Problem 1   Write the best **title lines** for the functions that are called by the following main program. **Do not supply blocks for the functions.**

```
int main() {
    int x = 0, y = 1, z = 2;
    double w[3] = {1.9, 2.3, 3.0};

    x = a(x + y, z);                // (a) sets x as the smaller of two values
    w[0] = b(x, y, y, w[2]);        // (b) sets w[0] as the largest of four values
    c(w, y, x);                     // (c) print the values of w indexed by x and y
    d(w[1], y);                     // (d) increase y by the nearest integer to w[1]
    d(e(y, z), y);                  // (e) applies e and then d
    return 0;
}
```

(a) Title line for **a**.

Answer:

```
int a(int x, int y)
```

(b) Title line for **b**.

Answer:

```
double b(int x, int y, int z, double w)
```

(c) Title line for **c**.

Answer:

```
void c(double w[], int x, int y)
```

(d) Title line for **d**.

Answer:

```
void d(double x, int &y)
```

(e) Title line for **e**.

Answer:

```
double e(int x, int y)
```

Problem 2   Write the best **title lines** for the functions that are called by the following main program. **Do not supply blocks for the functions.**

```
int main() {
    double x = 0, y = 1, z = 2;
    double w[3] = {1.9, 2.3, 3.0};

    x = f1(x + y, z);               // (a) sets x as the smaller of two values
    w[0] = f2(x, y, y, w[2]);       // (b) sets w[0] as the largest of four values
    f3(w, 3);                       // (c) print all values in w
    f4(w[1], y);                    // (d) decrease y by w[1]
    f4(f5(y, z), y);                // (e) applies f5 and then f4
    return 0;
}
```

(a) Title line for **f1**.

Answer:

```
double f1(double x, double y)
```

(b) Title line for **f2**.

Answer:

```
double f2(double x, double y, double z, double w)
```

(c) Title line for **f3**.

Answer:

```
void f3(double w[], int c)
```

(d) Title line for **f4**.

Answer:

```
void f4(double x, double &y)
```

(e) Title line for **f5**.

Answer:

```
double f5(double x, double y)
```

Problem 3   Write the best **title lines** for the functions that are called by the following main program. **Do not supply blocks for the functions.**

```
int main() {
    char x = '0', y = '1', z = '2';
    string w[3] = {"1.9", "2.3", "3.0"};

    x = a(x, z);                // (a) sets x as the smaller of two characters
    w[0] = b(x, y, y, w[2]);    // (b) sets w[0] as the concatenation
    c(w, 0, 1);                 // (c) prints the concatenation of w[0] and w[1]
    d(w[1], y);                 // (d) change y to the first character of w[1]
    d(e(y, z), y);              // (e) applies e and then d
    return 0;
}
```

(a) Title line for **a**.

Answer:

```
char a(char x, char y)
```

(b) Title line for **b**.

Answer:

```
string b(char x, char y, char z, string w)
```

(c) Title line for **c**.

Answer:

```
void c(string w[], int x, int y)
```

(d) Title line for **d**.

Answer:

```
void d(string x, char &y)
```

(e) Title line for **e**.

Answer:

```
string e(char x, char y)
```

Problem 4   Write the best **title lines** for the functions that are called by the following main program. **Do not supply blocks for the functions.**

```
int main() {
    double x = 0, y = 1, z = 2;
    string w[3] = {"1.9", "2.3", "3.0"};

    x = f1(x + y, z);              // (a) sets x as the smaller of two values
    w[0] = f2(x, y, y, w[2]);      // (b) sets w[0] using the four values
    f3(w, 3);                      // (c) print all values in w
    f4(w[1], y);                   // (d) decrease y by the numerical value of w[1]
    f4(f5(y, z), y);               // (e) applies f5 and then f4
    return 0;
}
```

(a) Title line for **f1**.

Answer:

```
double f1(double x, double y)
```

(b) Title line for **f2**.

Answer:

```
string f2(double x, double y, double z, string w)
```

(c) Title line for **f3**.

Answer:

```
void f3(string w[], int c)
```

(d) Title line for **f4**.

Answer:

```
void f4(string x, double &y)
```

(e) Title line for **f5**.

Answer:

```
string f5(double x, double y)
```

Problem 5   Write the best **title lines** for the functions that are called by the following main program. **Do not supply blocks for the functions.**

```
int main() {
    int i = 7, j = 8, k = 9;
    double a[3] = {1.1, 1.2, 1.3};
    double b[5] = {1.1, 9.1, 6.1, 8.1, 3.1};
    bool x[2][2] = {{true, true}, {false, true}};
    cout << min(i, j, k) << endl;            // (a) prints: 7
    printMax(b, 5);                          // (b) prints: 9.1
    cout << countFalse2d(x, 2, 2) << endl;   // (c) prints: 1 false entry
    swap (i, j);                             // (d) swaps i and j
    swapArrays (a, b, 2);        // (e) swaps first 2 elements of arrays a and b
    return 0;
}
```

(a) Title line for **min**.

Answer:

```
int min(int x, int y, int z)
```

(b) Title line for **printMax**.

Answer:

```
void printMax(double x[], int capacity)
```

(c) Title line for **countFalse2d**.

Answer:

```
string countFalse2d(bool x[][2], int r, int c)
```

(d) Title line for **swap**.

Answer:

```
void swap(int &x, int &y)
```

(e) Title line for **swapArrays**.

Answer:

```
void swapArrays(double x[], double y[], int number)
```

Problem 6   Consider the following C++ program.

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

int fun(int x) {
   int ans = 23456;
   if (x <= 0) return -1;
   if ((x >= 5) && (x < 10)) return ans % 1000;
   if (x >= 7) return -2;
   cout << x / 2;
   return fun(x + 1);
}

int main() {
    cout << fun(0) << endl;    // line (a)
    cout << fun(6) << endl;    // line (b)
    cout << fun(7) << endl;    // line (c)
    cout << fun(17) << endl;   // line (d)
    cout << fun(3) << endl;    // line (e)
}
```

(a) What is the output at line (a)?

Answer:

```
-1
```

(b) What is the output at line (b)?

Answer:

```
456
```

(c) What is the output at line (c)?

Answer:

456

(d) What is the output at line (d)?

Answer:

-2

(e) What is the output at line (e)?

Answer:

12456

Problem 7   Consider the following C++ program.

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

int fun(int x) {
    int ans = 2345;
    if (x <= 0) return -2;
    if ((x >= 6) && (x < 10)) return ans % 100;
    if (x >= 8) return -5;
    cout << x / 3;
    return fun(x - 1);
}

int main() {
    cout << fun(0) << endl;     // line (a)
    cout << fun(6) << endl;     // line (b)
    cout << fun(7) << endl;     // line (c)
    cout << fun(17) << endl;    // line (d)
    cout << fun(3) << endl;     // line (e)
}
```

(a) What is the output at line (a)?

Answer:

-2

(b) What is the output at line (b)?

Answer:

45

(c) What is the output at line (c)?

Answer:

45

(d) What is the output at line (d)?

Answer:

-5

(e) What is the output at line (e)?

Answer:

```
100-2
```

Problem 8   Consider the following C++ program.

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

int fun(int x) {
   int ans = 34567;
   if (x <= 0) return 0;
   if ((x >= 6) && (x < 10)) return ans % 1000;
   if (x >= 8) return -1;
   cout << x % 2;
   return fun(x + 2);
}

int main() {
   cout << fun(0) << endl;    // line (a)
   cout << fun(6) << endl;    // line (b)
   cout << fun(7) << endl;    // line (c)
   cout << fun(17) << endl;   // line (d)
   cout << fun(3) << endl;    // line (e)
}
```

(a) What is the output at line (a)?

Answer:

```
0
```

(b) What is the output at line (b)?

Answer:

```
567
```

(c) What is the output at line (c)?

Answer:

```
567
```

(d) What is the output at line (d)?

Answer:

```
-1
```

(e) What is the output at line (e)?

Answer:

```
11567
```

Problem 9   Consider the following C++ program.

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

int fun(int x) {
   int ans = 5432;
   if (x <= 0) return -1;
   if ((x >= 8) && (x < 13)) return ans % 100;
   if (x >= 10) return -5;
   cout << x % 3;
   return fun(x + 2);
}

int main() {
    cout << fun(0) << endl;     // line (a)
    cout << fun(6) << endl;     // line (b)
    cout << fun(7) << endl;     // line (c)
    cout << fun(17) << endl;    // line (d)
    cout << fun(3) << endl;     // line (e)
}
```

(a) What is the output at line (a)?

Answer:

-1

(b) What is the output at line (b)?

Answer:

032

(c) What is the output at line (c)?

Answer:

132

(d) What is the output at line (d)?

Answer:

-5

(e) What is the output at line (e)?

