COMPREHENSIVE EDITION

PROGRAMMING AND PROBLEM SOLVING WITH C++

SIXTH EDITION

Nell Dale and Chip Weems

Chapter 3

Numeric Types, Expressions, and Output

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squareCubeX.cpp

```
#include <iostream>
int Square(int);        // Declares these two
int Cube(int);          // value-returning functions
using namespace std;
int main()
{
    int x;
    cout << "Enter a number: "; // note: no new line
    cin >> x; // note: operator ">>" instead of "<<"
    cout << “The square of "
         << x  << " is “
         << Square(x)<< endl;     // Function call

    cout << “The cube of " << x << " is “
         << Cube(x)<< endl;     // Function call
    return 0;
}
```

squareCubeX.cpp (cont.)

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


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

Input Using cin (1)

```
...
  int x;
    cout << "Enter a number: "; // note: no new line
    cin >> x; // note: operator ">>" instead of "<<"
...
```

- cin (Console INput) can be used to obtain user input .
- **Unlike cout, use >> with cin, and not <<**
- When the program is run, cin will wait indefinitely for user input.
- cin will input a single value into a variable when it detects a *new line* from the input:
- Remember that before using inputting values into variables, the variables MUST have already been declared!

Chapter 3 Topics

- Evaluating Arithmetic Expressions
- Implicit Type Coercion and Explicit Type Conversion
- Calling a Value-Returning Function
- Using Function Arguments

Chapter 3 Topics

- Using C++ Library Functions in Expressions
- Calling a Void Function

Parentheses

- Parentheses can be used to change the usual order
- Parts in() are evaluated first
- Evaluate (7 *(10 - 5) % 3) * 4 + 9

```
(7 *(10 - 5)  %  3)  *  4   +   9
(7  *  5   %  3 )  * 4   +   9
        ( 35  %  3)   *   4   +   9
                 2    *   4   +   9
                              8   +   9
                                  17
```

Recall Assignment Operator Syntax

Variable = Expression

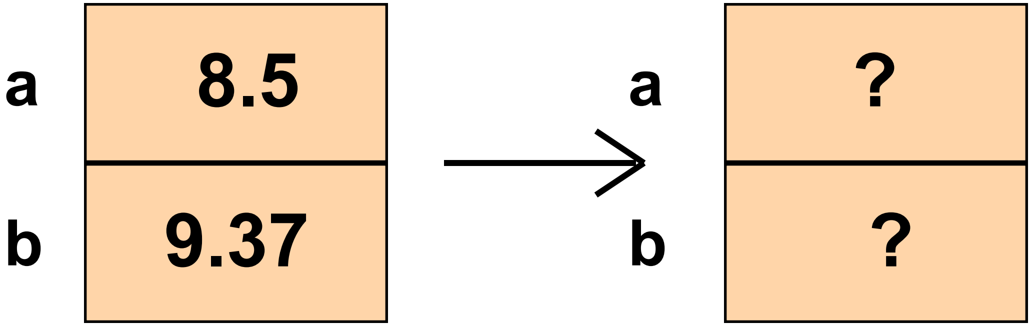
- First, expression on right is evaluated
- Then the resulting value is stored in the memory location of variable on left

Automatic Type Conversion

- Implict conversion by the compiler of a value from one data type to another is known as automatic type coercion
- An automatic type coercion occurs after evaluation but before the value is stored if the types differ for expression and variable

What value is stored?

```
float  a;
float  b;

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



a 8.5

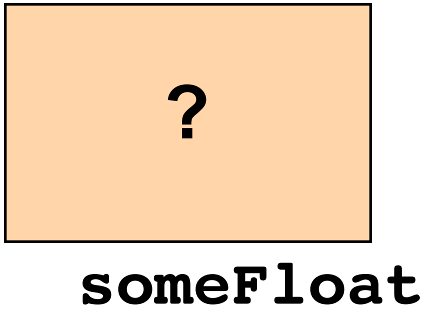
b 9.37

a ?

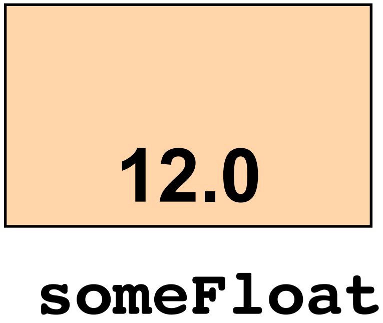
b ?

What is stored?

