1.8 Loops

Loops cause a section of program to be repeated a certain number of times. The repetition continues while condition is true.
When the condition becomes false, the loop ends and control passes to the statements following the loop.
There are three kinds of loops in C++ :
1-the for loop,
2-the while loop,
3-the do loop.

1.8.1 The for Loop

The for loop executes a section of code a fixed number of times.It's usually used when you know, before entering the loop, how many times you want to execute the code.
Here's an example, FORDEMO, that displays the squares of the numbers from 0 to 14:

```
#include <iostream.h>
int main()
{
int i; //define a loop variable
for(i=0; i<15; i++) //loop from 0 to 14,
cout << i * i << " "; //displaying the square of j
cout << endl;
return 0;}
```

Here's the output:

```
0 1 4 9 16 25 36 49 64 81 100 121 144 169 196
```

Multiple Statements in the Loop Body

```
for(i=1; i<=10; i++)
{
    cout << i  ;
int cube = i*i*i    ;
cubecout << setw(6) << cube << endl   ;
}    //There is no ; here after the brace.
```

```
#include <iostream.h>
#include <iomanip.h> //for setw
int main()
{
int i;   //define loop variable
for(i=1; i<=10; i++) //loop from 1 to 10
{
cout << setw(4) << i;    //display 1st column
int cube = i*i*i; //calculate cube
cout << setw(6) << cube << endl; //display 2nd column
}
return 0;}
```

Here's the output from the program:

```
   1     1
   2     8
   3    27
   4    64
   5   125
   6   216
   7   343
   8   512
   9   729
  10  1000
```

Blocks and Variable Visibility

The loop body, which consists of braces delimiting several statements, is called a block of code. a variable defined inside the block is not visible outside it. Visible means that program statements can access or "see" the variable. In example the variable cube define inside the block.

```
For (i=1; i<=10; i++)
{
cout << setw(4) << i;
int cube = i*i*i;
cout << setw(6) << cube << endl;
}
```

You can't access this variable outside the block; it's only visible within the braces. The statement cube = 10; after the loop body is an Error because the variable cube would be undefined outside the loop.

In the next example it decrements the loop variable. This program, FACTOR, asks the user to type in a number, and then calculates the factorial of this number. Thus the factorial of 5 is 5*4*3*2*1, or 120.)

```
// calculates factorials, demonstrates FOR loop
#include <iostream.h>
int main()
{
int numb;
int fact=1; //long for larger numbers
cout << "Enter a number: ";
cin >> numb; //get number
for(int j=numb; j>0; j--) //multiply 1 by
fact *= j; //numb, numb-1, ..., 2, 1
cout << "Factorial is " << fact << endl;
return 0;}
}
```

The following output shows how large factorials can be, even for small input numbers:

```
Enter a number: 10
Factorial is 3628800
```

Questions

Answers to these questions can be found in Appendix G.

1. A relational operator

a. assigns one operand to another.

b. yields a Boolean result.

c. compares two operands.

d. logically combines two operands.

2. Write an expression that uses a relational operator to return true if the variable george is
not equal to sally.
3. Is –1 true or false?
4. Name and describe the usual purpose of three expressions in a for statement.
5. In a for loop with a multistatement loop body, semicolons should appear following
a. the for statement itself.
b. the closing brace in a multistatement loop body.
c. each statement within the loop body.
d. the test expression.
6. True or false: The increment expression in a for loop can decrement the loop variable.
7. Write a for loop that displays the numbers from 100 to 110.
8. A block of code is delimited by ________________.
9. A variable defined within a block is visible
a. from the point of definition onward in the program.
b. from the point of definition onward in the function.
c. from the point of definition onward in the block.
d. throughout the function.
10. Write a while loop that displays the numbers from 100 to 110.
11. True or false: Relational operators have a higher precedence than arithmetic operators.

Exercises
***1. Assume that you want to generate a table of multiples of any given number. Write a program that allows the user to enter the number and then generates the table, formatting it into 10 columns and 20 lines. Interaction with the program should look like this (only the first three lines are shown):**

```
Enter a number: 7
  7    14    21   28    35    42   49   56    63    70
 77    84    91   98   105   112  119  126   133   140
147   154   161  168   175   182  189  196   203   210
```

***2. Write a temperature-conversion program that gives the user the option of converting Fahrenheit to Celsius or Celsius to Fahrenheit. Then carry out the conversion. Use floating-point numbers. Interaction with the program might look like this:**

```
Type 1 to convert Fahrenheit to Celsius, 2 to convert Celsius to Fahrenheit: 1
Enter temperature in Fahrenheit: 70
In Celsius that’s 21.111111
```

***Answers to Questions**

1. b, c

2. george != sally

3. –1 is true; only 0 is false.

