

Some Practice Problems for the C++ Exam and Solutions for the Problems

The problems below are *not* intended to teach you how to program in C++. You should not attempt them until you believe you have mastered all the topics on the "Checklist" in the document entitled "Computer Science C++ Exam".

There are 39 problems. The solutions for the problems are given at the end, after the statement of problem 39.

1. What is the exact output of the program below? Indicate a blank space in the output by writing the symbol \square . Indicate a blank line in the output by writing blank line .

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

int main()
{
    int n = 4, k = 2;

    cout << ++n << endl;
    cout << n << endl;

    cout << n++ << endl;
    cout << n << endl;

    cout << -n << endl;
    cout << n << endl;

    cout << --n << endl;
    cout << n << endl;

    cout << n-- << endl;
    cout << n << endl;

    cout << n + k << endl;
    cout << n << endl;
    cout << k << endl;
    cout << n << k << endl;

    cout << n << endl;
    cout << " " << n << endl;
    cout << " n" << endl;
    cout << "\n" << endl;

    cout << " n * n = "; //CAREFUL!
    cout << n * n << endl;
    cout << 'n' << endl;

    return 0;
}
```

2. What is the output of the program below?

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

int main()
{
    int n = 3;
    while (n >= 0)
    {
        cout << n * n << endl;
        --n;
    }

    cout << n << endl;

    while (n < 4)
        cout << ++n << endl;

    cout << n << endl;

    while (n >= 0)
        cout << (n /= 2) << endl;

    return 0;
}
```

3. What is the output of the program below?

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

int main()
{
    int n;

    cout << (n = 4) << endl;
    cout << (n == 4) << endl;
    cout << (n > 3) << endl;
    cout << (n < 4) << endl;
    cout << (n = 0) << endl;
    cout << (n == 0) << endl;
    cout << (n > 0) << endl;
    cout << (n && 4) << endl;
    cout << (n || 4) << endl;
    cout << (!n) << endl;

    return 0;
}
```

4. What is the output of the following program?

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

int main()
{
    enum color_type {red, orange, yellow, green, blue, violet};

    color_type shirt, pants;

    shirt = red;
    pants = blue;

    cout << shirt << " " << pants << endl;

    return 0;
}
```

5. What is the output when the following code fragment is executed?

```
int i = 5, j = 6, k = 7, n = 3;
cout << i + j * k - k % n << endl;
cout << i / n << endl;
```

6. What is the output when the following code fragment is executed?

```
int found = 0, count = 5;
if (!found || --count == 0)
    cout << "danger" << endl;
cout << "count = " << count << endl;
```

7. What is the output when the following code fragment is executed?

```
char ch;
char title[] = "Titanic";

ch = title[1];
title[3] = ch;

cout << title << endl;
cout << ch << endl;
```

8. Suppose that the following code fragment is executed.

```
const int LENGTH = 21;
char message[LENGTH];

cout << "Enter a sentence on the line below." << endl;
cin >> message;

cout << message << endl;
```

Suppose that in response to the prompt, the interactive user types the following line and presses Enter:

Please go away.

What will the output of the code fragment look like?

9. Suppose that the following code fragment is executed.

```
const int LENGTH = 21;
char message[LENGTH];

cout << "Enter a sentence on the line below." << endl;
cin.getline(message, LENGTH, '\n');

cout << message << endl;
```

a. Suppose that in response to the prompt, the interactive user types the following line and presses Enter:

Please go away.

What will the output of the code fragment look like?

b. Suppose that in response to the prompt, the interactive user types the following line and presses Enter:

Please stop bothering me.

What will the output of the code fragment look like?

10. Suppose that the following code fragment is executed.

```
const int LENGTH = 21;
char message[LENGTH];
int i;

cout << "Enter a sentence on the line below." << endl;
cin >> message[0];

i = 0;
while (i < LENGTH - 1 && message[i] != '\n')
{
    ++i;
    cin >> message[i];
}

message[i] = '\0'; // Replace '\n' if that was read.
                  // Otherwise replace the last character read.

cout << message << endl;
}
```

a. Suppose that in response to the prompt, the interactive user types the following line and presses Enter:

Please go away.

What will the output of the code fragment look like?

b. Suppose that the statement `cin >> message[0];` is replaced by the statement `cin.get(message[0]);`, and similarly `cin >> message[i];` is replaced by the statement `cin.get(message[i]);`. Now what will the output of the code fragment look like if, in response to the prompt, the interactive user types the following line and presses Enter?

Please go away.

11. The nested conditional statement shown below has been written by an inexperienced C/C++ programmer. The behavior of the statement is not correctly represented by the formatting.

```
if (n < 10)
    if (n > 0)
        cout << "The number is positive." << endl;
else
    cout << "The number is _____." << endl;
```

a. What is the output of the statement if the variable `n` has the value 7? If `n` has the value 15? If `n` has the value -3?

b. Correct the syntax of the statement so that the logic of the corrected statement corresponds to the formatting of the original statement. Also, replace the blank with an appropriate word or phrase.

c. Correct the formatting of the (original) statement so that the new format reflects the logical behavior of the original statement. Also, replace the blank with an appropriate word or phrase.

12. The loop shown below has been written by an inexperienced C/C++ programmer. The behavior of the loop is not correctly represented by the formatting.

```
int n = 10;

while (n > 0)
    n /= 2;
    cout << n * n << endl;
```

- a. What is the output of the loop as it is written?
- b. Correct the syntax of the loop so that the logic of the corrected loop corresponds to the formatting of the original loop. What is the output of the corrected loop?
- c. Correct the formatting of the (original) loop so that the new format reflects the logical behavior of the original loop.

13. Remove all the unnecessary tests from the nested conditional statement below.

```
float income;

cout << "Enter your monthly income: ";
cin >> income;

if (income < 0.0)
    cout << "You are going farther into debt every month." << endl;

else if (income >= 0.0 && income < 1200.00)
    cout << "You are living below the poverty line." << endl;

else if (income >= 1200.00 && income < 2500.00)
    cout << "You are living in moderate comfort." << endl;

else if (income >= 2500.00)
    cout << "You are well off." << endl;
```

14. Answer the questions below concerning the following fragment of code.

```
int n;

cout << "Enter an integer: ";
cin >> n;

if (n < 10)
    cout << "less than 10" << endl;

else if (n > 5)
    cout << "greater than 5" << endl;

else
    cout << "not interesting" << endl;
```

- a. What will be the output of the fragment above if the interactive user enters the integer value 0 ?
- b. What will be the output of the fragment above if the interactive user enters the integer value 15 ?
- c. What will be the output of the fragment above if the interactive user enters the integer value 7 ?
- d. What values for n will cause the output of the fragment above to be "not interesting"?

15. Rewrite the following code fragment so that it uses a "do...while..." loop to accomplish the same task.

```
int n;

cout << "Enter a non-negative integer: ";
cin >> n;

while (n < 0)
{
    cout << "The integer you entered is negative." << endl;
    cout << "Enter a non-negative integer: ";
    cin >> n;
}
```

16. In the code fragment below, the programmer has almost certainly made an error in the first line of the conditional statement.