```
float someFloat;
```

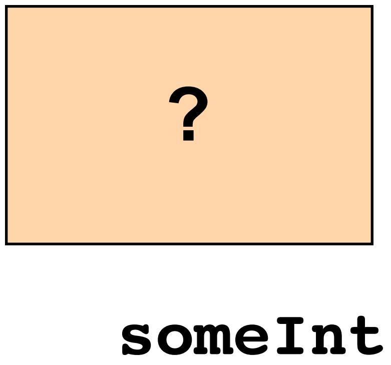


```
someFloat = 12;    // Causes implicit type conversion
```



What is stored?

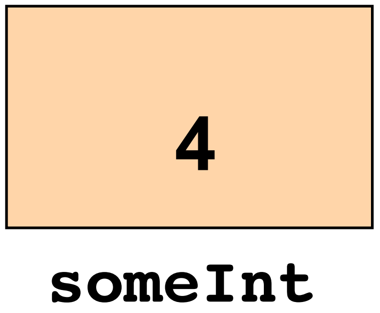
```
int   someInt;



someInt = 4.8;
```



?

someInt

// Causes implicit type conversion



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someInt

Type Casting is Explicit Conversion of Type

- Explicit type casting (or type conversion) used to clarify that the mixing of types is intentional, not an oversight
- Explicit type casting helps make programs clear and error free as possible

Examples of Explicit Typecasting

int(4.8)	has value	4
float(5)	has value	5.0
float(7/4)	has value	1.0
float(7) / float(4)	has value	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
cout << “How old are you?”	cout
cin >> age	cin
cout << age	cout

What values are stored?

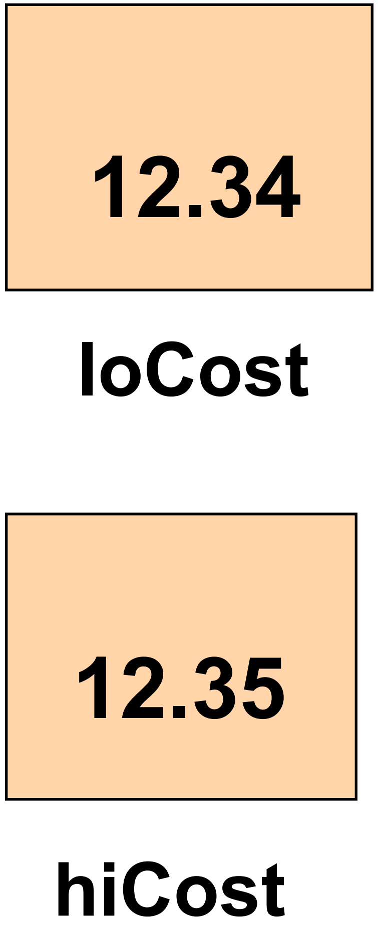
```
float  loCost;
float  hiCost;

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;
```

Values were rounded to 2 decimal places



12.34

loCost

12.35

hiCost

Functions

- Every C++ program must have a function called `main`

- Program execution always begins with function `main`

- Any other functions are subprograms and must be called by the `main` function

Function Calls

- One function calls another by using the name of the called function together with() containing an argument list

- A function call temporarily transfers control from the calling function to the called function

More About Functions

- It is not considered good practice for the body block of function main to be long

- Function calls are used to do subtasks

- Every C++ function has a return type

- If the return type is not void, the function returns a value to the calling block

Where are functions?

Functions are subprograms

- located in libraries, or
- written by programmers for their use in a particular program

HEADER FILE	FUNCTION	EXAMPLE OF CALL	VALUE
<cstdlib>	abs(i)	abs(-6)	6
<cmath>	pow(x,y)	pow(2.0,3.0)	8.0
	fabs(x)	fabs(-6.4)	6.4
<cmath>	sqrt(x)	sqrt(100.0)	10.0
	sqrt(x)	sqrt(2.0)	1.41421
<cmath>	log(x)	log(2.0)	.693147
<iomanip>	setprecision(n)	setprecision(3)	

Write C++ Expressions for

The square root of $b^2 - 4ac$