Answer:

02132

Problem 10   The following C++ program has errors at the lines marked a,b,c,d, and e. For each answer write a single line of C++ that fixes all errors in the corresponding line. Do not change anything that is correct.


```cpp
// Program reads integers x and y from an input file called inputFile.txt
// If they are equal, it prints Equal
// Otherwise it prints the smaller one
#include <iostream>
#include <fstream>
using namespace std;
```

```
int main() {

    int x, y;
    ifstream f;
    f.open(inputFile.txt);          // line a

    f >> x, y;                      // line b

    if (x = y) cout << "Equal";     // line c

    else if (x < y) cout << x else cout << y;   // line d

    cout endl; return;              // line e

}
```

(a) Correct line (a):

Answer:

```
    f.open("inputFile.txt");        // line a
```

(b) Correct line (b):

Answer:

```
    f >> x >> y;                    // line b
```

(c) Correct line (c):

Answer:

```
    if (x == y) cout << "Equal";    // line c
```

(d) Correct line (d):

Answer:

```
    else if (x < y) cout << x; else cout << y;   // line d
```

(e) Correct line (e):

Answer:

```
    cout << endl; return 0;         // line e
```

Problem 11   Write blocks of code to perform the functions used in the following main program. Your blocks must match the given title lines. Each block should be a short function of only a few lines.

```
int main() {
   int i = 2;
   int x[5] = {3, 1, 4, 1, 5};
// (a) Return the absolute value (ignoring a minus sign).  Here 2 is printed.
   cout << absVal(-2) << endl;
// (b) Return number of even entries, here 1 is printed.
   cout << numEven(x, 5) << endl;
// (c) Cube i. Here 8 is printed.
   cubeIt(i); cout << i << endl;
// (d) Find the (last) index of the smallest entry. Here 3 is printed.
   cout << findIndexMin(x, 5) << endl;
// (e) Is it a digit? Here print nothing.
   if (isDigit('h')) cout << "Digit" << endl;
   return 0;
}
```

Answer:

(a)

```
int absVal(int x) {
    if (x < 0) return -x;
    return x;
}
```

(b)

```
int numEven(int array[], int cap) {
   int ans = 0;
   for (int i = 0; i < cap; i++)
      if (array[i] % 2 == 0) ans++;
   return ans;
}
```

(c)

```
void cubeIt(int &x) {
   x = x * x * x;
}
```

(d)

```
int findIndexMin(int array[], int cap) {
   int ans = 0;
   for (int i = 0; i < cap; i++)
      if (array[i] <= array[ans]) ans = i;
   return ans;
}
```

(e)

```
bool isDigit(char x) {
   return '0' <= x && x <= '9';
}
```

Problem 12   Write blocks of code to perform the functions used in the following main program. Your blocks must match the given title lines. Each block should be a short function of only a few lines.

```
int main() {
   int i = 2;
   int x[7] = {3, 1, 4, 1, 5, 9, 2};
// (a) Return the exact quotient.  Here 0.4 is printed.
   cout << divide(i, 5) << endl;
// (b) Return number of odd entries. Here 5 is printed.
   cout << numOdd(x, 7) << endl;
// (c) Make a number from two copies of a (single) digit. Here 22 is printed.
   cout << doubleIt(2) << endl;
// (d) Find the last index of the largest entry. Here 5 is printed.
   cout << findIndexMax(x, 7) << endl;
// (e) Is it a lower case character? Here L is printed.
   if (isLowerCase('h')) cout << "L" << endl;
   return 0;
}
```

Answer:

(a)

```
double divide(int x, int y) {
    return x / ((double) y);
}
```

(b)

```
int numOdd(int array[], int cap) {
    int ans = 0;
    for (int i = 0; i < cap; i++)
        if (array[i] % 2 != 0) ans++;
    return ans;
}
```

(c)

```
int doubleIt(int x) {
    return 11 * x;
}
```

(d)

```
int findIndexMax(int array[], int cap) {
    int ans = 0;
    for (int i = 0; i < cap; i++)
        if (array[i] >= array[ans]) ans = i;
    return ans;
}
```

(e)

```
bool isLowerCase(char x) {
    return 'a' <= x && x <= 'z';
}
```

Problem 13   Write blocks of code to perform the functions used in the following main program. Your blocks must match the given title lines. Each block should be a short function of only a few lines.

```
int main() {
    int a = 123, b = 3;
    ifstream f;
    string s = "HELLO";
    f.open("testFile.txt");
 // (a) Tests whether a number has 3 digits, here Yes!
    if (is3digit(a)) cout << "Yes!" << endl;
 // (b) Doubles a string, here HELLOHELLO
    cout << doubleIt(s) << endl;
 // (c) Returns the number of words found in the input file before eof() is true
    cout << countWords(f) << endl;
 // (d) Print middle character of a string that has odd length here L, ignore even lengths
    cout << midChar(s) << endl;
 // (e) swap a and b so that 3,123 is printed
```

```
    swap(a, b);
    cout  << a << "," << b << endl;
    return 0;
}
```

Answer:

(a)

```
bool is3digit(int x) {
    return (x > 99) && (x < 1000);
}
```

(b)

```
string doubleIt(string x) {
    return x + x;
}
```

(c)

```
int countWords(ifstream &file) {
    string x; int count = 0;
    while (!file.eof()) {
        file >> x; count++;
    }
    return count;
}
```

(d)

```
char midChar(string x) {
    return x[x.length()/2];
}
```

(e)

```
void swap(int &x, int &y) {
    int temp = x;
    x = y; y = temp;
}
```

Problem 14   Write blocks of code to perform the functions used in the following main program. Your blocks must match the given title lines. Each block should be a short function of only a few lines.

```
int main() {
    int a = 2, b = 3, c = 4;
    ifstream f;
    string s = "HELLO";
    f.open("testFile.txt");
 // (a) Tests whether a number is even, here Even!
    if (even(c)) cout << "Even!" << endl;
 // (b) Removes first character from a string, here ELLO
    cout << removeFirst(s) << endl;
 // (c) Returns first word read from the input file
```

```
      cout << firstWord(f) << endl;
 // (d) Returns last character of a string, here 0
      cout << lastChar(s) << endl;
 // (e) Change a,b,c to be c, a, b so here it prints 423
      rotate(a, b, c);
      cout   << a << b << c << endl;
      return 0;
}
```

Answer:

(a)

```
bool even(int x) {
      return x % 2 == 0;
}
```

(b)

```
string removeFirst(string x) {
      return x.substr(1);
}
```

(c)

```
string firstWord(ifstream &file) {
      string x;
      file >> x;
      return x;
}
```

(d)

```
char lastChar(string x) {
      return x[x.length() - 1];
}
```

(e)

```
void rotate(int &x, int &y, int &z) {
      int temp = x;
      x = z;
      z = y;
      y = temp;
}
```

Problem 15   Consider the following C++ program.

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

string fun(int x) {
      string ans = "56789";
      if (x <= 0) return "0";
      if ((x >= 5) && (x < 10)) return ans.substr(x - 3);
```

```
      if (x >= 7) return "Error\nError";
      cout << x;
      return fun(x + 1);
}

int main() {
    cout << fun(0) << endl;     // line (a)
    cout << fun(6) << endl;     // line (b)
    cout << fun(7) << endl;     // line (c)
    cout << fun(17) << endl;    // line (d)
    cout << fun(3) << endl;     // line (e)
}
```

(a) What is the output at line (a)?

Answer:

0

(b) What is the output at line (b)?

Answer:

89

(c) What is the output at line (c)?

Answer:

9

(d) What is the output at line (d)?

Answer:

Error
Error

(e) What is the output at line (e)?

Answer:

34789

Problem 16   Write a complete C++ program that does the following:

1. Asks the user to enter 2 positive integers, x and y. If either is illegal then the program terminates.

2. Prints all integers n with $x \leq n \leq x^2$ for which the sum of the digits of n is exactly equal to y.

The numbers printed should appear on separate lines of output. Excessively long solutions (with more than 25 lines of code) may lose points.

For example, the following represents one run of the program:

```
Enter 2 integers : 5 6
6
15
24
```

Answer:

```
#include <iostream>
using namespace std;
int main() {
    int x, y;
    cout << "Enter 2 integers : ";
    cin >> x >> y;
    if (x <= 0 || y <= 0) return 0;
    for (int n = x; n <= x * x; n++) {
        int sum = 0, copy = n;
        while (copy > 0) {
            sum += copy % 10;
            copy /= 10;
        }
        if (sum == y) cout << n << endl;
    }
    return 0;
}
```

Problem 17 Write a complete C++ program that does the following:

1. Asks the user to enter 2 positive integers, x and y. If either is illegal then the program repeatedly asks the user to retype x and y until legal values are given.

2. Prints all integers n with $1 \leq n \leq x$ for which the product of the digits of n is exactly equal to y.

The numbers printed should appear on separate lines of output. Excessively long solutions (with more than 25 lines of code) may lose points.

For example, the following represents one run of the program:

```
Enter 2 integers : 35 6
6
16
23
32
```

Answer:

```
#include <iostream>
using namespace std;
int main() {
    int x, y;
    cout << "Enter 2 integers : ";
    cin >> x >> y;
    while (x <= 0 || y <= 0) {
        cout << "Illegal. Enter 2 positive integers: ";
        cin >> x >> y;
    }
    for (int n = 1; n <= x; n++) {
        int product = 1, copy = n;
        while (copy > 0) {
            product *= copy % 10;
            copy /= 10;
        }
        if (product == y) cout << n << endl;
    }
    return 0;
}
```

Problem 18 Write a complete C++ program that does the following:

1. Asks the user to enter 2 positive integers, x and y for which $0 < y \le 9$. If either is illegal then the program terminates.

2. Prints all integers n with $x \le n < x^2$ such that one of the digits of n is equal to y.

The numbers printed should appear on separate lines of output. Excessively long solutions (with more than 25 lines of code) may lose points.

For example, the following represents one run of the program:

```
Enter 2 integers : 5 2
12
20
21
22
23
24
```

Answer:

```cpp
#include <iostream>
using namespace std;
int main() {
    int x, y;
    cout << "Enter 2 integers : ";
    cin >> x >> y;
    if (x <= 0 || y <= 0 || y > 9) return 0;
    for (int n = x; n < x * x; n++) {
        int count = 0, copy = n;
        while (copy > 0) {
            if (copy % 10 == y) count++;
            copy /= 10;
        }
        if (count > 0) cout << n << endl;
    }
    return 0;
}
```

Problem 19   Write a complete C++ program that does the following:

1. Asks the user to enter 2 positive integers, x and y for which $0 < y \le 9$. If either is illegal then the program should repeatedly as the user to re-enter x and y.

2. Prints all integers n with $1 \le n \le x$ such that all of the digits of n are at least as large as y.

The numbers printed should appear on separate lines of output. Excessively long solutions (with more than 25 lines of code) may lose points.

For example, the following represents one run of the program:

```
Enter 2 integers : 100 8
8
9
88
89
98
99
```

Answer:

```cpp
#include <iostream>
using namespace std;
int main() {
```

```
    int x, y;
    cout << "Enter 2 integers : ";
    cin >> x >> y;
    while (x <= 0 || y <= 0 || y > 9) {
        cout << "Illegal. try again: ";
        cin >> x >> y;
    }
    for (int n = 1; n <= x; n++) {
        int copy = n;
        bool ok = true;
        while (copy > 0) {
            if (copy % 10 < y) ok = false;
            copy /= 10;
        }
        if (ok) cout << n << endl;
    }
    return 0;
}
```

Problem 20   Write blocks of code to perform the functions used in the following main program. Your blocks must match the given title lines. Each block should be a short function of only a few lines.