- a. What is the output of this code fragment as it is written?
- b. How can it be corrected to do what is the programmer surely intended?

```
int n = 5;

if (n = 0) // NOTE THE OPERATOR!!!
    cout << "n is zero" << ".\n";
else
    cout << "n is not zero" << ".\n";

cout << "The square of n is " << n * n << ".\n";
```

17. What is the output when the following code fragment is executed?

```
int n, k = 5;
n = (100 % k ? k + 1 : k - 1);
cout << "n = " << n << "    k = " << k << endl;
```

18. What is the output when the following code fragment is executed?

```
int n;
float x = 3.8;
n = int(x);
cout << "n = " << n << endl;
```

19. What is the output when the following code fragment is executed? Rewrite the fragment to obtain an equivalent code fragment in which the body of the loop is a simple statement instead of a compound statement.

```
int i = 5;
while (i > 0)
{
    --i;
    cout << i << endl;
}
```

20. The following loop is an endless loop: when executed it will never terminate. What modification can be made in the code to produce the desired output?

```
cout << "Here's a list of the ASCII values of all the upper"
    << " case letters.\n";
char letter = 'A';
while (letter <= 'Z')
    cout << letter << " " << int(letter) << endl;
```

21. Write a function named "sum_from_to" that takes two integer arguments, call them "first" and "last", and returns as its value the sum of all the integers between first and last inclusive. Thus, for example,

```
cout << sum_from_to(4,7) << endl; // will print 22 because 4+5+6+7 = 22
cout << sum_from_to(-3,1) << endl; // will print -5 'cause (-3)+(-2)+(-1)+0+1 = -5
cout << sum_from_to(7,4) << endl; // will print 22 because 7+6+5+4 = 22
cout << sum_from_to(9,9) << endl; // will print 9
```

22. Write a function named "enough" that takes one integer argument, call it "goal" and returns as its value the smallest positive integer n for which $1+2+3+\dots+n$ is at least equal to goal. Thus, for example,

```
cout << enough(9) << endl; // will print 4 because  $1+2+3+4 \geq 9$  but  $1+2+3 < 9$ 
cout << enough(21) << endl; // will print 6 'cause  $1+2+\dots+6 \geq 21$  but  $1+2+\dots+5 < 21$ 
cout << enough(-7) << endl; // will print 1 because  $1 \geq -7$  and 1 is the smallest
// positive integer
cout << enough(1) << endl; // will print 1 because  $1 \geq 1$  and 1 is the smallest
// positive integer
```

DEFINITION: A positive integer d is called a divisor of an integer n if and only if the remainder after n is divided by d is zero. In this case we also say that "d divides n", or that "n is divisible by d". Here are some examples:

- 7 is a divisor of 35; that is, 35 is divisible by 7.
- 7 is not a divisor of 27; that is, 27 is not divisible by 7.
- 1 is a divisor of 19; that is, 19 is divisible by 1 (in fact, 1 is a divisor of every integer n).
- 12 is a divisor of 0; that is, 0 is divisible by 12.

In C and C++ one can test the expression $n \% d$ to determine whether d is a divisor of n . The greatest common divisor of a pair of integers m and n (not both zero) is the largest positive integer d that is a divisor of both m and n . We sometimes use the abbreviation "g.c.d." for "greatest common divisor. Here are some examples: 10 is the g.c.d. of 40 and 50; 12 is the g.c.d. of 84 and 132; 1 is the g.c.d. of 256 and 625; 6 is the g.c.d. of 6 and 42; 32 is the g.c.d. of 0 and 32.

23. Write a function named "g_c_d" that takes two positive integer arguments and returns as its value the greatest common divisor of those two integers. If the function is passed an argument that is not positive (i.e., greater than zero), then the function should return the value 0 as a sentinel value to indicate that an error occurred. Thus, for example,

```
cout << g_c_d(40,50) << endl;    // will print 10
cout << g_c_d(256,625) << endl;  // will print 1
cout << g_c_d(42,6) << endl;     // will print 6
cout << g_c_d(0,32) << endl;     // will print 0 (even though 32
is the g.c.d.)
cout << g_c_d(10,-6) << endl;    // will print 0 (even though 2 is
the g.c.d.)
```

24. A positive integer n is said to be prime (or, "a prime") if and only if n is greater than 1 and is divisible only by 1 and n . For example, the integers 17 and 29 are prime, but 1 and 38 are not prime. Write a function named "is_prime" that takes a positive integer argument and returns as its value the integer 1 if the argument is prime and returns the integer 0 otherwise. Thus, for example,

```
cout << is_prime(19) << endl;    // will print 1
cout << is_prime(1) << endl;     // will print 0
cout << is_prime(51) << endl;    // will print 0
cout << is_prime(-13) << endl;   // will print 0
```

25. Write a function named "digit_name" that takes an integer argument in the range from 1 to 9, inclusive, and prints the English name for that integer on the computer screen. No newline character should be sent to the screen following the digit name. The function should not return a value. The cursor should remain on the same line as the name that has been printed. If the argument is not in the required range, then the function should print "digit error" without the quotation marks but followed by the newline character. Thus, for example,

```
the statement    digit_name(7);    should print seven on the screen;
the statement    digit_name(0);    should print digit error on the screen and place
the cursor at the beginning of the next line.
```

26. Write a function named "reduce" that takes two positive integer arguments, call them "num" and "denom", treats them as the numerator and denominator of a fraction, and reduces the fraction. That is to say, each of the two arguments will be modified by dividing it by the greatest common divisor of the two integers. The function should return the value 0 (to indicate failure to reduce) if either of the two arguments is zero or negative, and should return the value 1 otherwise. Thus, for example, if m and n have been declared to be integer variables in a program, then

[continued on the next page]

```

m = 25;
n = 15;
if (reduce(m,n))
    cout << m << '/' << n << endl;
else
    cout << "fraction error" << endl;

```

will produce the following output:

```
5/3
```

Note that the values of `m` and `n` were modified by the function call. Similarly,

```

m = 63;
n = 210;
if (reduce(m,n))
    cout << m << '/' << n << endl;
else
    cout << "fraction error" << endl;

```

will produce the following output:

```
3/10
```

Here is another example.

```

m = 25;
n = 0;
if (reduce(m,n))
    cout << m << '/' << n << endl;
else
    cout << "fraction error" << endl;

```

will produce the following output:

```
fraction error
```

The function `reduce` is allowed to make calls to other functions that you have written.

27. Write a function named `"swap_floats"` that takes two floating point arguments and interchanges the values that are stored in those arguments. The function should return no value. To take an example, if the following code fragment is executed

```

float x = 5.8, y = 0.9;
swap_floats (x, y);
cout << x << " " << y << endl;

```

then the output will be

```
0.9 5.8
```

28. Write a function named `"sort3"` that takes three floating point arguments, call them `"x"`, `"y"`, and `"z"`, and modifies their values, if necessary, in such a way as to make true the following inequalities: $x \leq y \leq z$. The function should return no value. To take an example, if the following code fragment is executed

```

float a = 3.2, b = 5.8, c = 0.9;
sort3 (a, b, c);
cout << a << " " << b << " " << c << endl;

```

then the output will be

```
0.9 3.2 5.8
```

The function `sort3` is allowed to make calls to other functions that you have written.

29. Write a function named "reverse" that takes as its arguments the following:

- (1) an array of floating point values;
- (2) an integer that tells how many floating point values are in the array.