```
sqrt(b * b - 4.0 * a * c)
```

The square root of the average of myAge and yourAge

```
sqrt((myAge  +  yourAge) / 2)
```

Function Call

- A function call temporarily transfers control to the called function's code

- When the function's code has finished executing, control is transferred back to the calling block

Function Call Syntax

Function Name = (Argument List)

- **The argument list is a way for functions to communicate with each other by passing information**

- **The argument list can contain zero, one, or more arguments, separated by commas, depending on the function**

A void function call stands alone

```
#include <iostream>

void  DisplayMessage(int  n);
// Declares function

int main()
{
    DisplayMessage(15);
    // Function call
    cout  <<  “Good Bye“  <<  endl;
    return 0;
}
```

A void function does NOT return a value

```
// Header and body here

void  DisplayMessage(int  n)
{
    cout  <<  “I have liked math for  “
          <<  n  <<  “ years”  << endl;
}
```

Two Kinds of Functions

Value-Returning	Void
Always returns a **single value** to its caller and is called from within an **expression**	Never returns a value to its caller and is called as a **separate statement**

<< is a binary operator

<< is called the output or insertion operator

<< is left associative

Expression	**Has value**
cout << age	cout

Statement

```
cout << “You are “  << age  <<  “ years old\n”;
```

<iostream> is header file

- For a library that defines 3 objects

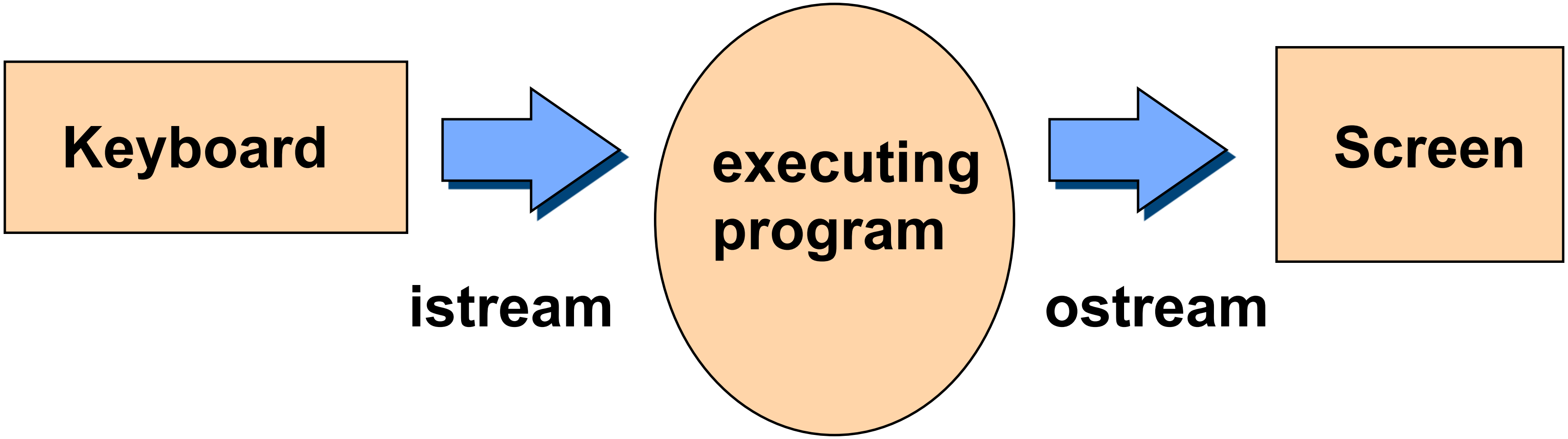
  An istream object named cin (keyboard)

  An ostream object named cout (screen)

  An ostream object named cerr (screen)

No I/O is built into C++

- Instead, a library provides input stream and output stream



Manipulators

- Manipulators are used only in input and output statements
- `endl`, `fixed`, `showpoint`, `setw`, and `setprecision` are manipulators that can be used to control output format
- `endl` is use to terminate the current output line and create blank lines in output

Insertion Operator(<<)

- The insertion operator `<<` takes 2 operands

- The left operand is a stream expression, such as `cout`

- The right operand is an expression of simple type, a `string`, or a manipulator

Output Statements

SYNTAX(revised)