4. The initialize expression initializes the loop variable, the test expression tests the loop
variable, and the increment expression changes the loop variable.

5. c, d

6. true

7.

```
for(int j=100; j<=110; j++)
cout << endl << j;
```

8. braces (curly brackets)

9. c

10.

```
int j = 100;
while( j <= 110 )
cout << endl << j++;
```

11. false

***Solutions to Exercises**

1.

```
#include <iostream.h>
#include <iomanip.h> //for setw()
int main()
```

```
{int n; //number
cout << "\nEnter a number: ";
cin >> n; //get number
for(int j=1; j<=200; j++) //loop from 1 to 200
{
cout << setw(5) << j*n << " "; //print multiple of n
if( j%10 == 0 ) //every 10 numbers,
cout << endl; //start new line}
return 0;
}
```

2.

```
#include <iostream.h>
int main()
{   int response;
double temper;
cout << "\nType 1 to convert fahrenheit to celsius,"
<< "\n 2 to convert celsius to fahrenheit: ";
cin >> response;
if( response == 1 )
{
cout << "Enter temperature in fahrenheit: ";
cin >> temper;
cout << "In celsius that's " << 5.0/9.0*(temper-32.0);
   }
```

1.8.2 The while Loop

```
#include <iostream.h>
int main()
{
int n = 99; // make sure n is not initialized to 0
while( n != 0 ) // loop until n is 0
cin >> n; // read a number into n
return 0;
}
```

Here's some sample output.

```
1
27
144
9
0
```

Multiple Statements in a while Loop

it calculates the fourth power of a series of integers. Let's assume that in this program it's important to put the results in a column four digits wide.

```
1 1
2 16
3 81
4 256
5 625
6 1296
7 2401
8 4096
9 6561
```

To ensure that the results fit this column width, we must stop the loop before the results become larger than 9999.

```
 // prints numbers raised to fourth power
#include <iostream.h>
#include <iomanip.h>                          //for setw
int main()
{ int pow=1;                                  //power initially 1
int numb=1;                                //numb goes from 1 to ???
while( pow<10000 )                         //loop while power <= 4 digits
{ cout << setw(2) << numb;                 //display number
cout << setw(5) << pow << endl;      //display fourth power
++numb; //get ready for next power
pow = numb*numb*numb*numb;   //calculate fourth power
}
cout << endl;
return 0;
}
```

1.9 The if Statement

The if statement is the simplest of the decision statements.

```
 #include <iostream.h>
int main()
{
 int x;
cout << "Enter a number: "; cin >> x;
 if( x > 100 )
 cout << "That number is greater than 100\n";
 return 0;}
 Enter a number: 2000
That number is greater than 100
```

Multiple Statements in the if body

```
#include <iostream.h>
int main()
{
int x;
cout << "Enter number";
cin >> x;
if( x > 100 )
{
cout << "The number " << x<<endl;
cout << " is greater than 100\n";
}
return 0;
}
```

Here's some output

```
Enter a number 12345
The number 12345
is greater than 100
```

Nesting ifs Inside Loops

Example:

PRIME, that nests an if within a for loop. This example tells you whether a number you enter is a prime number. (Prime numbers are integers divisible only by themselves and 1. The first few primes are 2, 3, 5, 7, 11, 13, 17.

```
#include <iostream.h>
#include <process.h> //for exit()
int main()
{
Int  n, j;
 cout << “Enter a number: “;
cin >> n;                           //get number to test
for(j=2; j <= n/2; j++)             //divide by every integer from
if(n%j == 0)                        //2 on up;if remainder is 0,
 {                                  //it’s divisible by j
cout << “It’s not prime; divisible by “ << j << endl;
 exit(0);  //exit from the program
}
cout << “It’s prime\n”;
 return 0;
 }
```

Here’s outputof the program:

```
 Enter a number: 13
It’s prime
Enter a number: 22229
It’s prime
Enter a number: 22231
It’s not prime; divisible by 11
```

IF example, with an else added to the if:

```
#include <iostream.h>
int main()
{
int x;
cout << “\nEnter a number: “;
cin >> x;
if( x > 100 )
cout << “That number is greater than 100\n”;
else
cout << “That number is not greater than 100\n”;
return 0;
}
```

Here’s output

```
Enter a number: 300
That number is greater than 100
Enter a number: 3
That number is not greater than 100
```

The operation of the if...else statement is shown

Questions

Answers to these questions can be found in Appendix G.