The function must reverse the order of the values in the array. Thus, for example, if the array that's passed to the function looks like this:

0	1	2	3	4
5.8	2.6	9.0	3.4	7.1

then when the function returns, the array will have been modified so that it looks like this:

0	1	2	3	4
7.1	3.4	9.0	2.6	5.8

The function should not return any value.

30. Write a function named "sum" that takes as its arguments the following:

- (1) an array of floating point values;
- (2) an integer that tells how many floating point values are in the array.

The function should return as its value the sum of the floating point values in the array. Thus, for example, if the array that's passed to the function looks like this:

0	1	2	3	4
5.8	2.6	9.0	3.4	7.1

then the function should return the value 27.9 as its value.

31. Write a function named "location_of_largest" that takes as its arguments the following:

- (1) an array of integer values;
- (2) an integer that tells how many integer values are in the array.

The function should return as its value the subscript of the cell containing the largest of the values in the array. Thus, for example, if the array that's passed to the function looks like this:

0	1	2	3	4
58	26	90	34	71

then the function should return the integer 2 as its value. If there is more than one cell containing the largest of the values in the array, then the function should return the smallest of the subscripts of the cells containing the largest values. For example, if the array that's passed to the function is

0	1	2	3	4	5	6
58	26	91	34	70	91	88

then the largest value occurs in cells 2 and 5, so the function should return the integer value 2.

32. Write a function named "location_of_target" that takes as its arguments the following:

- (1) an array of integer values;
- (2) an integer that tells how many integer values are in the array;
- (3) an integer "target value".

The function should determine whether the given target value occurs in any of the cells of the array, and if it does, the function should return the subscript of the cell containing the target value. If more than one of the cells contains the target value, then the function should return the largest subscript of the cells that contain the target value. If the target value does not occur in any of the cells, then the function should return the sentinel value -1. Thus, for example, if the target value that's passed to the function is 34 and the array that's passed to the function looks like this:

0	1	2	3	4	5	6
58	26	91	34	70	34	88

then the target value occurs in cells 3 and 5, so the function should return the integer value 5.

33. Write a function named "rotate_right" that takes as its arguments the following:

- (1) an array of floating point values;
- (2) an integer that tells the number of cells in the array;

The function should shift the contents of each cell one place to the right, except for the contents of the last cell, which should be moved into the cell with subscript 0 . Thus, for example, if the array passed to the function looks like this:

0	1	2	3	4
5.8	2.6	9.1	3.4	7.0

then when the function returns, the array will have been changed so that it looks like this:

0	1	2	3	4
7.0	5.8	2.6	9.1	3.4

The function should not return a value.

34. Write a function named "shift_right" that takes as its arguments the following:

- (1) an array of floating point values;
- (2) an integer, call it "left", that tells the leftmost cell of the part of the array to be shifted;
- (3) an integer, call it "right", that tells the rightmost cell of the part of the array to be shifted;
- (4) a positive integer, call it "distance" that tells how many cells to shift by.

The function should make sure that left is less than or equal to right, and that distance is greater than zero. If either of these conditions fails, the function should return the value 1 to indicate an error. Otherwise it should shift by distance cells the contents of the array cells with subscripts running from left to right . Thus, for example, if the array passed to the function looks like this:

0	1	2	3	4	5	6	7	8	9	10
5.8	2.6	9.1	3.4	7.0	5.1	8.8	0.3	-4.1	8.0	2.7	etc.

and if left has the value 3 , right has the value 7 , and distance has the value 2 , then the function should shift the contents of cells 3 , 4 , 5 , 6 , and 7 to the right by 2 cells, so that when the function returns, the array will have been changed so that it looks like this:

0	1	2	3	4	5	6	7	8	9	10
5.8	2.6	9.1	???	???	3.4	7.0	5.1	8.8	0.3	2.7	etc.

The question marks in cells 3 and 4 indicate that we don't care what numbers are in those cells when the function returns. Note that the contents of cells 8 and 9 have changed, but the contents of cell 10 is unchanged. The function need not take any precautions against the possibility that the cells will be shifted beyond the end of the array (the calling function should be careful not to let that happen).

35. Write a function named "subtotal" takes as its arguments the following:

- (1) an array of floating point values;
- (2) an integer that tells the number of cells in the array.

The function should replace the contents of each cell with the sum of the contents of all the cells in the original array from the left end to the cell in question. Thus, for example, if the array passed to the function looks like this:

0	1	2	3	4
5.8	2.6	9.1	3.4	7.0

then when the function returns, the array will have been changed so that it looks like this:

0	1	2	3	4
5.8	8.4	17.5	20.9	27.9

because $5.8 + 2.6 = 8.4$ and $5.8 + 2.6 + 9.1 = 17.5$ and so on. Note that the contents of cell 0 are not changed. The function should not return a value.

36. Write a function named "concatenate" that copies the cells of one array into a larger array, and then copies the cells of another array into the larger array just beyond the contents of the first array. The contents of the cells will be integers. The arguments will be as follows:

- (1) the first array that will be copied;
- (2) the number of cells that will be copied from the first array;
- (3) the second array that will be copied;
- (4) the number of cells that will be copied from the second array;
- (5) the large array into which all copying will be performed;
- (6) the number of cells available in the large array.

If the function discovers that the number of cells in the large array is not large enough to hold all the numbers to be copied into it, then the function should return 0 to indicate failure. Otherwise it should return 1. The function should not alter the contents of the first two arrays. To take an example, if the first two arrays passed to the function look like this:

0	1	2	3	4	5	6
58	26	91	34	70	34	88

and

0	1	2	3
29	41	10	66

then, provided the size of the large array is at least 11, the large array should look like this when the function returns:

0	1	2	3	4	5	6	7	8	9	10
58	26	91	34	70	34	88	29	41	10	66

37. Write a function named "number_of_matches" that compares the initial parts of two character arrays to see how many pairs of cells match before a difference occurs. For example, if the arrays are

0	1	2	3	4	5
'b'	'o'	'a'	's'	't'	'\0'

and

0	1	2	3	4
'b'	'o'	'a'	't'	'\0'

then the function should return the value 3 because only the first three pairs of cells in the arrays match (cell 0 matches cell 0, cell 1 matches cell 1, and cell 2 matches cell 2). Each of the character arrays will end with the character whose ASCII value is zero; this character, called NUL, is denoted by '\0' in the C and C++ programming languages (see the two arrays shown above). The pairwise cell comparisons should not go beyond the end of either array. If the two arrays are identical all the way to their terminating NUL characters, return the number of non-NUL characters. The function should take only two parameters, namely the two character arrays to be compared.

38. Write a function named "eliminate_duplicates" that takes an array of integers in random order and eliminates all the duplicate integers in the array. The function should take two arguments:

- (1) an array of integers;
- (2) an integer that tells the number of cells in the array.

The function should not return a value, but if any duplicate integers are eliminated, then the function should change the value of the argument that was passed to it so that the new value tells the number of distinct integers in the array. Here is an example. Suppose the array passed to the function is as shown below, and the integer passed as an argument to the function is 11.

0	1	2	3	4	5	6	7	8	9	10
58	26	91	26	70	70	91	58	58	58	66

Then the function should alter the array so that it looks like this:

0	1	2	3	4	5	6	7	8	9	10
58	26	91	70	66	??	??	??	??	??	??

and it should change the value of the argument so that it is 5 instead of 11 . The question marks in the cells after the 5th cell indicate that it does not matter what numbers are in those cells when the function returns.