```
int main() {
        double a[4] = {1.0, 2.0, -3.0, -4.0};
        double b[4] = {0.5, 1.5, 2.5, 3.5};
// (a) Return the last digit.  Here 7 is printed.
        cout << lastDigit(17) << endl;
// (b) Return whether \"Positive\", \"Negative\" or \"Zero\". Here Negative is printed.
        cout << positiveOrNegative(-77) << endl;
// (c) Return the greatest factor. (Assume input at least 2, return 1 for primes.)  Here 7 is printed.
        cout << greatestFactor(35) << endl;
// (d) Test whether all array entries are positive.  Here: Not all positive
        if (!allPositive(a, 4)) cout << "Not all positive\n";
// (e) Swap entries of the two arrays.
        swapArrays(a, b, 4);
        return 0;
}
```

Answer:

(a)

```
int lastDigit(int x) {
    return x % 10;
}
```

(b)

```
string positiveOrNegative(int x) {
    if (x > 0) return "Positive";
    if (x < 0) return "Negative";
    return "Zero";
}
```

(c)

```
int greatestFactor(int x) {
```

```
      int ans = x - 1;
      while (x % ans != 0) ans--;
      return ans;
}
```

(d)

```
bool allPositive(double x[], int capacity) {
   for (int i = 0; i < capacity; i++)
      if (x[i] <= 0) return false;
   return true;
}
```

(e)

```
void swapArrays(double x[], double y[], int capacity) {
   for (int i = 0; i < capacity; i++) {
      double temp = x[i];
      x[i] = y[i];
      y[i] = temp;
   }
}
```

Problem 21   Write a function called *firstDuplicate* that reports the first duplicate that it finds in an array of characters. If there is no duplicate your function should return '?' as its answer. Your solution should use no more than 15 lines of code.

For example, a program that uses the function *firstDuplicate* follows.

```
int main() {
   char x[7] = {'Q', 'u', 'e', 'e', 'n', 's', 'Q'};
   cout << firstDuplicate(x, 7) << endl;     // prints   e
   return 0;
}
```

In this example, the second letter e is the first duplicate found in the array. The duplicate letter Q comes later.

Answer:

```
char firstDuplicate(char x[], int c) {
   for (int i = 1; i < c; i++)
      for (int j = 0; j < i; j++)
         if (x[i] == x[j]) return x[i];
   return '?';
}
```

Problem 22   Write a function called *firstUnique* that reports the first entry that has no duplicate in an array of integers. If there is no such entry your function should return -1 as its answer. Your solution should use no more than 15 lines of code.

For example, a program that uses the function *firstUnique* follows.

```
int main() {
   int x[10] = {3, 1, 4, 1, 5, 9, 2, 6, 5, 3};
   cout << firstUnique(x, 10) << endl;     // prints   4
   return 0;
}
```

In this example, first two entries of 3 and 1 have later duplicates, so the result is given by the third entry of 4.

Answer:

```
int firstUnique(int x[], int c) {
   for (int i = 0; i < c; i++) {
      int count = 0;
      for (int j = 0; j < c; j++)
         if (x[i] == x[j]) count++;
      if (count == 1) return x[i];
   }
   return -1;
}
```

Problem 23   Write a function called *firstUniqueIndex* that reports the index of the first entry that has no duplicate in an array of integers. If there is no such entry your function should return −1 as its answer. Your solution should use no more than 15 lines of code.

For example, a program that uses the function *firstUniqueIndex* follows.

```
int main() {
   int x[10] = {3, 1, 4, 1, 5, 9, 2, 6, 5, 3};
   cout << firstUniqueIndex(x, 10) << endl;     // prints   2
   return 0;
}
```

In this example, indices 0 and 1 give entries of 3 and 1 that have later duplicates, so the result is the index 2.

Answer:

```
int firstUniqueIndex(int x[], int c) {
   for (int i = 0; i < c; i++) {
      int count = 0;
      for (int j = 0; j < c; j++)
         if (x[i] == x[j]) count++;
      if (count == 1) return i;
   }
   return -1;
}
```

Problem 24   Write a function called *firstDuplicateIndex* that reports the first index that contains a duplicate of an earler entry in an array of characters. If there is no duplicate your function should return −1 as its answer. Your solution should use no more than 15 lines of code.

For example, a program that uses the function *firstDuplicateIndex* follows.

```
int main() {
   char x[7] = {'Q', 'u', 'e', 'e', 'n', 's', 'Q'};
   cout << firstDuplicateIndex(x, 7) << endl;     // prints   3
   return 0;
}
```

In this example, the letter at index *e* which duplicates the earlier *e* at index 2.

Answer:

```
int firstDuplicateIndex(char x[], int c) {
   for (int i = 1; i < c; i++)
      for (int j = 0; j < i; j++)
         if (x[i] == x[j]) return i;
   return -1;
}
```

Problem 25   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It asks the user to enter an integer n that is between 1 and 18.

2. It repeatedly reads n from the user until the supplied value of n is legal.

3. It prints out a triangular picture (as shown in the diagram, but with n characters in the top row). Along each row the characters to be used is the sequence of uppercase letters A, B, C, ..., and so on.

Here is an example of how the program should work:

```
Give me an integer between 1 and 18:    5
ABCDE
ABCD
ABC
AB
A
```

Answer:

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

int main() {
    int n;
    cout << "Give me an integer between 1 and 18:";
    cin >> n;

    while (n < 1 || n > 18) {
        cout << "Illegal.  Try again: ";
        cin >> n;
    }

    for (int r = n; r >= 1; r--) {
        char out = 'A';
        for (int c = 0; c < r; c++) {
            cout << out;
            out++;
        }
        cout << endl;
    }
}
```

Problem 26   Write a function called *biggerDigits* that uses two positive integer parameters with the same number of digits and returns a result of *true* if every digit in the first parameter is bigger than the corresponding digit in the second parameter. Otherwise it returns *false*. If a negative parameter is given, or if parameters with unequal numbers of digits are given your function can return any result of your choosing. Excessively long solutions that use more than 6 lines of code may lose points.

For example, a program that uses the function *biggerDigits* follows.

```
int main() {
    cout << biggerDigits(987, 123) << endl;            // prints true
    cout << biggerDigits(123, 987) << endl;            // prints false
    cout << biggerDigits(98765, 12345) << endl;        // prints false
                    // because the last digit isn't bigger
    if (biggerDigits(76, 91)) cout << "Hello";         // doesn't print
    return 0;
}
```

Answer:

```
bool biggerDigits(int x, int y) {
   if (x == 0) return true;
   if ((x % 10) <= (y % 10)) return false;
   return biggerDigits(x/10, y/10);
}
```

Problem 27   Write a function called *sameEvens* that uses two positive integer parameters with the same number of digits and returns a result of *true* if the positions of the even digits in the two parameters are identical. Otherwise it returns *false*. For example, the even digits in both of the numbers 12345 and 98765 occupy the 2nd and 4th positions so that `sameEvens(12345, 98765)` would return *true*.

If a negative parameter is given, or if parameters with unequal numbers of digits are given your function can return any result of your choosing. Excessively long solutions that use more than 6 lines of code may lose points.

For example, a program that uses the function *sameEvens* follows.

```
int main() {
   cout << sameEvens(987, 123) << endl;          // prints true
   cout << sameEvens(123, 223) << endl;          // prints false
   cout << sameEvens(98765, 12345) << endl;      // prints true
   if (sameEvens(76, 91)) cout << "Hello";       // doesn't print
   return 0;
}
```

Answer:

```
bool sameEvens(int x, int y) {
   if (x == 0) return true;
   if ((x % 2) != (y % 2)) return false;
   return sameEvens(x/10, y/10);
}
```

Problem 28   Write a function called *sumGaps* that uses two positive integer parameters with the same number of digits and returns the sum of the gaps between their corresponding digits. For example if the numbers are 646 and 920 the gaps between their digits are 3 (between 6 and 9), 2 (between 4 and 2) and 6 (between 6 and 0).

If a negative parameter is given, or if parameters with unequal numbers of digits are given your function can return any result of your choosing. Excessively long solutions that use more than 6 lines of code may lose points.

For example, a program that uses the function *sumGaps* follows.

```
int main() {
   cout << sumGaps(9, 1) << endl;                // prints 8
   cout << sumGaps(123, 987) << endl;            // prints 18
   cout << sumGaps(91, 19) << endl;              // prints 16
   return 0;
}
```

Answer:

```
int sumGaps(int x, int y) {
   if (x == 0) return 0;
   if ((x % 10) > (y % 10)) return x % 10 - y % 10 + sumGaps(x/ 10, y/10);
   return y% 10 - x % 10 + sumGaps(x/10, y/10);
}
```

Problem 29   Write a function called *productGaps* that uses two positive integer parameters with the same number of digits and returns the product of the gaps between their corresponding digits. For example if the numbers are 646 and 920 the gaps between their digits are 3 (between 6 and 9), 2 (between 4 and 2) and 6 (between 6 and 0).