1. A relational operator
a. assigns one operand to another.
b. yields a Boolean result.
c. compares two operands.
d. logically combines two operands.

2. Write an expression that uses a relational operator to return true if the variable george is
not equal to sally.

3. Is –1 true or false?

4. Name and describe the usual purpose of three expressions in a for statement.

5. In a for loop with a multistatement loop body, semicolons should appear following
a. the for statement itself.
b. the closing brace in a multistatement loop body.
c. each statement within the loop body.
d. the test expression.

6. True or false: The increment expression in a for loop can decrement the loop variable.

7. Write a for loop that displays the numbers from 100 to 110.

8. A block of code is delimited by ________________.

9. A variable defined within a block is visible

a. from the point of definition onward in the program.

b. from the point of definition onward in the function.

c. from the point of definition onward in the block.

d. throughout the function.

10. Write a while loop that displays the numbers from 100 to 110.

11. True or false: Relational operators have a higher precedence than arithmetic operators.

12. How many times is the loop body executed in a do loop?

13. Write a do loop that displays the numbers from 100 to 110.

14. Write an if statement that prints Yes if a variable age is greater than 21.

15. The library function exit() causes an exit from

a. the loop in which it occurs.

b. the block in which it occurs.

c. the function in which it occurs.

d. the program in which it occurs.

16. Write an if...else statement that displays Yes if a variable age is greater than 21, and
displays No otherwise.

17. The getche() library function

a. returns a character when any key is pressed.

b. returns a character when Enter is pressed.

c. displays a character on the screen when any key is pressed.

d. does not display a character on the screen.

18. What is the character obtained from cin when the user presses the Enter key?

19. An else always matches the _________ if, unless the if is _________.

20. The else...if construction is obtained from a nested if...else by ________________.

Exercises

5. Use for loops to construct a program that displays a pyramid of Xs on the screen. The pyramid should look like this

```
X
XXX
XXXXX
XXXXXXX
XXXXXXXXX
```

except that it should be 20 lines high, instead of the 5 lines shown here. One way to do this is to nest two inner loops, one to print spaces and one to print Xs, inside an outer loop that steps down the screen from line to line. 6. Modify the FACTOR program in this chapter so that it repeatedly asks for a number and calculates its factorial, until the user enters 0, at which point it terminates. You can enclose the relevant statements in FACTOR in a while loop or a do loop to achieve this effect.

7. Write a program that calculates how much money you'll end up with if you invest an amount of money at a fixed interest rate, compounded yearly. Have the user furnish the initial amount, the number of years, and the yearly interest rate in percent. Some interaction with the program might look like this:

```
Enter initial amount: 3000
Enter number of years: 10
Enter interest rate (percent per year): 5.5
At the end of 10 years, you will have 5124.43 dollars.
```

At the end of the first year you have 3000 + (3000 * 0.055), which is 3165. At the end of the second year you have 3165 + (3165 * 0.055), which is 3339.08. Do this as many times as there are years. A for loop makes the calculation easy.

8. Write a program that repeatedly asks the user to enter two money amounts expressed in old-style British currency: pounds, shillings, and pence. The program should then add the two amounts and display the answer, again in pounds, shillings, and pence. Use a do loop that asks

the user whether the program should be terminated. Typical interaction might be

```
Enter first amount: £5.10.6
Enter second amount: £3.2.6
Total is £8.13.0
Do you wish to continue (y/n)?
```

To add the two amounts, you'll need to carry 1 shilling when the pence value is greater than 11, and carry 1 pound when there are more than 19 shillings.

10. Write another version of the program from Exercise 7 so that, instead of finding the final amount of your investment, you tell the program the final amount and it figures out how many years it will take, at a fixed rate of interest compounded yearly, to reach this amount. What sort of loop is appropriate for this problem? (Don't worry about fractional years; use an integer value for the year.)