39. Write an entire C++ program that reads a positive integer entered by an interactive user and then prints out all the positive divisors of that integer in a column and in decreasing order. The program should allow the user to repeat this process as many times as the user likes. Initially, the program should inform the user about how the program will behave. Then the program should prompt the user for each integer that the user wishes to enter.

The program may be terminated in any of two ways. One way is to have the program halt if the user enters an integer that's negative or zero. In this case the user should be reminded with each prompt that the program can be terminated in that way. Alternatively, after an integer has been entered and the divisors have been printed, the program can ask the user whether he/she wishes to enter another integer. In this case, when the user accidentally enters a zero or negative integer to have its divisors calculated, the program should inform the user that the input is unacceptable and should allow the user to try again (and again!).

Here is an illustration of how the program and the interactive user might interact. The user's responses to the program are shown in bold italics.

```
This program is designed to exhibit the positive divisors of
positive integers supplied by you. The program will repeatedly
prompt you to enter a positive integer. Each time you enter a
positive integer, the program will print all the divisors of your
integer in a column and in decreasing order.
```

```
Please enter a positive integer: 36
```

```
36
18
12
9
6
4
3
2
1
```

```
Would you like to see the divisors of another integer (Y/N)? y
```

```
Please enter a positive integer: -44
```

```
-44 is not a positive integer.
```

```
Please enter a positive integer: 0
```

```
0 is not a positive integer.
```

```
Please enter a positive integer: 109
```

```
109
1
```

```
Would you like to see the divisors of another integer (Y/N)? m
```

```
Please respond with Y (or y) for yes and N (or n) for no.
```

```
Would you like to see the divisors of another integer (Y/N)? n
```

Answers

1. The output would be as shown below.

```
5
5
5
6
-6
6
5
5
5
4
6
4
2
42
4
_x( )_x( )4
_x( ) n
blank line
blank line
_x( ) n * n = 16
n
```

2. The output would be as shown below. The program contains an endless loop.

```
9
4
1
0
-1
0
1
2
3
4
4
2
1
0
0 [endlessly]
```

3. The output would be as shown below.

```
4
1
1
0
0
1
0
0
1
1
```

4. The output would be as shown below.

```
0 4
```

5. The output would be as shown below.

```
46
1
```

6. The output would be as shown below, because when it is discovered that `"!found"` is true, the second half of the OR expression is not evaluated, and thus `count` is not decremented.

```
danger
count = 5
```

7. The output would be as shown below. The 'a' in "Titanic" has been changed to an 'i'.

```
Titinic
i
```

8. The output would be as shown below. The line in italics would be typed by the interactive user.

```
Enter a sentence on the line below.
Please go away.
Please
```

The reason that only the word "Please" is picked up in the `message` array is that the extraction operator `>>` ignores leading white space characters and then reads non-white space characters up to the next white space character. (White space characters include the blank character and the newline character as well as several other control characters.) That is, `>>` is "word oriented", not line oriented.

9 a. The output would be as shown below. The line in italics would be typed by the interactive user.

Enter a sentence on the line below.

Please go away.

Please go away.

b. The output would be as shown below. The line in italics would be typed by the interactive user.

Enter a sentence on the line below.

Please stop bothering me.

Please stop botherin

The reason that the entire line typed by the user is not picked up in the `message` array is that the `getline` instruction will read at most 20 characters from the keyboard.

10 a. If the interactive user types only `Please go away.` and presses the Enter key, then there will be no output; instead, the program will "hang" and wait for more input. The reason for this is that the instruction `"cin >> message[i];"` removes and discards each white space character that it encounters in the input stream. Thus the loop will discard the two blanks in the input and the newline at the end, producing this condition in the input array:

0	1	2	3	4	5	6	7	8	9	10	11	12
'P'	'l'	'e'	'a'	's'	'e'	'g'	'o'	'a'	'w'	'a'	'y'	'.'

Since `message[i]` will never pick up the newline character, the only way that the loop can end is for the loop variable `i` to reach the value 20. This cannot happen unless the interactive user types at least eight more non-white space characters.

b. The instruction `"cin.get(message[i]);"` inputs into the array whatever character it finds in the input stream, including all white space characters. Thus if the user types `Please go away.` and presses the Enter key, then the loop will end when `message[15]` gets the newline character, and the output will be exactly the same as the input.

11 a. The original statement is formatted in such a way that it appears that the `"else"` clause of the statement is the alternative to the `"if (n < 10)"` case, but in fact, the C or C++ compiler will treat the `"else"` clause as the alternative to the `"if (n > 0)"` clause. If `n` has the value 7, the output will be `"The number is positive"`. If `n` has the value 15, then there will be no output. If `n` has the value -3 then the output will be `"The number is _____"`.

b. If we want the statement to behave according the logic that's suggested by the formatting of the original statement, we can write

```
if (n < 10)
{
    if (n > 0)
        cout << "The number is positive." << endl;
}
else
    cout << "The number is greater than 10." << endl;
```

c. If we want the statement to be formatted so as to reflect the actual logic of the original statement, we can write

```

if (n < 10)
    if (n > 0)
        cout << "The number is positive." << endl;
    else
        cout << "The number is negative." << endl;

```

12 a. Since there are no braces surrounding the last two lines of the code, the compiler treats only the statement "n /= 2;" as the body of the loop. Thus n will successively assume the values 5, 2, 1, and 0, at which point the loop will exit and the "cout" statement will print 0. The values 5, 2, and 1 will not be printed.

b. If we want the statement to behave according to the logic that's suggested by the formatting of the original statement, we can put braces around the last two lines of code to make a compound statement as the body of the loop:

```

int n = 10;

while (n > 0)
{
    n /= 2;
    cout << n * n << endl;
}

```

In this case the output of the loop will be

```

25
4
1
0

```

c. If we want the statement to be formatted so as to reflect the actual logic of the original statement, we can write

```

int n = 10;

while (n > 0)
    n /= 2;

cout << n * n << endl;

```

13. The conditional statement should be modified as follows:

```

if (income < 0.0)
    cout << "You are going farther into debt every month." << endl;

else if (income < 1200.00)
    cout << "You are living below the poverty line." << endl;
else if (income < 2500.00)
    cout << "You are living in moderate comfort." << endl;
else
    cout << "You are well off." << endl;

```

- 14 a.** The output will be "less than 10".
b. The output will be "greater than 15".
c. The output will be "less than 10".
d. There is no value for `n` that will cause the output to be "not interesting". That part of the code can never be executed!

15. Using `do...while...` in this situation makes the code a little simpler.

```
int n;

do
{
    cout << "Enter a non-negative integer: ";
    cin >> n;

    if (n < 0)
        cout << "The integer you entered is negative." << endl;
}
while (n < 0);
```

16 a. The output of the code fragment as it is written will be

```
n is not zero.
The square of n is 0.
```

The reason for this is that the "if" part assigns the value 0 to `n`, and the value returned by that assignment statement is 0, so this is treated as "false", which causes the alternative statement to be executed. But even though the program prints "n is not zero.", in fact, `n` does have the value zero after the conditional statement is finished.

b. The correction consists simply of replacing "`n = 0`" by "`n == 0`".

17. The output of the code fragment is as follows:

```
n = 4    k = 5
```

18. The output of the code fragment is as follows:

```
n = 3
```

The fractional part of the floating point value is discarded when the value is cast to integer type.