If a negative parameter is given, or if parameters with unequal numbers of digits are given your function can return any result of your choosing. Excessively long solutions that use more than 6 lines of code may lose points.

For example, a program that uses the function *productGaps* follows.

```
int main() {
    cout << productGaps(9, 1) << endl;              // prints 8
    cout << productGaps(678, 987) << endl;          // prints 3
    cout << productGaps(91, 19) << endl;            // prints 64
    return 0;
}
```

Answer:

```
int productGaps(int x, int y) {
    if (x == 0) return 1;
    if ((x % 10) > (y % 10)) return (x % 10 - y % 10) * productGaps(x/ 10, y/10);
    return (y% 10 - x % 10) * productGaps(x/10, y/10);
}
```

Problem 30   Write a function called *digitMatch* that uses two positive integer parameters with the same number of digits and returns the number of positions where the two parameters have the same digit. If a negative parameter is given, or if parameters with unequal numbers of digits are given your function can return any result of your choosing. Excessively long solutions that use more than 10 lines of code may lose points.

For example, a program that uses the function *digitMatch* follows.

```
int main() {
    cout << digitMatch(111, 222) << endl;           // prints 0
    cout << digitMatch(111, 212) << endl;           // prints 1
    cout << digitMatch(12345, 11335) << endl;       // prints 3
    cout << digitMatch(12345, 54321) << endl;       // prints 1
    return 0;
}
```

Answer:

```
int digitMatch(int x, int y) {
    if (x == 0) return 0;
    int ans = digitMatch(x/10, y/10);
    if (x % 10 == y % 10) return ans + 1;
    return ans;
}
```

Problem 31   Write the best **title lines** for the functions that are called by the following main program. **Do not supply blocks for the functions.**

```
int main() {
    int i = 123, arr1[3] = {1, 2, 3} , arr2[2][2] = {{1, 0}, {2, 4}};
    double d1 = 1.23, d2 = 12.3;
    printLine(arr2, 2, 2);              // (a) prints: 1 0 2 4
    printFancy(arr1, 3);               // (b) prints: 1 * 2 ** 3 ***
    cout << doNothing (i, (int) d1);   // (c) prints: This is a useless function
    switchValues(d1, d2);    // (d) switches the values: now, d1 = 12.3 and d2 = 1.23
    cout << goodDayWishes();           // (e) prints: Have a good day
    return 0;
}
```

(a) Title line for **printLine**.

Answer:

```
void printLine(int x[][2], int r, int c)
```

(b) Title line for **printFancy**.

Answer:

```
void printFancy(int a[], int cap)
```

(c) Title line for **doNothing**.

Answer:

```
string doNothing(int a, int b)
```

(d) Title line for **switchValues**.

Answer:

```
void switchValues(double &x, double &y)
```

(e) Title line for **goodDayWishes**.

Answer:

```
string goodDayWishes()
```

Problem 32   Write the best **title lines** for the functions that are called by the following main program. **Do not supply blocks for the functions.**

```
int main() {
    int arr1[3] = {1, 2, 3} , arr2[2][2] = {{1, 0}, {2, 4}};
    string s1 = "Final", s2 = "Exam";
    cout << max(arr2, 2, 2);     // (a) prints: 4
    cout << endl;
    printMax(arr1, 3);           // (b) prints max, here: 3
    cout << firstOne(s1, s1);    // (c) returns the first, here: Final
    cout << endl;
    switchValues(s1, s2);        // (d) switches the values: now, s1 = "Exam" and s2 = "Final"
    goodDayWishes(arr1[1], arr2[1][1]);       // (e) prints: Have a good day
    return 0;
}
```

(a) Title line for **max**.

Answer:

```
int max(int x[][2], int r, double c)
```

(b) Title line for **printMax**.

Answer:

```
void printMax(int a[], int cap)
```

(c) Title line for **firstOne**.

Answer:

```
string firstOne(string a, string b)
```

(d) Title line for **switchValues**.

Answer:

```
void switchValues(string &x, string &y)
```

(e) Title line for **goodDayWishes**.

Answer:

```
void goodDayWishes(int x, int y)
```

Problem 33   Write blocks of code to perform the functions used in the following main program. Your blocks must match the given title lines. Each block should be a short function of only a few lines.

```
int main() {
    int a[5] = {3, 1, 4, 1, 5}, b[5] = {2, 7, 1, 8, 2};
    string s = "Final", t = "Exam";
 // (a) Prints the array.
    printArray(a, 5);                       // output:  3 1 4 1 5
 // (b) Finds index of max entry.
    cout << maxIndex(a, 5) << endl;    // output:  4
 // (c) Swaps array entries
    swapArrays(a, b, 5);
    printArray(a, 5);                       // output: 2 7 1 8 2
 // (d) find piece of t starting at: a (assume a is present).
    cout << cutFrom(t, "a") << endl;   // output:  am
 // (e) determine whether s or t has more characters
    if (hasMore(s,t)) cout << "s is longer\n";
    return 0;
}
```

Answer:

(a)

```
void printArray(int x[], int c) {
    for (int i = 0; i < c; i++) cout << x[i] << " ";
    cout << endl;
}
```

(b)

```
int maxIndex(int x[], int c) {
    int ans = 0;
    for (int i = 1; i < c; i++)
      if (x[i] > x[ans]) ans = i;
    return ans;
}
```

(c)

```
void swapArrays(int x[], int y[], int c) {
   for (int i = 0; i < c; i++) {
      int temp = x[i];
      x[i] = y[i];
      y[i] = temp;
   }
}
```

(d)

```
string cutFrom(string x, string target) {
    return x.substr(x.find(target));
}
```

(e)

```
bool hasMore(string x, string y) {
   return x.length() > y.length();
}
```


Problem 34   Write blocks of code to perform the functions used in the following main program. Your blocks must match the given title lines. Each block should be a short function of only a few lines.

```
int main() {
   int i = 12;
   int x[5] = {3, 1, 4, 1, 5};
// (a) Return the largest odd factor.
   cout << oddFactor(i) << endl;      // output: 3
// (b) Return the sum of even entries.
   cout << sumEven(x, 5) << endl;     // output: 4
// (c) last digit of i.
   cout << lastDigit(i) << endl;      // output: 2
// (d) Find the (last) index of the smallest entry.
   cout << findIndexMin(x, 5) << endl;  // output: 3
// (e) Is it upper case?
   if (isUpper('h')) cout << "Digit" << endl;    // No output here.
   return 0;
}
```

Answer:

(a)

```
int oddFactor(int x) {
    if (x % 2 != 0) return x;
    return oddFactor(x / 2);
}
```

(b)

```
int sumEven(int array[], int cap) {
   int ans = 0;
   for (int i = 0; i < cap; i++)
      if (array[i] % 2 == 0) ans += array[i];
   return ans;
}
```

(c)

```
int lastDigit(int x) {
   return x % 10;
}
```

(d)

```
int findIndexMin(int array[], int cap) {
   int ans = 0;
   for (int i = 0; i < cap; i++)
      if (array[i] <= array[ans]) ans = i;
   return ans;
}
```

(e)

```cpp
bool isUpper(char x) {
    return 'A' <= x && x <= 'Z';
}
```

Problem 35   Consider the following C++ program.

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

int func1(double &d, string s) {
    s = "Final Exam";
    d = 13.14 - 3.14;
    cout << "s" << endl;
    return 13 + 1;
}

int func2 (int &a, int &b, int c) {
    a = b + c;
    b = 1;
    return c;
}

int main() {
    double piDoubled = 3.14 + 3.14;
    string str = " CSCI ";
    func1 (piDoubled, str);                     // line (a)
    cout << func1(piDoubled , str) << endl;  // line (b)
    cout << piDoubled << piDoubled  << endl; // line (c)
    int x = 1 , y = 11 ;
    cout << 2 * (func2(x, y, x)) << endl;    // line (d)
    cout << x << y << endl;                   // line (e)
    return 0;
}
```

(a) What is the output at line (a)?

Answer:

s

(b) What is the output at line (b)?

Answer:

s
14

(c) What is the output at line (c)?

Answer:

1010

(d) What is the output at line (d)?

Answer:

2

(e) What is the output at line (e)?

121

Answer:

Problem 36   Consider the following C++ program. It is compiled to **a.out** and executed with the command **./a.out 007**.

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

int fun(int &x, int y, int &z) {
    y = x;
    x = z;
    z = y;
    cout << z;
    return x;
}

int main(int argc, char *argv[]) {
    int x = 3, y = 1, z = 4;
    fun(x, y , z); cout << endl;          // line (a)
    cout << x << y << z << endl;          // line (b)
    cout << fun(x, y , z) << endl;        // line (c)
    cout << argc << endl;                 // line (d)
    cout << argv[1] << endl;              // line (e)
    return 0;
}
```

(a) What is the output at line (a)?

Answer:

3

(b) What is the output at line (b)?

Answer:

413

(c) What is the output at line (c)?

Answer:

43

(d) What is the output at line (d)?

Answer:

2

(e) What is the output at line (e)?

Answer:

007

Problem 37   Write a function called *triPrint* that uses the entries of an array of characters to print a triangle. The first row of the triangle has the first entry, the second row the first two entries and so on. Your solution should use no more than 6 lines of code.)

For example, a program that uses the function *triPrint* follows.

```
int main() {
    char x[7] = {'c', 's', 'c', 'i', '1', '1', '1'};
    triPrint(x, 7);
    return 0;
}
```

The ouput from this program would be:

```
c
cs
csc
csci
csci1
csci11
csci111
```

Answer:

```
void triPrint(char x[], int c) {
    for (int r = 1; r <= c; r++) {
        for (int c = 0; c < r; c++) cout << x[c];
        cout << endl;
    }
}
```

Problem 38   Write a function called *sums* that replaces each entry in an array of integers by the sum of that entry and all earlier entries in the original input array. Your solution should use no more than 6 lines of code.)