Answers to Questions

1. b, c
2. george != sally
3. –1 is true; only 0 is false.
4. The initialize expression initializes the loop variable, the test expression tests the loop
variable, and the increment expression changes the loop variable.
5. c, d
6. true
7.

```
for(int j=100; j<=110; j++)
cout << endl << j;
```

8. braces (curly brackets)
9. c
10.

```
int j = 100;
while( j <= 110 )
cout << endl << j++;
```

11. false
12. at least once

13.

```
int j = 100;
do
cout << endl << j++;
while( j <= 110 );
```

14.

```
if(age > 21)
cout << “Yes”;
```

15.D

16.

```
if( age > 21 )
cout << “Yes”;
else
cout << “No”;
```

17. a, c

18. ‘\r’

19. preceding, surrounded by braces

20. reformatting

Solutions to Exercises

1.

```
#include <iostream.h>
#include <iomanip.h > //for setw()
int main()
{int  n; //number
cout << “\nEnter a number: “;
cin >> n; //get number
for(int j=1; j<=200; j++) //loop from 1 to 200
{
cout << setw(5) << j*n << “ “; //print multiple of n
if( j%10 == 0 ) //every 10 numbers,
cout << endl; //start new line
}
return 0;}
```

2.

```
#include <iostream.h>
```

```
int main()
{
int response;
int temper;
cout << “\nType 1 to convert fahrenheit to celsius,”
<< “\n 2 to convert celsius to fahrenheit: “;
cin >> response;
if( response == 1 )
{
cout << “Enter temperature in fahrenheit: “;
cin >> temper;
cout << “In celsius that’s “ << 5.0/9.0*(temper-32.0);
} else
{
cout << “Enter temperature in celsius: “;
cin >> temper;
cout << “In fahrenheit that’s “ << 9.0/5.0*temper + 32.0;
}
cout << endl;
return 0;}
```

3.

```
#include <iostream.h>
#include <conio.h> //for getche()
int main()
{
char ch;
Int  total = 0; //this holds the number
cout << “\nEnter a number: “;
while( (ch=getche()) != ‘\r’ ) //quit on Enter
total = total*10 + ch-’0’; //add digit to total*10
cout << “\nNumber is: “ << total << endl;
return 0;
}
```

1.9.1 The switch Statement

```
#include <iostream.h>
int main()
{ int speed; cout << “\nEnter 33, 45, or 78: “;
  cin >> speed;
  switch(speed)
{
   case 33: cout << “USER SELECTED 33   \n”;
   break;
   case 45: cout << “USER SELECTED 45 \n ”;
   break;
   case 78:
   cout << “USER SELECTED 78 \n”;
   break;  }
return 0;
}
```

Here’s an example of the output:

```
Enter 33, 45, or 78: 45
```

You can also use type char as in next example.

```
#include <iostream.h>
#include <conio.h> //for getche()
int main()
{
char dir=’a’;
int x=10, y=10;
while( dir != ‘\r’ )
    {
     cout << “\nYour location is “ << x << “, “ << y;
     cout << “\nEnter direction (n, s, e, w): “;
     dir = getche(); //get character
     switch(dir) //switch on it
        {
    case ‘n’: y--; break; //go north
    case ‘s’: y++; break; //go south
    case ‘e’: x++; break; //go east
```

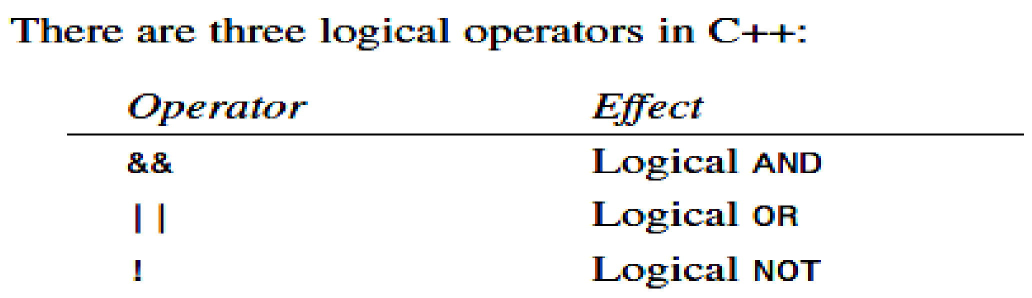
```
   case ‘w’: x--; break; //go west
   case ‘\r’: cout << “Exiting\n”; break; //Enter key
   default: cout << “Try again\n”; //unknown char
       } //end switch
    } //end while
return 0;
}
```

These operators allow you to logically combine Boolean variables (that is, variables of type bool, with true or false values).

