Program

```
1  // Fig. 2.3: fig02_03.cpp
2  // Printing a line of text with multiple statements.
3  #include <iostream> // allows program to output data to the screen
4
5  // function main begins program execution
6  int main()
7  {
8     std::cout << "Welcome ";
9     std::cout << "to C++!\n";
10
11    return 0; // indicate that program ended successfully
12
13 } // end function main
```

多行语句打印一行文本

```
Welcome to C++!
```

2.4 Modifying Our First C++ Program

```
1  // Fig. 2.4: fig02_04.cpp
2  // Printing multiple lines of text with a single statement.
3  #include <iostream> // allows program to output data to the screen
4
5  // function main begins program execution
6  int main()
7  {
8     std::cout << "Welcome\nto\n\nC++!\n";
9
10    return 0; // indicate that program ended successfully
11
12 } // end function main
```

一行语句打印多行文本

```
Welcome
to

C++!
```

Q & A

- 编写程序，输出

```
    *
   ***
  *****
```

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- **2.5 Streams(流)**
- 2.6 Stream Input(输入流)/ Stream Output(输出流)
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2.5 Streams(流)

- C++的输入/输出(I/O)是以字节流的形式实现的, 流实际上就是一个字节序列.
  - 在输入操作中, 字节从输入设备(如键盘、磁盘、网络连接等)流向内存;
  - 在输出操作中, 字节从内存流向输出设备(如显示器、打印机、磁盘、网络连接等).

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- 2.4 Modifying Our First C++ Program
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- **2.6 Stream Input(输入流)/ Stream Output(输出流)**
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2.6 Stream Input(输入流)/ Stream Output(输出流)

- C++中提供了一套输入输出流类的对象, 它们是cin、cout和cerr等, 分别指向终端输入、终端输出和标准出错输出(也从终端输出)
- cout、cerr与<<一起完成输出与标准错误输出.

```
std::cout<<“Hello, world!”<<“Hi”<<std::endl;
```

注意箭头的方向。在输出中使用endl（end of line）, 表示换行, 注意最后一个是字符‘l’, 而不是数字1, endl相当于C语言的'\n‘, 表示输出一个换行.

2.6 Stream Input(输入流)/ Stream Output(输出流)

- 标准输入流对象cin, cin与>>一起完成输入操作

  在C++程序中, 数据的输入(从键盘输入上读取数据)通常采用cin流对象来完成, 其格式如下:

  - std::cin>>变量1;
  - std::cin>>变量1>>变量2>>……>>变量n;
  - “>>”是流提取运算符.

- 一般在该语句之前用cout输出一个需要输入数据的提示信息, 以正确引导和提示用户输入正确的数据:

  - std::cout<< "请输入一个整数： ";

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- 2.8 Memory Concepts
- 2.9 Arithmetic
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```cpp
// Fig. 2.5: fig02_05.cpp
// Addition program that displays the sum of two numbers.
#include <iostream> // allows program to perform input and output

// function main begins program execution
int main()
{
   // variable declarations
   int number1; // first integer to add
   int number2; // second integer to add
   int sum; // sum of number1 and number2

   std::cout << "Enter first integer: "; // prompt user for data
   std::cin >> number1; // read first integer from user into number1

   std::cout << "Enter second integer: "; // prompt user for data
   std::cin >> number2; // read second integer from user into number2

   sum = number1 + number2; // add the numbers; store result in sum

   std::cout << "Sum is " << sum << std::endl; // display sum; end line

   return 0; // indicate that program ended successfully

} // end function main
```

声明(Declarations)
三个变量(Variables).

int number1, number2, sum;

```cpp
// Fig. 2.5: fig02_05.cpp
// Addition program that displays the sum of two numbers.
#include <iostream> // allows program to perform input and output