For example, a program that uses the function *sums* follows.

```
int main() {
    int x[6] = {3, 1, 4, 1, 5, 9};
    sums(x, 6);
    for (int i = 0; i < 6; i++) cout << x[i] << " ";
    cout << endl;
    return 0;
}
```

The ouput from this program would be:

```
3 4 8 9 14 23
```

because, for example $3 + 1 + 4 + 1 + 5 = 14$ and $3 + 1 + 4 + 1 + 5 + 9 = 23$.

Answer:

```
void sums(int x[], int c) {
    if (c <= 1) return;
    sums(x, c - 1);
    x[c - 1] += x[c - 2];
}
```

Problem 39   Write a function called *swapTwo* that has an integer parameter that is at least 10. It returns an integer obtained by swapping the first two digits in the input number. If an argument less than 10 is given your function can return any result of your choosing.

Your function need not use more than 2 instructions. Excessively complicated long solutions that use more than 6 lines of code may lose points.

For example, a program that uses the function *swapTwo* follows.

```
int main() {
   cout << swapTwo(19683) << endl;          // prints 91683
   cout << swapTwo(10) << endl;             // prints 1
   cout << swapTwo(swapTwo(19683)) << endl; // prints 19683
   return 0;
}
```

Answer:

```
int swapTwo(int x) {
   if (x < 100) return x / 10 + 10 * (x % 10);
   return 10 * swapTwo(x/10) + x % 10;
}
```

Problem 40   Write a function called *bigGap* that has an integer parameter that is at least 10. It returns an integer that gives the biggest gap between adjacent digits in the input number. If an argument less than 10 is given your function can return any result of your choosing.

Your function need not use more than 6 instructions. Excessively complicated long solutions that use more than 12 lines of code may lose points.

For example, a program that uses the function *bigGap* follows.

```
int main() {
   cout << bigGap(19683) << endl;           // prints 8 found as the gap in 19
   cout << bigGap(38691) << endl;           // prints 8 found as the gap in 91
   return 0;
}
```

Answer:

```
int bigGap(int x) {
   int lastGap = (x / 10) % 10 - x % 10;
   if (lastGap < 0) lastGap = -lastGap;
   if (x < 100) return lastGap;
   int earlierGap = bigGap(x / 10);
   if (earlierGap > lastGap) return earlierGap;
   return lastGap;
}
```

Problem 41   Write a complete C++ program that does the following:

1. Asks the user to enter 2 integers, x and y. Both should be between 2 and 10 (inclusive), and if either is illegal then the program terminates.

2. Fills a table (as part of a 2d-array) with characters entered by the user. The table should have as many rows as x and as many columns as the double of y. The user should enter the characters separated by spaces.

3. Prints the characters in the last column in reverse order without spaces.

For example, the following represents one run of the program:

Enter 2 integers : 3 2

Enter 12 characters : a b c d e f g h i j k l

The characters in the last column (reversed): lhd

Answer:

```
#include <iostream>
using namespace std;
int main() {
   int x, y, r, c;
   char table[10][20];
   cout << "Enter 2 integers: ";
   cin >> x >> y;
   if (x < 2 || x > 10 || y < 2 || y > 10) return 0;
   cout << "Enter " << 2 * x * y << " characters: ";
   for (r = 0; r < x; r++)
     for (c = 0; c < 2 * y; c++)
        cin >> table[r][c];
   cout << "The characters in the last column (reversed): ";
   for (r = x - 1; r >= 0; r--)
      cout << table[r][2*y - 1];
   cout << endl;
   return 0;
}
```

Problem 42   Write a complete C++ program that does the following:

1. Asks the user to enter an integer x. It should be between 2 and 10 (inclusive), and if it is illegal then the program terminates.

2. Makes the user to enter x words (strings) of text, each of which should have at least 4 characters. Any word with fewer characters is replaced by the string "Error".

3. Prints the third character from each word, beginning with the last word and ending with the first.

For example, the following represents one run of the program:

Enter an integer : 3

Enter 3 words: Final Exam CSCI111

The third characters in reverse order: Can

Answer:

```
#include <iostream>
using namespace std;
int main() {
   int x, r;
   string words[10];
   cout << "Enter an integer: ";
   cin >> x;
   if (x < 2 || x > 10) return 0;
   cout << "Enter " << x << " words: ";
   for (r = 0; r < x; r++)
        cin >> words[r];
   cout << "The third characters in reverse order: ";
   for (r = x - 1; r >= 0; r--)
      cout << words[r][2];
   cout << endl;
   return 0;
}
```

Problem 43   Write the best **title lines** for the functions that are called by the following main program. **Do not supply blocks for the functions.**

```
int main() {
   int x = 2, y = 3, z[4];
   bool a = true, b = false, c[4];
```

```
        string s = "Hello", t = "goodbye", u[4][5];
        for (int i = 0; i < 4; i++) c[i] = data(x, y, 2.5);      // (a)
        setToFive(z, c, 4);   cout << z[1] << endl;              // (b) prints 5
        y = speedLimit(x, z[1]); cout << x << y << endl;         // (c) prints 55
        cout << numberStrings(4, u, 5) << endl;                  // (d) prints 20
        f(numberStrings(0, u, 0), data(y, x, f(20, a || b)));    // (e)
        return 0;
}
```

(a) Title line for **data**.

Answer:

```
bool data(int x, int y, double z)
```

(b) Title line for **setToFive**.

Answer:

```
void setToFive(int a[], bool b[], int cap)
```

(c) Title line for **speedLimit**.

Answer:

```
int speedLimit(int &a, int b)
```

(d) Title line for **numberStrings**.

Answer:

```
int numberStrings(int a, string b[][5], int c)
```

(e) Title line for **f**.

Answer:

```
double f(int a, bool b)
```

Problem 44   Write the best **title lines** for the functions that are called by the following main program. **Do not supply blocks for the functions.**

```
int main() {
    int a = 2, b = 3, c[4];
    bool s = true, t = false, u[4];
    string x = "Hello", y = "goodbye", z[4][5];
    for (int i = 0; i < 4; i++) c[i] = data(x, y, 2.5);      // (a)
    setToFive(z, c, 4);   cout << z[1][1] << endl;          // (b) prints 5
    y = speedLimit(x, z[1][1]); cout << x << y << endl;     // (c) prints 55
    cout << numberStrings(s, t, b, u) << endl;             // (d) prints 20
    numberStrings(f(a), f(a), a, u);                        // (e)
    return 0;
}
```

(a) Title line for **data**.

Answer:

```
int data(string x, string y, double z)
```

(b) Title line for **setToFive**.

Answer:

```
void setToFive(string a[][5], int b[], int cap)
```

(c) Title line for **speedLimit**.

Answer:

```
string speedLimit(string &a, string b)
```

(d) Title line for **numberStrings**.

Answer:

```
int numberStrings(bool a, bool b, int c, bool d[])
```

(e) Title line for **f**.

Answer:

```
bool f(int a)
```

Problem 45   Write the best **title lines** for the functions that are called by the following main program. **Do not supply blocks for the functions.**

```
int main() {
   int x = 2, z[3] = {3, 1, 4};
   bool a = true, c[5];
   string s = "Hello", u[7][9];
   for (int i = 0; i < 4; i++) c[i] = A(x, x, 2.5);      // (a)
   cout << B(c, c, u);                                   // (b) prints: part B
   x = C(x, u[1][1]); cout << x << endl;                 // (c) prints 55
   D(4, z, 5); cout << z[1] << endl;                     // (d) prints 3
   E(E(a, s), s); cout << endl;                          // (e) prints 33
   return 0;
}
```

(a) Title line for **A**.

Answer:

```
bool A(int x, int y, double z)
```

(b) Title line for **B**.

Answer:

```
string B(bool a[], bool b[], string[][9])
```

(c) Title line for **C**.

Answer:

```
int C(int a, string b)
```

(d) Title line for **D**.

Answer:

```
void D(int a, int b[], int c)
```

(e) Title line for **E**.

Answer:

```
bool E(bool a, string b)
```

Problem 46   Write the best **title lines** for the functions that are called by the following main program. **Do not supply blocks for the functions.**

```
int main() {
    int a = 2, c[3] = {3, 1, 4};
    bool s = true, u[5];
    string x = "Hello", z[7][9];
    for (int i = 0; i < 4; i++) c[i] = A(x, x, 2.5);        // (a)
    cout << B(c, c, u);                                     // (b) prints: part B
    x = C(x, u[1]); cout << x << endl;                      // (c) prints 55
    D(4, z, 5); cout << z[1][1] << endl;                    // (d) prints 3
    E(E(a, s), s); cout << endl;                            // (e) prints 33
    return 0;
}
```

(a) Title line for **A**.

Answer:

```
int A(string x, string y, double z)
```

(b) Title line for **B**.

Answer:

```
string B(int a[], int b[], bool[])
```

(c) Title line for **C**.

Answer:

```
string C(string a, bool b)
```

(d) Title line for **D**.

Answer:

```
void D(int a, string b[][9], int c)
```

(e) Title line for **E**.

Answer:

```
int E(int a, bool b)
```

Problem 47   Consider the following C++ program.