20. The loop can be modified as follows:

```
while (letter <= 'Z')
{
    cout << letter << "  " << int(letter) << endl;
    ++letter;
}
```

21.

```
/****** S U M F R O M T O *****/
```

DESCRIPTION: Computes and returns the sum of all the integers between "first" and "last" inclusive.

PARAMETERS:

first, last The two "endpoints" of the sequence of integers to be summed.

RETURNS: Returns the sum of all the integers from "first" to "last". For example, if first is 9 and last is 12 then the function will return 42 (= 9+10+11+12). If first is 11 and last is 8, then the function will return 38 (= 11+10+9+8). If first is 5 and last is 5, the function will return 5.

ALGORITHM: If first <= last, the addition begins at first and goes up to last. If, instead, first > last, then the addition begins at first and goes down to last.

AUTHOR: W. Knight

```
*****/
```

```
int sum_from_to (int first, int last)
{
    int i, partial_sum = 0;

    if (first <= last)
        for (i = first; i <= last; ++i)
            partial_sum += i;

    else
        for (i = first; i >= last; --i)
            partial_sum += i;

    return partial_sum;
}
```

22.

```
***** E N O U G H *****
```

DESCRIPTION: Computes and returns the smallest positive integer n for which $1+2+3+\dots+n$ equals or exceeds the value of "goal".

PARAMETER:

goal The integer which $1+2+3+\dots+n$ is required to meet or exceed.

RETURNS: Returns the smallest positive integer n for which $1+2+3+\dots+n$ equals or exceeds "goal". For example, if goal has the value 9, then the function will return 4 because $1+2+3+4 \geq 9$ but $1+2+3 < 9$. If goal has a value

less than or equal to 1, then the function will return the value 1.

ALGORITHM: First the value $n = 1$ is tried to see if $1 \geq \text{goal}$. If that is not true, then successively larger values of n are added to a summing variable until that sum reaches or exceeds goal.

AUTHOR: W. Knight

```
*****/
```

```
int enough (int goal)
{
    int n = 1, sum = 1;

    while (sum < goal)
        sum += ++n;

    return n;
}
```

23. There is a well-known algorithm called "Euclid's Algorithm" for computing the g.c.d. of two positive integers. The second of the two solutions below employs that algorithm. The first solution employs a somewhat more straight-forward search process, in which we simply try one integer after another, starting with the smaller of the two arguments, until we find an integer that divides both. For the purposes of the C++ exam, the first solution is acceptable (even though it is far less efficient than the solution that uses Euclid's Algorithm).

```
/****** G_C_D (VERSION 1) *****/
```

DESCRIPTION: Computes and returns the greatest common divisor (g.c.d.) of the arguments passed to it.

PARAMETERS:

a , b The integers whose g.c.d. will be computed.

RETURNS: If either argument is less than or equal to zero, the value zero will be returned as a sentinel to indicate an error. If both arguments are strictly positive, then their g.c.d. will be returned. Thus, for example, if parameter a has the value 28 and b has the value 70, then the function will return the value 14.

ALGORITHM: If both arguments are positive, then the smaller of the two arguments is tested to see whether it is a divisor of both arguments. If it is not, then successively smaller integers are tried. If no common divisor larger than 1 is found, then the loop will automatically stop with trial_divisor having the value 1 because 1 is a divisor of every positive integer.

AUTHOR: W. Knight

```
*****/
```

```
int g_c_d (int a, int b)
{
    if (a <= 0 || b <= 0) // a parameter is not positive
        return 0;       // exit and return the error sentinel

    int trial_divisor;
    trial_divisor = ( a <= b ? a : b ); // set it to the smaller

    while (a % trial_divisor != 0 || b % trial_divisor != 0)
        --trial_divisor;

    return trial_divisor;
}
```

A version of the previous algorithm that uses the Euclidean algorithm is given on the next page.

/****** G_C_D (VERSION 2) *****/

DESCRIPTION: Computes and returns the greatest common divisor (g.c.d.) of the arguments passed to it.

PARAMETERS:

a , b The integers whose g.c.d. will be computed.

RETURNS: If either argument is less than or equal to zero, the value zero will be returned as a sentinel to indicate an error. If both arguments are strictly positive, then their g.c.d. will be returned. Thus, for example, if parameter a has the value 28 and b has the value 70, then the function will return the value 14.

ALGORITHM: If both arguments are positive, then Euclid's algorithm for the g.c.d. is employed. The first integer is divided by the second, and then the second is divided by the remainder, and then the first remainder is divided by the second, and so on until a remainder of 0 is obtained.
The g.c.d. will be the divisor that produced 0 remainder.

AUTHOR: W. Knight

*****/

```
int g_c_d (int a, int b)
{
    if (a <= 0 || b <= 0) // a parameter is not positive
        return 0;       // exit and return the error sentinel

    int remainder = a % b; // Get remainder when a is divided by b.

    while (remainder != 0)
    {
        a = b;
        b = remainder;
        remainder = a % b;
    }

    return b; // Return the divisor that produced a remainder of 0.
}
```

24.

```
***** I S P R I M E *****
```

DESCRIPTION: Determines whether an integer is prime.

PARAMETER:

n The integer to be examined to see whether it is prime.

RETURNS: 1 if the integer n is prime; otherwise it returns 0.

ALGORITHM: If n is less than or equal to 1, then it is not prime.
 If n is greater than 1, then trial divisors, starting
 with 2 and going no farther than n-1 are examined to
 determine whether they divide n. If no divisor less
 than n is found, then n is prime.

AUTHOR: W. Knight

```
*****/
```

```
int is_prime (int n)
{
    if (n <= 1)
        return 0; // n cannot be prime if n <= 1.

    int trial_divisor = 2;

    while (trial_divisor < n && n % trial_divisor != 0)
        ++trial_divisor;

    // When the loop exits, one of two conditions must be satisfied:
    // either trial_divisor will have reached the value n -- which
    // means that n is prime or else n will be divisible by
    // trial_divisor, in which case n will not be prime. The only
    // exception to this is when n is 2, in which case n is prime.

    if (trial_divisor == n) // n must be prime
        return 1;
    else
        return 0; // n is not prime.
}
```


25.

```
/****** D I G I T   N A M E ******/
```

DESCRIPTION: _Prints the English name of an integer from 1 to 9.

PARAMETER:

n The integer whose English name will be printed.

RETURNS: Void (no value).

ALGORITHM: A switch statement selects the appropriate word.
If "n" is not in the range 1,2,3,...,9, then an
error phrase is printed.

AUTHOR: W. Knight

```
*****/
```

```
void digit_name (int digit_value)
{
    switch (digit_value)
    {
        case 1 : cout << "one";    break;
        case 2 : cout << "two";    break;
        case 3 : cout << "three";  break;
        case 4 : cout << "four";   break;
        case 5 : cout << "five";   break;
        case 6 : cout << "six";    break;
        case 7 : cout << "seven";  break;
        case 8 : cout << "eight";  break;
        case 9 : cout << "nine";   break;
        default : cout << "digit error" << endl;
    }
}
```

26.

```
***** R E D U C E *****
```

DESCRIPTION: Reduces a positive fraction to lowest terms.

PARAMETERS:

num, denom The numerator and denominator of the fraction to be reduced. These are reference parameters, so the arguments passed to them may be changed by the function.

RETURNS: 1 if the arguments are both positive, 0 otherwise.