// function main begins program execution
int main()
{
   // variable declarations
   int number1; // first integer to add
   int number2; // second integer to add
   int sum; // sum of number1 and number2

   std::cout << "Enter first integer: "; // prompt user for data
   std::cin >> number1; // read first integer from user into number1

   std::cout << "Enter second integer: "; // prompt user for data
   std::cin >> number2; // read second integer from user into number2

   sum = number1 + number2; // add the numbers; store result in sum

   std::cout << "Sum is " << sum << std::endl; // display sum; end line

   return 0; // indicate that program ended successfully

} // end function main
```

基本数据类型，如：double，char

2.7 Another C++ Program: Adding Integers

Integral Types	Floating-Point Types
bool 布尔型(真、假)	float 浮点型
char 字符型	double 双精度浮点型
signed char	long double
unsigned char	
short int	
unsigned short int	
int 整型 -2^{31}~2^{31}-1 （-2147483648 ~ 2147483647）	
unsigned int	
long int	
unsigned long int	
wchar_t	

```cpp
// Fig. 2.5: fig02_05.cpp
// Addition program that displays the sum of two numbers.
#include <iostream> // allows program to perform input and output

// function main begins program execution
int main()
{
   // variable declarations
   int number1; // first integer to add
   int number2; // second integer to add
   int sum; // sum of number1 and number2

   std:
   std:                                                    er1

   std:
   std:                                                    ber2

   sum                                                     um

   std::cout << "Sum is " << sum << std::endl; // display sum; end line

   return 0; // indicate that program ended successfully

} // end function main
```

变量名：程序中用于保存值value的内存区域

1. 字母、数字、下划线(_)的组合，大小写敏感；
2. 不能以数字打头，不建议_打头；
3. 不能和关键字重复；
4. 变量的使用必须在声明之后；
5. 应使用有意义的变量名，例如采用匈牙利命名法.

2.7 Another C++ Program Adding Integers

- 匈牙利命名法
  - 微软的总设计师, 查尔斯·西蒙尼发明.
  - 在匈牙利命名法中, 一个变量名由一个或多个小写字母开始, 这些字母有助于记忆变量的类型; 紧跟着的就是首字母大写的由程序员选择的有助于描述变量作用的名词.
- 例子
  - **bBusy** : 布尔型
  - **nSize** : 整型
  - **fPrice**: 浮点数
  - **pFoo** : 指针

```cpp
// Fig. 2.5: fig02_05.cpp
// Addition program that displays the sum of two numbers.
#include <iostream> // allows program to perform input and output

// function main begins program execution
int main()
{
   // variable declarations
   int number1; // first integer to add
   int number2; // second integer to add
   int sum; // sum of number1 and number2

   std::cout << "Enter first integer: "; // prompt user for data
   std::cin >> number1; // read first integer from user into number1

   s                                    ompt user for data
   std::cin >> number2; // read second integer from user into number2

   sum = number1 + number2; // add the numbers; store result in sum

   std::cout << "Sum is " << sum << std::endl; // display sum; end line

   return 0; // indicate that program ended successfully

} // end function main
```

从键盘输入，用回车键表示输入结束

```
Enter first integer: 45
Enter second integer: 72
Sum is 117
```

```
6  int main()
7  {
8     // variable declarations
9     int number1; // first integer to add
10    int number2; // second integer to add
11    int sum; // sum of number1 and number2
12
13    std::cout << "Enter first integer: "; // prompt user for data
14    std::cin
15
16    std::cou
17    std::cin
18
19    sum = number1 + number2; // add the numbers; store result in sum
20
21    std::cout << "Sum is " << sum << std::endl; // display sum; end line
22
23    return 0;
24
25 } // end func
```

很多std::, 如何简化?

=: 赋值运算符（ assignment operator ）;

+: 算术运算符（Arithmetic operator）, 例如+, -, *, /, %

等价于:

```
std::cout << "Sum is " << number1 + number2 << std::endl;
```

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2.8 Memory Concepts

- Variables (变量)
  - Variable names correspond to locations in the computer's memory
  - Every variable has a name, a type, a size and a value
  - Whenever a new value is placed into a variable (through cin, for example), it replaces (and destroys) the previous value
  - Reading variables from memory does not change them (读出变量的值不会改变存储器的值).
- number1和它对应的值

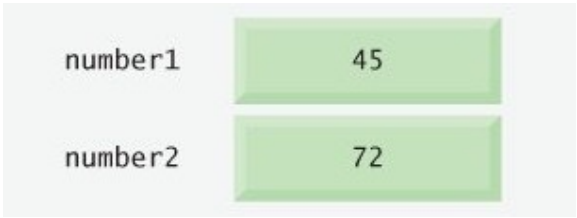
2.8 Memory Concepts

- std::cin >> number1; // read first integer from user into number1

  执行之后:

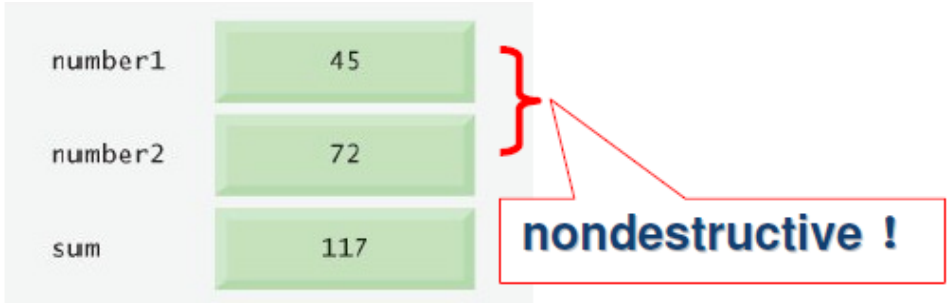
- std::cin >> number2; // read second integer from user into number2

  执行之后:



- sum = number1 + number2; // add the numbers; store result in sum

  执行之后:



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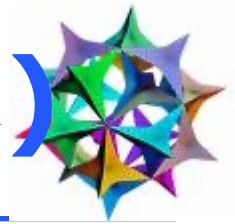
- 2.6 Stream Input(输入流)/ Stream Output(输出流)
- 2.7 Another C++ Program: Adding Integers
- 2.8 Memory Concepts
- **2.9 Arithmetic**
- 2.10 Decision Making: Equality and Relational Operators

2.9 Arithmetic (算术运算)



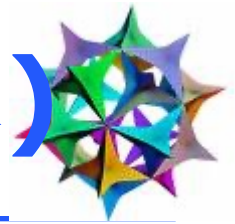
- **Arithmetic calculations(算术运算)**
  - * multiplication(乘)
  - / division (除)
    - int1/int2：整除, truncates(截去) remainder(余数)
    - 7 / 5 evaluates to 1
  - % Modulus operator(取模) returns the remainder
    - 7 % 5 evaluates to 2
- **Operator precedence(运算符优先级)**
  - Example: Find the average of three variables a, b and c
    - a + b + c / 3　　(a + b + c) / 3

2.9 Arithmetic (算术运算)

C++ operation	C++ arithmetic operator	Algebraic expression	C++ expression
Addition	+	$f + 7$	f + 7
Subtraction	-	$p - c$	p - c
Multiplication	*	bm or $b \cdot m$	b * m
Division	/	x / y or $\frac{x}{y}$ or $x \div y$	x / y
Modulus	%	$r \bmod s$	r % s

Operator(s)	Operation(s)	Order of evaluation (precedence)
( )	Parentheses	优先级最高，最内层的括号最先运算，同级的括号，从左到右。
*	Multiplication	Evaluated second. If there are several, they are evaluated left to right.
/	Division	优先级次之，从左到右。
%	Modulus	
+	Addition	优先级最低，从左到右。
-	Subtraction	

2.9 Arithmetic (算术运算)



Algebra: $m = \frac{a + b + c + d + e}{5}$

C++:
```
m = ( a + b + c + d + e ) / 5;
```

Algebra: $y = mx + b$

C++:
```
y = m * x + b;
```

2.9 Arithmetic (算术运算)
-优先级实例

Step 1. `y = 2 * 5 * 5 + 3 * 5 + 7;` *(Leftmost multiplication)*

`2 * 5 is 10`

Step 2. `y = 10 * 5 + 3 * 5 + 7;` *(Leftmost multiplication)*

`10 * 5 is 50`

Step 3. `y = 50 + 3 * 5 + 7;` *(Multiplication before addition)*

`3 * 5 is 15`

Step 4. `y = 50 + 15 + 7;` *(Leftmost addition)*

`50 + 15 is 65`

Step 5. `y = 65 + 7;` *(Last addition)*

`65 + 7 is 72`

Step 6. `y = 72` *(Last operation—place 72 in y)*

Topics

- 2.1 Introduction
- 2.2 First Program in C++: Printing a Line of Text
- 2.3 Standard library(标准库)
- 2.4 Modifying Our First C++ Program
- 2.5 Streams(流)
- 2.6 Stream Input(输入流)/ Stream Output(输出流)
- 2.7 Another C++ Program: Adding Integers
- 2.8 Memory Concepts
- 2.9 Arithmetic
- **2.10 Decision Making: Equality and Relational Operators**

2.10 Decision Making: Equality and Relational Operators
(判断：相等与关系运算符)

Standard algebraic equality or relational operator	C++ equality or relational operator	Sample C++ condition	Meaning of C++ condition
Relational operators			
>	>	x > y	x is greater than y
<	<	x < y	x is less than y
≥	>=	x >= y	x is greater than or equal to y
≤	<=	x <= y	x is less than or equal to y
Equality operators			
=	==	x == y	x is equal to y
≠	!=	x != y	x is not equal to y

2.10 Decision Making: Equality and Relational Operators
(判断：相等与关系运算符)

if (condition)

statements of if-body

if control structure

- **If a condition is true, then the body of the if statement executed**
  - **0 is false, non-zero is true**

2.10 Decision Making: Equality and Relational Operators
(判断：相等与关系运算符)

- 例： **Figure 2.13. Equality and relational operators**

  判断两个整数的大小关系。