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

int F(int x[], int c) {
    if (c < 3) return 0;
    return x[c - 1] + F(x, c - 1);
}

int G(int a, int &b) {
    b = b - a;
    a = b + a;
    return a;
}

int main() {
    int a = 4, b = 1;
    int x[5] = {3, 1, 4, 1, 5};
    string s = "Problem Number 2";
    cout << x[2 + 2] + x[2] << endl;        // line (a)
```

```
        cout << s.substr(2, 3) << endl;              // line (b)
        cout << s.substr(s.find("b")) << endl;       // line (c)
        cout << G(b, a); cout <<   a << b << endl;   // line (d)
        cout <<   F(x, 5) << endl;                   // line (e)
        return 0;
}
```

(a) What is the output at line (a)?

Answer:

9

(b) What is the output at line (b)?

Answer:

obl

(c) What is the output at line (c)?

Answer:

blem Number 2

(d) What is the output at line (d)?

Answer:

431

(e) What is the output at line (e)?

Answer:

10

Problem 48   Consider the following C++ program.

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

int F(int x[], int c) {
  if (c < 1) return 0;
  return x[c - 1] + F(x, c - 1);
}

int G(int &a, int b) {
   b = b - a;
   a = b + a;
   return a;
}

int main() {
   int a = 7, b = 5;
   int x[5] = {3, 1, 4, 1, 5};
   string s = "String Question";
   cout << x[2 / 2] * x[2] << endl;             // line (a)
   cout << s.substr(2, 3) << endl;              // line (b)
   cout << s.substr(s.rfind("s")) << endl;      // line (c)
   cout << G(b, a); cout <<   a << b << endl;   // line (d)
   cout <<   F(x, 4) << endl;                   // line (e)
   return 0;
}
```

(a) What is the output at line (a)?

Answer:

4

(b) What is the output at line (b)?

Answer:

rin

(c) What is the output at line (c)?

Answer:

stion

(d) What is the output at line (d)?

Answer:

777

(e) What is the output at line (e)?

Answer:

9

Problem 49   Consider the following C++ program.

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

int F(int a, int &b) {
   b = b - a;
   a = b + a;
   return a;
}

int G(int x[], int c) {
  if (c < 3) return 0;
  return x[c - 1] + G(x, c - 1);
}

int main() {
    int a = 5, b = 3;
    int x[5] = {2, 7, 1, 8, 2};
    string s = "Final Exam";
    cout << x[2 + 2] + x[2] << endl;          // line (a)
    cout << s.substr(2, 3) << endl;           // line (b)
    cout << s.substr(s.find("a")) << endl;    // line (c)
    cout << F(b, a); cout <<   a << b << endl; // line (d)
    cout <<   G(x, 5) << endl;                // line (e)
    return 0;
}
```

(a) What is the output at line (a)?

Answer:

3

(b) What is the output at line (b)?

Answer:

nal

(c) What is the output at line (c)?

Answer:

al Exam

(d) What is the output at line (d)?

Answer:

523

(e) What is the output at line (e)?

Answer:

11

Problem 50   Consider the following C++ program.

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

int F(int &a, int b) {
   b = b - a;
   a = b + a;
   return a;
}

int G(int x[], int c) {
  if (c < 1) return 0;
  return x[c - 1] + G(x, c - 1);
}

int main() {
    int a = 6, b = 4;
    int x[5] = {2, 7, 1, 8, 2};
    string s = "Queens College";
    cout << x[2 / 2] * x[2] << endl;        // line (a)
    cout << s.substr(5, 1) << endl;         // line (b)
    cout << s.substr(s.rfind("e")) << endl;   // line (c)
    cout << F(b, a); cout <<   a << b << endl; // line (d)
    cout <<   G(x, 4) << endl;               // line (e)
    return 0;
}
```

(a) What is the output at line (a)?

Answer:

7

(b) What is the output at line (b)?

Answer:

s

(c) What is the output at line (c)?

Answer:

e

(d) What is the output at line (d)?

Answer:

666

(e) What is the output at line (e)?

Answer:

18

Problem 51   Write blocks of code to perform the functions used in the following main program. Your blocks must match the given title lines. Each block should be a short function of only a few lines.

```
int main() {
    int a[2][4] = {{1, 2, 3, 4}, {0, 1, 2, 3}};
    int b[4] = {3, 1, 4, 1};
    int x = 1, y = 2;
    string s = "hello";
// (a) Return true if at least one of x and y is positive.  Here   Yes   is printed
    if (positive(x, y)) cout << "Yes" << endl;
// (b) Return the sum of the first row. Here   10   is printed.
    cout << rowSum(a, 2, 4) << endl;
// (c) Return the smallest element. Here  1  is printed.
    cout << smallest(b, 4) << endl;
// (d) Remove the first letter.  Here   ello   is printed.
    cout << removeFirst(s) << endl;
// (e) Insert an X at the specified position.  Here   heXllo   is printed.
    addX(s, 2);
    cout << s << endl;
    return 0;
}
```

Answer:

(a)

```
bool positive(int x, int y) {
    return x > 0 || y > 0;
}
```

(b)

```
int rowSum(int a[][4], int r, int c) {
    int ans = 0;
    for (int j = 0; j < c; j++)
        ans += a[0][j];
    return ans;
}
```

(c)

```cpp
int smallest(int x[], int c) {
    int ans = x[0];
    for (int i = 0; i < c; i++)
        if (x[i] < ans) ans = x[i];
    return ans;
}
```

(d)

```cpp
string removeFirst(string s) {
    return s.substr(1);
}
```

(e)

```cpp
void addX(string &s, int y) {
    s.insert(y, "X");
}
```

Problem 52   Write blocks of code to perform the functions used in the following main program. Your blocks must match the given title lines. Each block should be a short function of only a few lines.

```cpp
int main() {
    int a[2][4] = {{1, 2, 3, 4}, {0, 1, 2, 3}};
    int b[4] = {3, 1, 4, 1};
    int x = 1, y = 2;
    string s = "hello";
// (a) Return true if both of x and y are positive.  Here  Yes  is printed
    if (positive(x, y)) cout << "Yes" << endl;
// (b) Return the sum of the second row. Here  6  is printed.
    cout << rowSum(a, 2, 4) << endl;
// (c) Return the largest element. Here  4  is printed.
    cout << largest(b, 4) << endl;
// (d) Return the first two letters.  Here  he  is printed.
    cout << firstTwo(s) << endl;
// (e) Insert a specified number of X's at the end.  Here  helloXX  is printed.
    addX(s, 2);
    cout << s << endl;
    return 0;
}
```

Answer:

(a)

```cpp
bool positive(int x, int y) {
    return x > 0 && y > 0;
}
```

(b)

```cpp
int rowSum(int a[][4], int r, int c) {
    int ans = 0;
```

```
        for (int j = 0; j < c; j++)
            ans += a[1][j];
        return ans;
}
```

(c)

```
int largest(int x[], int c) {
    int ans = x[0];
    for (int i = 0; i < c; i++)
        if (x[i] > ans) ans = x[i];
    return ans;
}
```

(d)

```
string firstTwo(string s) {
    return s.substr(0, 2);
}
```

(e)

```
void addX(string &s, int y) {
    for (int i = 0; i < y; i++) s = s + "X";
}
```

Problem 53   Write blocks of code to perform the functions used in the following main program. Your blocks
must match the given title lines. Each block should be a short function of only a few lines.

```
int main() {
    int x = 1, y = 2;
    string a[2][3] = {{"CS", "111", "Final"}, {"Question", "number", "3"}};
    string b[3] = {"An", "Easy", "Problem"};
// (a) Return true if at least one of x and y is negative.  Here nothing is printed
    if (negative(x, y)) cout << "Yes" << endl;
// (b) Return the first entry in the first row. Here  CS  is printed.
    cout << firstEntry(a, 2, 3) << endl;
// (c) Return the longest element. Here    Problem   is printed.
    cout << longest(b, 3) << endl;
// (d) Remove the first letter.  Here  umber  is printed.
    cout << removeFirst(a[1][1]) << endl;
// (e) Insert a Q at the specified position of a string.  Here  CQS  is printed.
    addQ(a[0][0], 1);
    cout << a[0][0] << endl;
    return 0;
}
```

Answer:

(a)

```
bool negative(int x, int y) {
    return x < 0 || y < 0;
}
```

(b)

```
string firstEntry(string a[][3], int r, int c) {
    return a[0][0];
}
```

(c)

```
string longest(string x[], int c) {
    string ans = x[0];
    for (int i = 0; i < c; i++)
        if (x[i].length() > ans.length()) ans = x[i];
    return ans;
}
```

(d)

```
string removeFirst(string s) {
    return s.substr(1);
}
```

(e)

```
void addQ(string &s, int y) {
    s.insert(y, "Q");
}
```

Problem 54   Write blocks of code to perform the functions used in the following main program. Your blocks must match the given title lines. Each block should be a short function of only a few lines.

```
int main() {
    int x = 1, y = 2;
    string a[2][3] = {{"CS", "111", "Final"}, {"Question", "number", "3"}};
    string b[3] = {"An", "Easy", "Problem"};
// (a) Return true if both of x and y are negative.  Here nothing is printed
    if (negative(x, y)) cout << "Yes" << endl;
// (b) Return the first entry in the second column. Here  111  is printed.
    cout << firstEntry(a, 2, 3) << endl;
// (c) Return the shortest element. Here  An  is printed.
    cout << shortest(b, 3) << endl;
// (d) Return the first two letters.  Here  Fi  is printed.
    cout << firstTwo(a[0][2]) << endl;
// (e) Insert the specified number of Qs at the start of a string.  Here  QQCS  is printed.
    addQ(a[0][0], 2);
    cout << a[0][0] << endl;
    return 0;
}
```

Answer:

(a)

```
bool negative(int x, int y) {
    return x < 0 && y < 0;
}
```

(b)

```
string firstEntry(string a[][3], int r, int c) {
    return a[0][1];
}
```

(c)

```
string shortest(string x[], int c) {
    string ans = x[0];
    for (int i = 0; i < c; i++)
        if (x[i].length() < ans.length()) ans = x[i];
    return ans;
}
```

(d)

```
string firstTwo(string s) {
    return s.substr(0, 2);
}
```

(e)

```
void addQ(string &s, int y) {
  for (int i = 0; i < y; i++)
      s = "Q" + s;
}
```

Problem 55   Write a function called *randFill* that fills the entries of an array with random integers in the range from 10 to 99 (inclusive). (You should use the *rand* function to generate the values. You do not need to call *srand*. Your solution should use no more than 6 lines of code.)