ALGORITHM: If both arguments are positive, then each of them is divided by their greatest common divisor.

AUTHOR: W. Knight

```
*****/
```

```
int reduce (int & num, int & denom)
{
    if (num <= 0 || denom <= 0)
        return 1;

    else
    {
        int common = g_c_d (num, denom);
        num /= common;
        denom /= common;
    }
}
```

27.

```
/****** S W A P   F L O A T S   *****/
```

DESCRIPTION: Interchanges the values of the two floating point variables passed to it.

PARAMETERS:

a, b The two parameters whose values will be interchanged. These are both reference parameters, so their values may be changed by the function.

RETURNS: Void (no value).

ALGORITHM: Stores the value of parameter a in a temporary location, then copies the value in b into a, and finally copies the stored original value of a into b.

AUTHOR: W. Knight

```
*****/
```

```
void swap_floats (float & a, float & b)
{
    float temp = a;
    a = b;
    b = temp;
}
```

28. Here is one solution among many possible. It uses the `swap_floats` function of problem 27.

```
/****** S O R T 3 *****/
DESCRIPTION:  Sorts the three values passed to it into increasing
order.
```

PARAMETERS:

`x, y, z` The three floating point numbers to be sorted.
All three parameters are reference parameters, so the arguments passed to them may be changed by the function.

RETURNS: Void (no value).

ALGORITHM:

First `x, y,` and `z` are compared to see if they are already in increasing order. If they are, no changes are made.
If `x <= y` but `y > z`, then `y` and `z` are swapped, and then `x` and the new value of `y` (what was `z`) are compared and put in correct order.
If `x > y`, then `x` and `y` are swapped so that `x < y`.
Next it is necessary to discover where `z` belongs in relation to `x` and `y`. If `y <= z`, nothing more needs doing.
If, instead, `z < y`, then `y` and `z` are swapped and then `x` and the new `y` are compared and put in order.

AUTHOR: W. Knight

```
*****/
```

```
void sort3 (float & x, float & y, float & z)
```

```
{
    float temp;

    if (x <= y && y <= z) // the values are already in order;
        ;                // do nothing

    else if (x <= y) // then z < y (or we'd have stopped above)
    {
        swap_floats (z, y); // After this call, y < z and x <= z are
                            // true but we don't know how x and y
        if (x > y)         // compare.
            swap_floats (x, y); // Now x < y <= z must be true.
    }

    else // If neither of the above is true, then we know that y < x
    {
        swap_floats (x, y); // After this call, x < y is true.

        if (y <= z) // the values are now in correct order;
            ;      // do nothing

        // [ Continued on the next page ]
    }
}
```

```
else // it must be the case that z < y
{
    swap_floats (y, z); // After this call, y <= z is true.

    if (x > y)
        swap_floats (x, y);
}
}
```

29. The following function calls the `swap_floats` function given in problem 27.

```
/****** R E V E R S E *****/
```

DESCRIPTION: Reverses the order of the objects in an array.

PARAMETERS:

- a The array of floating point numbers whose objects will be reversed.
- n The number of objects in the array, starting at cell 0.

RETURNS: Void (no value).

ALGORITHM: One array index starts at the left end of the array and moves to the right, while another starts at the right end and moves to the left. Objects in the cells indicated by these two indexes are swapped. The process ends when the two indexes meet or cross each other.

AUTHOR: W. Knight

```
*****/
```

```
void reverse (float a[], int n)
{
    int i = 0, j = n - 1;

    while (i < j)
        swap_floats (a[i++], a[j--]);
}
```

30.

```
/****** S U M *****/
```

DESCRIPTION: Calculates and returns the sum of the numbers in an array.

PARAMETERS:

a The array of floating point numbers to be summed
n The number of objects in the array, starting at cell 0.

RETURNS: The sum $a[0] + a[1] + \dots + a[n-1]$.

ALGORITHM: A summing variable is initialized to zero and then each floating point value in the array is added in turn.

AUTHOR: W. Knight

```
*****/
```

```
float sum (const float a[], int n)
{
    float sum_so_far = 0.0;
    int i;

    for (i = 0; i < n; ++i)
        sum_so_far += a[i];

    return sum_so_far;
}
```

31. Here is the simplest solution.

```
/****** LOCATION OF LARGEST *****/  
DESCRIPTION: Finds the index of the largest number in an array.  
PARAMETERS:  
    a          An array of integers to be scanned.  
    n          The number of objects in the array, starting at cell 0.  
RETURNS:      The index of the cell containing the largest integer.  
              If the largest integer appears in more than one cell,  
              then the index of the leftmost cell where it appears  
              will be returned.  
ALGORITHM:    A variable that will hold the index of the largest  
              integer is initialized to zero, and we pretend to have  
              scanned that cell and found that it contains the  
              largest integer seen "so far". Then successive cells  
              are examined and compared with the cell containing the  
              largest integer so far. When a cell containing a new  
              largest integer is encountered, the variable that holds  
              the index of the largest integer seen so far is  
              modified to the new index.
```

AUTHOR: W. Knight

```
*****/  
int location_of_largest (const int a[], int n)  
{  
    int best = 0; // Location of the largest so far.  
    int i;  
  
    for (i = 1; i < n; ++i) // Start comparing at the second cell.  
        if (a[i] > a[best])  
            best = i;  
  
    return best;  
}
```

[Another solution, not as elegant as the one above, is given on the following page.
An INCORRECT solution, commonly given by students, is shown two pages father along.]

The following solution is not as elegant as the one on the preceding page.

```
/****** L O C A T I O N   O F   L A R G E S T   *****/
```

DESCRIPTION: Finds the index of the largest number in an array.

PARAMETERS:

a An array of integers to be scanned.

n The number of objects in the array, starting at cell 0.

RETURNS: The index of the cell containing the largest integer.
If the largest integer appears in more than one cell,
then the index of the leftmost cell where it appears
will be returned.

ALGORITHM: A variable that will hold the index of the largest
integer is initialized to zero, and we pretend to have
scanned that cell and found that it contains the
largest integer seen "so far". We initialize a
"largest_value" variable to the value a[0]. Then
successive cells are examined and compared with the
value of the largest integer so far. When a cell
containing a new largest integer is encountered, the
variable that holds the index of the largest integer
seen so far is modified to the new index, and the
largest_value variable is updated.

AUTHOR: W. Knight

```
*****/
```

```
int location_of_largest (const int a[], int n)
{
    int largest_value = a[0]; // First cell contains largest so far.
    int best = 0;            // Location of the largest so far.
    int i;

    for (i = 1; i < n; ++i)
        if (a[i] > largest_value)
        {
            largest_value = a[i];
            best = i;
        }

    return best;
}
```

[A commonly given -- but INCORRECT -- solution is shown on the next page.]

The following is NOT an acceptable solution because it does not allow for the possibility that all the integers in the array may be negative or zero.

```
int location_of_largest (const int a[], int n) // NOT ACCEPTABLE
{
    int largest_value = 0; // Assume the largest value will be > 0.
    int best;             // Eventual location of the largest value.
    int i;

    for (i = 0; i < n; ++i)
        if (a[i] > largest_value) // Will be true for some i only if
            {                       // the array contains at least one
                largest_value = a[i]; // value strictly greater than 0.
                best = i;
            }

    return best;
}
```

The incorrect solution above can be corrected by initializing `largest_value` to the most negative possible integer value (`INT_MIN`, which is defined in the header file `<limits.h>`) and initializing `best` to 0.