1.10 Logical AND Operator

```
#include <iostream.h>
#include <process.h> //for exit()
#include <conio.h> //for getche()
int main()
{
char dir=’a’;
int x=10, y=10;
while( dir != ‘\r’ )
{cout << “\nYour location is “ << x << “, “ << y;
cout << “\nEnter direction (n, s, e, w): “;
dir = getche();
            switch(dir)
{
case ‘n’: y--; break; //update coordinates
case ‘s’: y++; break;
case ‘e’: x++; break;
case ‘w’: x--; break;
}
if( x==7 && y==11 )
{cout << “\nYou found the treasure!\n”;
exit(0);
 }}
```

```
return                                                                    0;
```



There are three logical operators in C++:

Operator	*Effect*
&&	Logical AND
||	Logical OR
!	Logical NOT

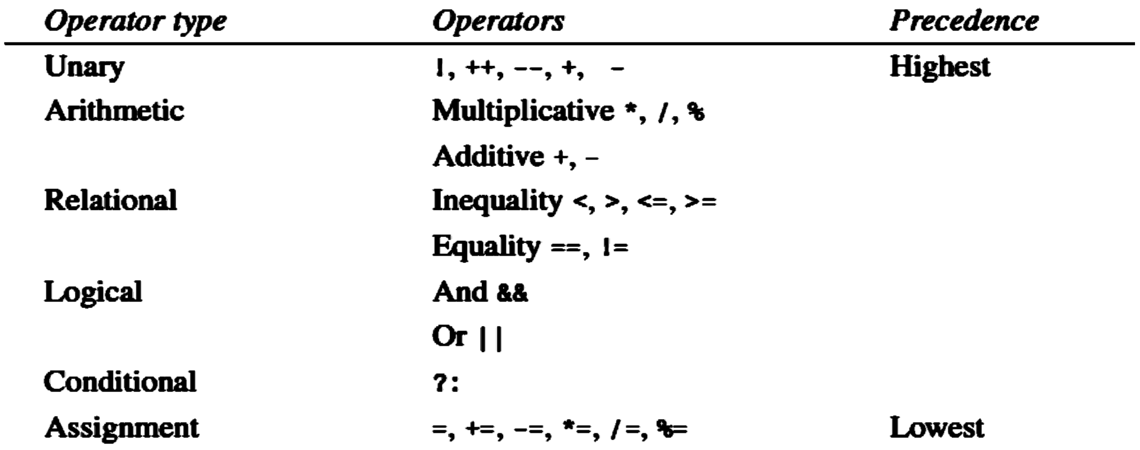
1.10.1 Logical OR Operator

```
#include <iostream.h>
#include <process.h> //for exit()
#include <conio.h> //for getche()
int main()
{char dir='a';  int x=10, y=10;
while( dir != '\r' )
{
cout << "\n\nYour location is " << x << ", " << y;
if( x<5 || x>15 )
cout << "\nBeware: dragons lurk here";
cout << "\nEnter direction (n, s, e, w): ";
dir = getche();
switch(dir)
{
case 'n': y--  ; break;
case 's': y++; break;
case 'e': x++; break;
case 'w': x-- ; break;
} //end switch
} //end while
return 0;
} //end main()
```

1.10.2 Logical NOT Operator

The logical NOT operator ! is a unary operator—that is, it takes only one operand. The effect of the ! is that the logical value of its operand is reversed: If something is true, ! makes it false;
if it is false, ! makes it true.

Precedence Summary



Operator type	*Operators*	*Precedence*
Unary	**!, ++, --, +, -**	**Highest**
Arithmetic	**Multiplicative *, /, %**	
	Additive +, -	
Relational	**Inequality <, >, <=, >=**	
	Equality ==, !=	
Logical	**And &&**	
	Or ||	
Conditional	**?:**	
Assignment	**=, +=, -=, *=, /=, %=**	**Lowest**

Questions

20. The else...if construction is obtained from a nested if...else by ________________.

21. Write a switch statement that prints Yes if a variable ch is ‘y’, prints No if ch is ‘n’, and prints Unknown response otherwise.

22. Write a statement that uses a conditional operator to set ticket to 1 if speed is greater than 55, and to 0 otherwise.

23. The && and || operators

a. compare two numeric values.

b. combine two numeric values.

c. compare two Boolean values.

d. combine two Boolean values.