```
cout  <<  ExpressionOrManipulator
          <<  ExpressionOrManipulator  . . .;
```

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;
```

Using Manipulators
Fixed and Showpoint

- Use the following statement to specify that (for output sent to the cout stream) decimal format (not scientific notation) be used,
- and that a decimal point be included (even for floating values with 0 as fractional part)

```
cout  <<  fixed <<  showpoint;
```

setprecision(n)

- Requires `#include <iomanip>` and appears in an expression using insertion operator(<<)

- If `fixed` has already been specified, argument `n` determines the number of places displayed after the decimal point for floating point values

- Remains in effect until explicitly changed by another call to `setprecision`

What is exact output?

```
#include  <iomanip> // For setw() and setprecision()
#include  <iostream>

using  namespace  std;

int main()
{
    float   myNumber  =  123.4587;
    cout  <<  fixed  <<   showpoint;
    // Use decimal format
    // Print decimal points
    cout  <<  “Number is ”  <<  setprecision(3)
          <<  myNumber     <<  endl;

    return  0;
}
```

OUTPUT

```
Number is 123.459
```

Value is **rounded** if necessary to be displayed with exactly **3 places** after the decimal point

Manipulator `setw`

- "Set width" lets us control how many character positions the next data item should occupy when it is output

- `setw` is only for formatting numbers and strings, not `char` type data

`setw(n)`

- Requires `#include <iomanip>` and appears in an expression using insertion operator(<<)
- Argument `n` is called the **fieldwidth specification**
- Argument `n` determines the number of character positions in which to display a right-justified number or string (not char data)

setw(n)

- The number of character positions used is expanded if n is too narrow

- "Set width" affects only the very next item displayed and is useful to align columns of output

A) What is exact output?

```
#include  <iomanip>                // For setw()
#include  <iostream>
#include  <string>

using  namespace  std;
```

A) What is exact output?, cont...

```
int  main()
{
    int  myNumber    =  123;
    int  yourNumber  =  5;

    cout <<  setw(10)  <<  “Mine”
         <<  setw(10)  <<  “Yours”  << endl
         <<  setw(10)  <<  myNumber
         <<  setw(10)  <<  yourNumber << endl;

    return 0;
}
```

Output

```
position   12345678901234567890
                 Mine     Yours
                  123         5
```

Each is displayed right-justified and each is located in a total of 10 positions

B) What is exact output?

```
#include  <iomanip> // For setw() and setprecision()
#include  <iostream>

using  namespace  std;

int  main()
{
    float myNumber    =  123.4;
    float yourNumber  =  3.14159;
```

B) What is exact output, continued?

```
cout  <<  fixed  << showpoint;
    // Use decimal format; print decimal points
    cout  <<  “Numbers are: ”  <<  setprecision(4)
          <<  endl  <<  setw(10) <<  myNumber
          <<  endl  <<  setw(10) <<  yourNumber
          <<  endl;
    return 0;
}
```

OUTPUT

```
12345678901234567890
Numbers are:
  123.4000
    3.1416
```

Each is displayed right-justified and rounded if necessary and each is located in a total of 10 positions with 4 places after the decimal point