For example, a program that uses the function *randFill* follows.

```
int main() {
    int x[5];
    randFill(x, 5);
    for (int i = 0; i < 5; i++)
        cout << x[i] << " ";   // prints 5 random numbers
    cout << endl;              // such as  93 73 12 69 40
    return 0;
}
```

Answer:

```
#include <cstdlib>

void randFill(int x[], int cap) {
    for (int i = 0; i < cap; i++)
       x[i] = rand() % 90 + 10;
}
```

Problem 56   Write a function called *randAdd* that changes each entry of an array by generating a random integer between 1 and 10 and adding it to the entry. (You should use the *rand* function to generate the values. You do not need to call *srand*. Your solution should use no more than 6 lines of code.)

For example, a program that uses the function *randAdd* follows.

```
int main() {
    int x[5] = {3, 1, 4, 1, 5};
    randAdd(x, 5);
    for (int i = 0; i < 5; i++)
        cout << x[i] << " ";  // prints 5 randomly adjusted entries
    cout << endl;            // such as  93 73 12 69 40
    return 0;
}
```

Answer:

```
#include <cstdlib>

void randAdd(int x[], int cap) {
    for (int i = 0; i < cap; i++)
        x[i] += rand() % 10 + 1;
}
```

Problem 57   Write a function called *maxIndex* that reports the index of a row that contains the largest entry in a 2-dimensional array of integers (with 3 columns).

For example, a program that uses the function *maxIndex* follows.

```
int main() {
    int x[3][3] = {{3,1,4},{1,5,9}, {2,6,5}};
    cout << maxIndex(x, 3, 3) << endl; // prints 1
                                        // because the entry 9 is in row 1
    return 0;
}
```

Answer:

```
int maxIndex(int x[][3], int r, int c) {
    int a = 0, b = 0;
    for (int i = 0; i < r; i++)
        for (int j = 0; j < c; j++)
            if (x[i][j] > x[a][b]) {
                a = i;
                b = j;
            }
    return a;
}
```

Problem 58   Write a function called *maxIndex* that reports the index of a column that contains the largest entry in a 2-dimensional array of integers (with 3 columns).

For example, a program that uses the function *maxIndex* follows.

```
int main() {
    int x[3][3] = {{3,1,4},{1,5,9}, {2,6,5}};
    cout << maxIndex(x, 3, 3) << endl; // prints 2
                                        // because the entry 9 is in column 2
    return 0;
}
```

Answer:

```
int maxIndex(int x[][3], int r, int c) {
    int a = 0, b = 0;
    for (int i = 0; i < r; i++)
        for (int j = 0; j < c; j++)
            if (x[i][j] > x[a][b]) {
                a = i;
                b = j;
            }
    return b;
}
```

Problem 59   Write a function called *evenUp* that returns the result of increasing the first even digit in a positive integer parameter by 1. (Your solution should use no more than 10 lines of code. Your function can return any convenient value of your choice if the parameter is not positive.)

For example, a program that uses the function *evenUp* follows.

```
int main() {
    cout << evenUp(1232) << endl;  // prints 1332  only the first even 2 changes
    cout << evenUp(1332) << endl;  // prints 1333
    cout << evenUp(1333) << endl;  // prints 1333  no even digit to change
    cout << evenUp(22) << endl;    // prints 32
    cout << evenUp(2) << endl;     // prints 3
    return 0;
}
```

Answer:

```
int evenUp(int x) {
    if (x <= 0) return 0;
    int y = evenUp(x / 10);
    if (x % 2 == 1) return 10 * y + x % 10;
    if (y > x / 10) return 10 * y + x % 10;
    return x + 1;
}
```

Problem 60   Write a function called *oddDown* that returns the result of decreasing the first odd digit in a positive integer parameter by 1. (Your solution should use no more than 10 lines of code. Your function can return any convenient value of your choice if the parameter is not positive.)

For example, a program that uses the function *oddDown* follows.

```
int main() {
    cout << oddDown(321) << endl;  // prints 221 only the first odd digit changes
    cout << oddDown(221) << endl;  // prints 220
    cout << oddDown(220) << endl;  // prints 220 because no odd digit to decrease
    cout << oddDown(7) << endl;    // prints   6
    cout << oddDown(6) << endl;    // prints   6
    return 0;
}
```

Answer:

```
int oddDown(int x) {
    if (x <= 0) return 0;
    int y = oddDown(x / 10);
```

```
    if (x % 2 == 0) return 10 * y + x % 10;
    if (y < x / 10) return 10 * y + x % 10;
    return x - 1;
}
```

Problem 61   Write a function called *evenUp* that returns the result of increasing the last even digit in a positive integer parameter by 1. (Your solution should use no more than 5 lines of code. Your function can return any convenient value of your choice if the parameter is not positive.)

For example, a program that uses the function *evenUp* follows.

```
int main() {
    cout << evenUp(1234) << endl;   // prints 1235
    cout << evenUp(1335) << endl;   // prints 1335
    cout << evenUp(2) << endl;      // prints 3
    cout << evenUp(3) << endl;      // prints 3
    return 0;
}
```

Answer:

```
int evenUp(int x) {
    if (x % 2 == 0) return x + 1;
    if (x < 10) return x;
    return 10 * evenUp(x / 10) + x % 10;
}
```

Problem 62   Write a function called *oddDown* that returns the result of decreasing the last odd digit in a positive integer parameter by 1. (Your solution should use no more than 5 lines of code. Your function can return any convenient value of your choice if the parameter is not positive.)

For example, a program that uses the function *oddDown* follows.

```
int main() {
    cout << oddDown(3234) << endl;   // prints 3224
    cout << oddDown(3224) << endl;   // prints 2224
    cout << oddDown(1214) << endl;   // prints 1204
    cout << oddDown(1204) << endl;   // prints  204
    cout << oddDown(2) << endl;      // prints    2
    cout << oddDown(1) << endl;      // prints    0
    return 0;
}
```

Answer:

```
int oddDown(int x) {
    if (x % 2 == 1) return x - 1;
    if (x < 10) return x;
    return 10 * oddDown(x / 10) + x % 10;
}
```

Problem 63   Write a complete C++ program that is to be used for a psychology study into random number choices by a human volunteer. Your program is to operate as follows. (Programs that correctly carry out some of the tasks will receive partial credit. Your program should not be more than 30 lines long.)

Ask the user (the volunteer) to repeatedly type 2 digit numbers onto the screen.

Read the user input and discard any number that is less than 10 or greater than 99, but keep track of numbers within this range.

When the total of the legal numbers typed exceeds 100000 the experiment ends and the program prints a summary with the following form (with one line of output for each of the numbers from 10 to 99):

```
User chose 99 for 2.1% of choices.
User chose 98 for 0.7% of choices.
User chose 97 for ...
```

Answer:

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

int main() {
    int n = 0, total = 0, x;
    int counts[100];
    for (int i = 0; i < 100; i++)
        counts[i] = 0;
    while (total <= 100000) {
        cout << "Enter a 2 digit number: ";
        cin >> x;
        if (10 <= x && x <= 99) {
            counts[x]++;
            total += x;
            n++;
        }
    }
    for (x = 99; x >= 10; x--)
        cout << "User chose " << x << " for "
            << 100.0 * counts[x] / n << "% of choices.\n";
}
```

Problem 64   Write a complete C++ program that is to be used for a psychology study into random number choices by a human volunteer. Your program is to operate as follows. (Programs that correctly carry out some of the tasks will receive partial credit. Your program should not be more than 30 lines long.)

Ask the user (the volunteer) to repeatedly type single digit numbers onto the screen.

Read the user input and discard any number that is less than 1 or greater than 9, but keep track of numbers within this range.

When the total of the legal numbers typed exceeds 10000 the experiment ends and the program prints a list of the most frequent choice (or choices if two or more numbers are tied).

Output should appear as:

```
The most frequent choice(s):  3 7
```

Answer:

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

int main() {
    int total = 0, x, max = 0;
    int counts[10];
    for (int i = 0; i < 10; i++)
        counts[i] = 0;
    while (total <= 10000) {
        cout << "Enter a single digit number: ";
```

```
      cin >> x;
      if (1 <= x && x <= 9) {
         counts[x]++;
         total += x;
      }
   }
   for (x = 1; x <= 10; x++)
      if (counts[x] > max) max = counts[x];
   cout << "The most frequent choice(s):  ";
   for (x = 1; x <= 10; x++)
      if (counts[x] == max) cout << x << " ";
   cout << endl;
}
```

Problem 65   Write a complete C++ program that is to be used for a marketing study into cent values that appear in gas prices. Your program is to operate as follows. (Programs that correctly carry out some of the tasks will receive partial credit. Your program should not be more than 30 lines long.)

Ask the user to repeatedly type numbers in the range 0 to 99 (representing cents in prices observed) onto the screen.