24. Write an expression involving a logical operator that is true if limit is 55 and speed is greater than 55.

25. Arrange in order of precedence (highest first) the following kinds of operators: logical, unary, arithmetic, assignment, relational, conditional.

26. The break statement causes an exit

a. only from the innermost loop.

b. only from the innermost switch.
c. from all loops and switches.
d. from the innermost loop or switch.
27. Executing the continue operator from within a loop causes control to go to ________.
Exercises
***4. Create the equivalent of a four-function calculator. The program should ask the user to a number, an operator, and another number. (Use floating point.) It should then carry out the specified arithmetical operation: adding, subtracting, multiplying, or dividing the two numbers. Use a switch statement to select the operation. Finally, display the result. When it finishes the calculation, the program should ask whether the user wants to do another calculation. The response can be 'y' or 'n'. Some sample interaction with the program might look like this:**

```
Enter first number, operator, second number: 10 / 3
Answer = 3.333333
Do another (y/n)? y
Enter first number, operator, second number: 12 + 100
Answer = 112
Do another (y/n)? n
```

6. Modify the FACTOR program in this chapter so that it repeatedly asks for a number and calculates its factorial, until the user enters 0, at which point it terminates. You can enclose the relevant statements in FACTOR in a while loop or a do loop to achieve this effect.
7. Write a program that calculates how much money you'll end up with if you invest an amount of money at a fixed interest rate, compounded yearly. Have the user furnish the initial amount, the number of years, and the yearly interest rate in percent. Some interaction with the program might look like this:

```
Enter initial amount: 3000
Enter number of years: 10
Enter interest rate (percent per year): 5.5
At the end of 10 years, you will have 5124.43 dollars.
```

At the end of the first year you have 3000 + (3000 * 0.055), which is 3165. At the end of

the second year you have 3165 + (3165 * 0.055), which is 3339.08. Do this as many times as there are years. A for loop makes the calculation easy.

8. Write a program that repeatedly asks the user to enter two money amounts expressed in old-style British currency: pounds, shillings, and pence. The program should then add the two amounts and display the answer, again in pounds, shillings, and pence. Use a do loop that asks the user whether the program should be terminated. Typical interaction might be

```
Enter first amount: £5.10.6
Enter second amount: £3.2.6
Total is £8.13.0
Do you wish to continue (y/n)?
```

To add the two amounts, you'll need to carry 1 shilling when the pence value is greater than 11, and carry 1 pound when there are more than 19 shillings.

11. Create a three-function calculator for old-style English currency, where money amounts are specified in pounds, shillings, and pence. The calculator should allow the user to add or subtract two money amounts, or to multiply a money amount by a floating-point number. (It doesn't make sense to multiply two money amounts; there is no such thing as square money. We'll ignore division. Use the general style of the ordinary four-function calculator in Exercise 4)

12. Create a four-function calculator for fractions. Here are the formulas for the four arithmetic operations applied to fractions:

Addition: a/b + c/d = (a*d + b*c) / (b*d)

Subtraction: a/b - c/d = (a*d - b*c) / (b*d)

Multiplication: a/b * c/d = (a*c) / (b*d)

Division: a/b / c/d = (a*d) / (b*c)

The user should type the first fraction, an operator, and a second fraction. The program should then display the result and ask whether the user wants to continue.

Answers to Questions
20. reformatting
21.
```
switch(ch)
{
case ‘y’:
cout << “Yes”;
break;
case ‘n’:
cout << “No”;
break;
default:
cout << “Unknown response”;
}
```
22. ticket = (speed > 55) ? 1 : 0;
23. d
24. limit == 55 && speed > 55
25. unary, arithmetic, relational, logical, conditional, assignment
26. d
27. the top of the loop
28. b

__________________4.
```
#include <iostream.h>
int main()
{float n1, n2, ans;
char oper, ch;
do
{cout << “\nEnter first number, operator, second number: “;
cin >> n1 >> oper >> n2;
switch(oper)
{case ‘+’: ans = n1 + n2; break;
case ‘-’: ans = n1 - n2; break;
case ‘*’: ans = n1 * n2; break;
case ‘/’: ans = n1 / n2; break;
default: ans = 0;}
cout << “Answer = “ << ans;
cout << “\nDo another (Enter ‘y’ or ‘n’)? “;
cin >> ch;
} while( ch != ‘n’ );
return 0;}
```