32. Here is the simplest solution. It searches from right to left and quits when (if) it finds the target.

```
/****** L O C A T I O N   O F   T A R G E T   *****/
```

DESCRIPTION: Finds the index of the cell (if any) where a "target" integer is stored.

PARAMETERS:

a An array of integers to be scanned.
n The number of objects in the array, starting at cell 0.
target The integer that we hope to find in some cell of
 array a.

RETURNS: The index of the cell containing the integer "target" provided there is such a cell. If there is not, then the function returns -1 as a sentinel value. If the target integer appears in more than one cell, then the index of the rightmost cell where it appears will be returned.

ALGORITHM: The value parameter "n" is used to scan backward across the array, looking for a cell containing a copy of "target". If a copy is found, the search is halted and the index of that cell is returned. If no such cell is found, "n" will run off the left end of the array and wind up with value -1.

AUTHOR: W. Knight

```
*****/
```

```
int location_of_target (const int a[], int n, int target)
{
    --n; // Make n "point" to the last cell of the array.
    while (n >= 0 && a[n] != target) // Search right to left
        --n;
    return n; // Returns -1 if target is not in array a[].
}
```

[Another solution, which in general is not as efficient as the one above, is on the next page.]

The following solution is acceptable, although it is not in general as efficient as the one above because it always examines every cell of the array.

```
/****** L O C A T I O N   O F   T A R G E T   *****/
```

DESCRIPTION: Finds the index of the cell (if any) where a "target" integer is stored.

PARAMETERS:

a An array of integers to be scanned.

n The number of objects in the array, starting at cell 0.

target The integer that we hope to find in some cell of array a.

RETURNS: The index of the cell containing the integer target, provided there is such a cell. If there is not, then the function returns -1 as a sentinel value. If the target integer appears in more than one cell, then the index of the rightmost cell where it appears will be returned.

ALGORITHM: A location variable is initialized to -1 in case no copy of "target" is found. Then each cell of the array is examined, starting at the left end, and each time a copy "target" is found, the location variable is updated to the index of that cell.

AUTHOR: W. Knight

```
*****/
```

```
int location_of_target (const int a[], int n, int target)
{
    int location = -1; // Target not seen yet.
    int i;

    for (i = 0; i < n; ++i)
        if (a[i] == target)
            location = i;

    return location;
}
```

33.

***** ROTATE RIGHT *****

DESCRIPTION: Shifts the contents of array cells one cell to the right, with the last cell's contents moved to the left end.

PARAMETERS:

a The floating point array to be modified.

n The number of objects in the array, starting at cell 0.

RETURNS: Void (no value).

ALGORITHM: The object in the right-most cell is copied to a temporary location, and then the object each cell to the left of the last cell is copied to its immediate right neighbor; the process moves from right to left. Finally, the object in the temporary location is copied to the leftmost cell.

AUTHOR: W. Knight

*****/

```
void rotate_right (float a[], int n)
{
    float temp = a[n-1]; // Hold the contents of the last cell.

    int i;

    for (i = n - 1; i >= 1; --i)
        a[i] = a[i-1];

    a[0] = temp;
}
```

34.

```
/****** S H I F T   R I G H T   *****/
```

DESCRIPTION: Shifts the contents of some subarray in an array to the right by a specified number of cells.

PARAMETERS:

a The floating point array to be modified.

left The index of the leftmost cell of the subarray to be shifted.

right The index of the rightmost cell of the subarray.

distance The number of cells by which the subarray will be shifted.

RETURNS: 1 provided left <= right and distance > 0; returns 0 if either of these conditions is violated.

ALGORITHM: An index variable is initialized to "point" to the rightmost cell of the subarray to be shifted; another index variable is initialized to point to the cell to which the rightmost object will be copied. Then the copying takes place and the indexes are moved to the left (decremented by 1). The occurs repeatedly until the object in the leftmost cell of the subarray has been copied.

AUTHOR: W. Knight

```
/******/
```

```
int shift_right (float a[], int left, int right, int distance)
{
    if (left > right || distance <= 0)
        return 1;

    int i = right,           // points to the cell to be shifted
        j = i + distance; // points to the receiving cell

    while (i >= left)
    {
        a[j] = a[i];
        --i;
        --j;
    }

    return 0;
}
```

[A more elegant version is given on the next page.]

Here is a slightly more elegant version.

```
/****** S H I F T   R I G H T   *****/
```

DESCRIPTION: Shifts the contents of some subarray in an array to the right by a specified number of cells.

PARAMETERS:

a The floating point array to be modified.

left The index of the leftmost cell of the subarray to be shifted.

right The index of the rightmost cell of the subarray.

distance The number of cells by which the subarray will be shifted.

RETURNS: 1 provided left <= right and distance > 0; returns 0 if either of these conditions is violated.

ALGORITHM: An index variable is initialized to "point" to the rightmost cell of the subarray to be shifted. Then the object in that cell is copied to the cell that's "distance" units to the right. Then the index is decremented by 1 and the same process is repeated. This continues until all objects in the subarray have been copied.

AUTHOR: W. Knight

```
*****/
```

```
int shift_right (float a[], int left, int right, int distance)
{
    if (left > right || distance <= 0)
        return 1;

    int i;

    for (i = right; i >= left; --i)
        a[i + distance] = a[i];

    return 0;
}
```

35.

```
/****** S U B T O T A L *****/
```

DESCRIPTION: Replaces each number in an array with the sum of all the numbers up to that location in the original array.

PARAMETERS:

- a The floating point array to be modified.
- n The number of objects in the array, starting at cell 0.

RETURNS: Void (no value).

ALGORITHM: Starting with cell 1 and moving right, the number in each cell is replaced by the sum of that number and the sum that's now in the cell just to the left.

AUTHOR: W. Knight

```
*****/
```

```
void subtotal (float a[], int n)
{
    int i;

    for (i = 1; i < n; ++i)
        a[i] += a[i-1];
}
```


36.

***** C O N C A T E N A T E *****

DESCRIPTION: Copies numbers from two arrays into a third array. The numbers from the second array are placed to the right of the numbers copied from the first array.

PARAMETERS:

a, b The arrays from which numbers will be copied into "c".

c The array that will receive the copied numbers.

m, n The number of numbers to be copied from arrays a and b respectively, starting in each case at cell 0.

p The capacity of array c.

RETURNS: 1, provided the capacity of c is at least equal to the number of numbers that are to be copied from arrays a and b; 0 is returned if this condition fails.

ALGORITHM: If c has adequate capacity, then the leftmost m cells of array a are copied to the leftmost m cells of c, and then the leftmost n cells of b are copied into the n cells of c lying just to the right of the first m cells.

AUTHOR: W. Knight

*****/

```
int concatenate (const int a[], int m,
                const int b[], int n,
                int c[], int p)
{
    if (m + n > p)
        return 1;

    int i, j;

    for (i = 0; i < m; ++i)
        c[i] = a[i];

    for (j = 0; j < n; ++j)
        c[i++] = b[j];        // Increment i and j after each assignment

    return 0;
}
```

37.

***** N U M B E R O F M A T C H E S *****

DESCRIPTION: Compares two NUL-terminated character arrays to determine how many of the initial characters match.