More Examples

```
312.0
  x
```

```
4.827
  y
```

```
    float   x   =  312.0;
    float   y   =  4.827;

OUTPUT
    cout  << fixed << showpoint;

    cout  << setprecision(2)
          << setw(10) << x  << endl
           << setw(10) << y  << endl;

    cout  << setprecision(1)
          << setw(10) << x  << endl
           << setw(10) << y  << endl;

    cout  << setprecision(5)
          << setw(7) << x  << endl
           << setw(7) << y << endl;
```

```
,,,, 312.00
,,,,,, 4.83

,,,,, 312.0
,,,,,,, 4.8

312.00000
  4.82700
```

HEADER FILE	MANIPULATOR	ARGUMENT TYPE	EFFECT
<iostream>	endl	none	terminates output line
<iostream>	showpoint	none	displays decimal point
<iostream>	fixed	none	activates scientific notation
<iomanip>	setw(n)	int	sets fieldwidth to n positions
<iomanip>	setprecision(n)	int	sets precision to n digits

`length` Function

- Function `length` returns an unsigned integer value that equals the number of characters currently in the string
- Function `size` returns the same value as function length
- You must use **dot notation** in the call to function `length` or `size`

`find` Function

- Function `find` returns an unsigned integer value that is the beginning position for the first occurrence of a particular substring within the string
- The substring argument can be a `string` constant, a `string` expression, or a `char` value
- If the substring was not found, function `find` returns the special value `string::npos`

`substr` Function

- Function `substr` returns a particular substring of a string
- The first argument is an unsigned integer that specifies a starting position within the string
- The second argument is an unsigned integer that specifies the length of the desired substring
- Positions of characters within a string are numbered starting from 0, not from 1

Mortgage Payments

Problem Your parents are thinking about refinancing their mortgage, and have asked you to help them with the calculations. Now that you're learning C++, you realize that you can save yourself a lot of calculator button-pressing by writing a program to do the calculations automatically.

Algorithm

```
Define Constants
    Set LOAN_AMOUNT = 50000.00
    Set NUMBER_OF_YEARS = 7
    Set YEARLY_INTEREST = 0.0524
Calculate Values
    Set monthlyInterest  to YEARLY_INTEREST divided by 12
    Set numberOfPayments to NUMBER_OF_YEARS  times 12
    Set payment to(LOAN_AMOUNT *
            pow(monthlyInterest+1,numberrOfPayments)
            * monthlyInterest))
             /(pow(monthlyInterest+1, numberOfPayments) - 1)
Output Results
    Print "For a loan amount of " LOAN_AMOUNT "with an interest rate of "
            YEARLY_INTEREST  " and a " NUMBER_OF_YEARS   "
            year mortgage, "
    Print "your monthly payments are $"  payment  "."
```

C++ Program

```
//***************************************************
// Mortgage Payment Calculator program
// This program determines the monthly payments on a
// mortgage given the loan amount, the yearly interest,
// and the number of years.
//***************************************************
#include <iostream>          // Access cout
#include <cmath>             // Access power function
#include <iomanip>           // Access manipulators
using namespace std;
const float LOAN_AMOUNT = 50000.00;  // Amount of loan
const float YEARLY_INTEREST = 0.0524;// Yearly interest
const int NUMBER_OF_YEARS = 7;       // Number of years
```

C++ Program

```
int main()
{
    // Local variables
    float monthlyInterest; // Monthly interest rate
    int numberOfPayments;  // Total number of payments
    float payment;         // Monthly payment
    // Calculate values
    monthlyInterest = YEARLY_INTEREST / 12;
    numberOfPayments = NUMBER_OF_YEARS * 12;
    payment =(LOAN_AMOUNT *
        pow(monthlyInterest + 1, numberOfPayments)
        * monthlyInterest)/(pow(monthlyInterest + 1,
        numberOfPayments) - 1);
```

C++ Program

```
    // Output results
    cout << fixed << setprecision(2)
         << "For a loan amount of "
         << LOAN_AMOUNT  << " with an interest rate of "
         << YEARLY_INTEREST << " and a "
         << NUMBER_OF_YEARS
         << " year mortgage, " << endl;
    cout << " your monthly payments are $" << payment
         << "." << endl;
    return 0;
}
```