```
1  // Fig. 2.13: fig02_13.cpp
2  // Comparing integers using if statements, rel
3  // and equality operators.
4  #include <iostream> // allows program to perfo
5
6  using std::cout; // program uses cout
7  using std::cin;  // program uses cin
8  using std::endl; // program uses endl
9
10 // function main begins program execution
11 int main()
12 {
13    int number1; // first integer to compare
14    int number2; // second integer to comp
15
16    cout << "Enter two integers to compare
17    cin >> number1 >> number2; // read two
18
19    if ( number1 == number2 )
20       cout << number1 << " == " << number2 << endl;
21
22    if ( number1 != number2 )
23       cout << number1 << " != " << number2 << endl;
24
25    if ( number1 < number2 )
26       cout << number1 << " < " << number2 << endl;
27
28    if ( number1 > number2 )
29       cout << number1 << " > " << number2 << endl;
30
```

Line 6-8: using声明

- then we can use

cout instead of std::cout

cin instead of std::cin, and

endl instead of std::endl

两个输入间以空白字符分隔, 如空格、TAB键或者回车键, 3<SP>7<RET>

条件判断语句
体内只有一条语句，缩进

```
31    if ( number1 <= number2 )
32       cout << number1 << " <= " << number2 << endl;
33
34    if ( number1 >= number2 )
35       cout << number1 << " >= " << number2 << endl;
36
37    return 0; // indicate that program ended successfully
38
39 } // end function main
```

fig02_13.cpp

(2 of 2)

```
Enter two integers to compare: 3 7
3 != 7
3 < 7
3 <= 7
```

```
Enter two integers to compare: 22 12
22 != 12
22 > 12
22 >= 12
```

```
Enter two integers to compare: 7 7
7 == 7
7 <= 7
7 >= 7
```

2.10 Decision Making: Equality and Relational Operators
(判断：相等与关系运算符)

BOOK. P48

Operators				Associativity	Type	
()				left to right	parentheses	
*	/	%		left to right	multiplicative	算术
+	-			left to right	additive	
<<	>>			left to right	stream insertion/extraction	流
<	<=	>	>=	left to right	relational	关系
==	!=			left to right	equality	等值
=				right to left	assignment	赋值

同一优先级的运算符具备相同的结合性!

2.10 Decision Making: Equality and Relational Operators
(判断：相等与关系运算符)

- **Associativity (结合性) and Precedence(优先级)**
- 表达式求值时, 首先按运算符的优先级从高到低执行, 其次同一优先级运算符根据结合性处理:
  - **a+b-c*d+e/f** // 从左到右
  - **a=b=c+d** // 从右到左
- 如果不确定优先顺序，则加括号以确保正确！

总结

- 理解简单的C++程序
- 简单的输入、输出语句
- 使用基本的数据类型
- 理解变量和程序对内存的使用
- 使用算术运算符
- 算术和关系运算符的优先级关系
- 简单的判断语句

Homework

- 实验必做题目：

  2.19, 2.25, 2.28

- 实验选做题目：

  2.20