PARAMETERS:

a, b The character arrays to be compared. Each is terminated by the NUL character '\0'.

RETURNS: The number of non-NUL initial matches in the two arrays. For example, if the arrays contain "boasted" and "boats" (with NUL following the final 'd' and 's' respectively), then 3 will be returned because "boa" matches "boa".

ALGORITHM: The characters are compared pairwise, starting at cell 0, until a NUL is reached or a pair of characters does not match.

AUTHOR: W. Knight

*****/

```
int number_of_matches (const char a[], const char b[])
{
    const char NUL = '\0';

    int i = 0; // i keeps track of how many pairs of cells match

    while (a[i] != NUL && b[i] != NUL && a[i] == b[i])
        ++i;

    return i;
}
```

38.

```
/****** E L I M I N A T E   D U P L I C A T E S   *****/
```

DESCRIPTION: Examines an array of integers and eliminates all duplication of values. The distinct integers are all moved to the left part of the array.

PARAMETERS:

a The integer array to be modified.

n The number of integers in the array, starting at cell 0. This is a reference parameter; its value will be changed if necessary to indicate the number of distinct integers that end up in the left part of the array.

RETURNS: Void (no value).

ALGORITHM: At all times during the algorithm, an integer keeps track of the last cell of the subarray containing all the distinct integers that have been found and moved to that subarray. Another integer moves along the unexamined portion of the array. Each time a new integer is encountered, it is checked against all the integers in the subarray of distinct integers to see whether it should be added to that subarray.

AUTHOR: W. Knight

```
*****/
```

```
void eliminate_duplicates (int a[], int & n)
{
    int last_unique = 0; // Keeps track of the end of the subarray of
                        // integers known to be all different.
    int i;
    for (i = 1; i < n; ++i) // Start i at the second cell (number 1).
    {
        // Determine whether a[i] is already present among the integers
        // in cells a[0],...,a[last_unique].
        int j = 0;
        while (j <= last_unique && a[i] != a[j])
            ++j;
        if (j > last_unique) // then a[i] is not present
            a[++last_unique] = a[i]; // earlier, so put a[i] into the
                                    // list of all different integers.
    }
    n = last_unique + 1; // Modify n so that it tells the number of
                        // distinct integers in the processed array.
}
```

39.

```

/*****
PROGRAMMER:      William Knight

DESCRIPTION:     This program prompts an interactive user to enter
                 positive integers, and it prints all the positive
                 divisors of each positive integer entered.

NOTE:           If the user enters one or more non-numeric characters
                 when prompted for an integer, the program will go
                 into an endless loop.

*****/

#include <iostream>
using namespace std;

/*****  G L O B A L   C O N S T A N T S   *****/

const int FALSE = 0, TRUE = 1;

/*****  F U N C T I O N   P R O T O T Y P E S   *****/

void print_initial_explanation (void);
void get_number_from_user (int & n);
void print_divisors (int n);
int  user_wishes_to_repeat (void);

/*****  M A I N   *****/

int main (void)
{
    int users_integer;

    print_initial_explanation();

    do
    {
        get_number_from_user (users_integer);

        print_divisors (users_integer);
    }
    while (user_wishes_to_repeat());
}

```

***** PRINT INITIAL EXPLANATION *****

DESCRIPTION: This function prints some text on the screen.

PARAMETERS: None.

RETURNS: Void (no value).

WRITTEN BY: W. Knight

*****/

```
void print_initial_explanation (void)
```

```
{  
    cout << "\n\nThis program is designed to exhibit the positive \n";  
    cout << "divisors of positive integers supplied by you. The\n";  
    cout << "program will repeatedly prompt you to enter a \n";  
    cout << "positive integer. Each time you enter a positive \n";  
    cout << "integer, the program will print all the divisors of \n";  
    cout << "your integer in a column and in decreasing order.\n\n";  
}
```

***** GET NUMBER FROM USER *****

DESCRIPTION: This function prompts an interactive user for a positive integer, reads the integer, and returns it in the variable passed to this function.

PARAMETER:

n The positive integer supplied by the user. This is a reference parameter. It is intended that the argument passed through this parameter will receive a new value.

RETURNS: Void (no value).

ALGORITHM: The user is prompted for the positive integer. If the integer entered by the user is zero or negative, the user will be informed that the input is not positive and will be given another chance to enter valid data. The function will not exit until the user has entered valid data.

WRITTEN BY: W. Knight

*****/

```

void get_number_from_user (int & n)
{
    do
    {
        cout << "Please enter a positive integer: ";
        cin >> n;
        if (n <= 0)
            cout << '\n' << n << " is not a positive integer.\n";
    }
    while (n <= 0);
}
// -----
// COMMENT: In the function "get_number_from_user", if the
// interactive user enters a non-numeric character in response to the
// prompt for a positive integer, then the program will go into
// an endless loop. That can be avoided as follows:
// place an "#include <stdlib.h>" directive at the top of the
// program, and then use this loop:
// do
// {
//     cout << "Please enter a positive integer: ";
//     cin >> n;
//     if (!cin.good()) // cin.good() returns 0 if cin >> n has
failed
//     {
//         cout << "\n\n *** Non-numeric data entered. Program";
//         cout << " cannot recover, so will exit. *** \n\n" <<
endl;
//         exit (1); // ABORT THE PROGRAM (exit is defined in
stdlib.h)
//     }
//
//     if (n <= 0)
//         cout << '\n' << n << " is not a positive integer.\n";
// }
// while (n <= 0);

```

```
/****** P R I N T   D I V I S O R S   *****/
```

DESCRIPTION: This function prints all the divisors of a positive integer in a column and in decreasing order.

PARAMETER:

n The positive integer whose divisors will be printed.

RETURNS: Void (no value).

ALGORITHM: First the value of n is printed. Then, starting with the next possible smaller divisor (n/2), each integer down to 1 is tested to see if it is a divisor of n, and every divisor is printed.

WRITTEN BY: W. Knight

```
*****/
```

```
void print_divisors (int n)
{
    cout << n << endl;

    int trial_divisor;

    for (trial_divisor = n / 2; trial_divisor >= 1; --trial_divisor)
        if (n % trial_divisor == 0)
            cout << trial_divisor << endl;

    cout << endl;
}
```

***** U S E R W I S H E S T O R E P E A T *****/

DESCRIPTION: This function determines whether an interactive user wishes to enter another positive integer.

PARAMETERS: None.

RETURNS: TRUE if the user wishes to repeat, FALSE if not.

ALGORITHM: The user is asked to type Y for "yes, I wish to repeat"

or N for "no, I do not". The user's response is then read from the keyboard, and if it is neither Y nor N (the lower case versions of these characters are also accepted), then the user is asked to re-enter a response.

WRITTEN BY: W. Knight

*****/

```
int user_wishes_to_repeat (void)
{
    char response;

    cout << "Would you like to see the divisors of another";
    cout << " integer (Y/N)? ";
    cin >> response;

    while (response != 'Y' && response != 'y' && response != 'N'
           && response != 'n')
    {
        cout << "\nPlease respond with Y (or y) for yes and N (or n)";
        cout << " for no." << endl;

        cout << "Would you like to see the divisors of another";
        cout << " integer (Y/N)? ";
        cin >> response;
    }

    if (response == 'Y' || response == 'y')
        return TRUE;
    else
        return FALSE;
}
```