Read the user input and discard any number that is out of range. As soon as every possible cent value has been seen at least once, the program ends by printing a summary with the following form (with one line of output for each of the numbers from 0 to 99):

```
99 cents for 12.1% of prices.
98 cents for 0.7% of prices.
97 cents for 0.35% of ...
```

Answer:

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

int main() {
   int numberOfValues = 0, total = 0, x;
   int counts[100];
   for (int i = 0; i < 100; i++)
      counts[i] = 0;
   while (numberOfValues < 100) {
      cout << "Enter a number between 0 and 99: ";
      cin >> x;
      if (0 <= x && x <= 99) {
         if (counts[x] == 0) numberOfValues++; // a new price has just been seen
         counts[x]++;
         total++;
      }
   }
   for (x = 99; x >= 0; x--)
      cout << x << " cents for " << 100.0 * counts[x] / total
           << "% of prices.\n";
}
```

Problem 66   Write a complete C++ program that is to be used for an economics study into mortgage interest rates. Your program is to operate as follows. (Programs that correctly carry out some of the tasks will receive partial credit. Your program should not be more than 30 lines long.)

Ask the user to repeatedly type integers in the range 0 to 8 (representing interest rates observed) onto the screen.

Read the user input and discard any number that is out of range. As soon as every possible input value has been seen at least once, the program ends by showing the most frequent rate (or rates in case of a tie). For example, output might be:

Most common rate(s): 3 4

Answer:

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

int main() {
   int numberOfValues = 0, x, max = 0;
   int counts[9];
   for (int i = 0; i < 9; i++)
      counts[i] = 0;
   while (numberOfValues < 9) {
      cout << "Enter a number between 0 and 8: ";
      cin >> x;
      if (0 <= x && x <= 8) {
         if (counts[x] == 0) numberOfValues++; // a new rate has just been seen
         counts[x]++;
      }
   }
   for (x = 0; x < 9; x++)
      if (counts[x] > max) max = counts[x];
   cout << "Most common rate(s):   ";
   for (x = 0; x < 9; x++)
      if (counts[x] == max) cout << x << " ";
   cout << endl;
}
```

Problem 67   Write the best **title lines** for the functions that are called by the following main program. **Do not supply blocks for the functions.**

```cpp
int main() {
   double x = 0.0, y = 3.1, z = 2.5;
   int array[5] = {3,1,4,1,5};
   string s;

   cout << middle(x, y, z) << endl;                   // (a) prints middle value 2.5
   increase(x); cout << x << endl;                    // (b) prints 1.0
   printBoth(y, z);                                   // (c) prints 3.1 2.5
   s = allOf(array, 5); cout << s << endl;            // (d) prints 3 1 4 1 5
   increase(array, 5); cout << allOf(array,5) << endl; // (e) prints 4 2 5 2 6
   return 0;
}
```

(a) Title line for **middle**.
Answer:

```cpp
double middle(double a, double b, double c)
```

(b) Title line for **increase**.
Answer:

```cpp
void increase(double &x)
```

(c) Title line for **printBoth**.
Answer:

```cpp
void printBoth(double a, double b)
```

(d) Title line for **allOf**.

Answer:

```
string allOf(int a[], int cap)
```

(e) Title line for **increase**.

Answer:

```
void increase(int x[], int cap)
```

Problem 68   Write the best **title lines** for the functions that are called by the following main program. **Do not supply blocks for the functions.**

```
int main() {
    int x = 0, y = 3, z = 2;
    char array[5] = {'a','b','c','d','e'};
    string s;

    cout << biggest(x, y, z) << endl;          // (a) prints biggest: 3
    x = increase(x); cout << x << endl;         // (b) prints 1
    s = printBoth(y, z); cout << s << endl;     // (c) prints 3 2
    allOf(array, 5);                            // (d) prints a b c d e
    upper(array, 5); allOf(array,5);            // (e) prints A B C D E
    return 0;
}
```

(a) Title line for **biggest**.

Answer:

```
int biggest(int a, int b, int c)
```

(b) Title line for **increase**.

Answer:

```
int increase(int x)
```

(c) Title line for **printBoth**.

Answer:

```
string printBoth(int a, int b)
```

(d) Title line for **allOf**.

Answer:

```
void allOf(char a[], int cap)
```

(e) Title line for **upper**.

Answer:

```
void upper(char x[], int cap)
```

Problem 69   Write the best **title lines** for the functions that are called by the following main program. **Do not supply blocks for the functions.**

```
int main() {
    int x = 0, y = 3, z = 2;
    string array[5] = {"A","B","C","D","E"};
    string s;

    cout << least(x, y, z) << endl;                    // (a) prints least: 0
    x = decrease(y); cout << x << " " << y << endl;    // (b) prints 2 2
    s = printBoth(z, z); cout << s << endl;            // (c) prints 2 2
    allOf(array, 5);                                   // (d) prints A B C D E
    lower(array, 5); allOf(array,5);                   // (e) prints a b c d e
    return 0;
}
```

(a) Title line for **least**.

Answer:

```
int least(int a, int b, int c)
```

(b) Title line for **decrease**.

Answer:

```
int decrease(int &x)
```

(c) Title line for **printBoth**.

Answer:

```
string printBoth(int a, int b)
```

(d) Title line for **allOf**.

Answer:

```
void allOf(string a[], int cap)
```

(e) Title line for **lower**.

Answer:

```
void lower(string x[], int cap)
```

Problem 70   Write the best **title lines** for the functions that are called by the following main program. **Do not supply blocks for the functions.**

```
int main() {
    double x = 0.0, y = 3.1, z = 2.5;
    int array[5] = {3,1,4,1,5};
    string s;

    cout << second(x, x, z) << endl;                        // (a) prints second value 0.0
    increase(x); cout << x << endl;                         // (b) prints 1.0
    printBoth(y, z);                                        // (c) prints 3.1 2.5
    s = allOf(array, 5); cout << s << endl;                 // (d) prints 3 1 4 1 5
    rotate(array, 5); cout << allOf(array,5) << endl;       // (e) prints 1 4 1 5 3
    return 0;
}
```

(a) Title line for **second**.

Answer:

```
double second(double a, double b, double c)
```

(b) Title line for **increase**.

Answer:

```
void increase(double &x)
```

(c) Title line for **printBoth**.

Answer:

```
void printBoth(double a, double b)
```

(d) Title line for **allOf**.

Answer:

```
string allOf(int a[], int cap)
```

(e) Title line for **rotate**.

Answer:

```
void rotate(int x[], int cap)
```

Problem 71   Consider the following C++ program.

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

string fun(string x) {
  if (x.length() <= 4) {
     return "00";
  }
  return fun(x.substr(4)) + x.substr(4);
}

int main() {
    int x = 43;
    int y = x / 10;
    cout << x / 10 + x % 10 << endl;            // line (a)
    if (((x > 40) || (x < 50)) && ((y > 4) || (y < 5)))
       cout << x % y << endl;                   // line (b)
    cout << fun("Easy") << endl;                // line (c)
    cout << fun("12345") << endl;               // line (d)
    cout << fun("123456789") << endl;           // line (e)
}
```

(a) What is the output at line (a)?

Answer:

7

(b) What is the output at line (b)?

Answer:

3

(c) What is the output at line (c)?

Answer:

00

(d) What is the output at line (d)?

Answer:

005

(e) What is the output at line (e)?

Answer:

00956789

Problem 72   Consider the following C++ program.

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

string fun(string x) {
  if (x.length() <= 4) {
    return "XX";
  }
  return fun(x.substr(3)) + x.substr(4);
}

int main() {
    int x = 34;
    int y = x / 10;
    cout << x / 10 + x % 10 << endl;        // line (a)
    if (((x > 30) && (x < 50)) || ((y > 3) && (y < 5)))
        cout << x % y << endl;              // line (b)
    cout << fun("Easy") << endl;            // line (c)
    cout << fun("ABCDE") << endl;           // line (d)
    cout << fun("ABCDEFG") << endl;         // line (e)
}
```

(a) What is the output at line (a)?

Answer:

7

(b) What is the output at line (b)?

Answer:

1

(c) What is the output at line (c)?

Answer:

XX

(d) What is the output at line (d)?

Answer:

XXE

(e) What is the output at line (e)?

Answer:

Problem 73   Consider the following C++ program.

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

string fun(string x) {
  if (x.length() <= 5) {
     return "00";
  }
  return fun(x.substr(5, 1)) + x.substr(5, 1);
}

int main() {
    int x = 78;
    string y = "Hello";
    cout << x / 10 + x % 10 << endl;        // line (a)
    cout << y.find("l") << endl;            // line (b)
    cout << fun("Easy") << endl;            // line (c)
    cout << fun("234567") << endl;          // line (d)
    cout << fun("23456789") << endl;        // line (e)
}
```

(a) What is the output at line (a)?

Answer:

15

(b) What is the output at line (b)?

Answer:

2

(c) What is the output at line (c)?

Answer:

00

(d) What is the output at line (d)?

Answer:

007

(e) What is the output at line (e)?

Answer:

007

Problem 74   Consider the following C++ program.

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

string fun(string x) {
```

```
    if (x.length() <= 3) {
        return "XX";
    }
    return fun(x.substr(1,2)) + x.substr(1,2);
}

int main() {
    int x = 53;
    string y = "easy";
    cout << x / 10 + x % 10 << endl;          // line (a)
    cout << y.rfind("a") << endl;             // line (b)
    cout << fun(y) << endl;                   // line (c)
    cout << fun("y") << endl;                 // line (d)
    cout << fun("yxwvuts") << endl;           // line (e)
}
```

(a) What is the output at line (a)?

Answer:

8

(b) What is the output at line (b)?

Answer:

1

(c) What is the output at line (c)?

Answer:

XXas

(d) What is the output at line (d)?

Answer:

XX

(e) What is the output at line (e)?

Answer:

XXxw

Problem 75   Write blocks of code to perform the functions used in the following main program. Your blocks must match the given title lines. Each block should be a short function of only a few lines.

```
int main() {
    int a[4] = {1, 2 ,-3, -4};
    int x = 5, y = 6;
// (a) Return the cube. Here 8 is printed.
    cout << cube(2) << endl;
// (b) Return the larger number. Here 6 is printed.
    cout << larger(x, y) << endl;
// (c) Return the largest element. Here 2 is printed.
    cout << largest(a, 4) << endl;
// (d) Test whether all array entries are positive.  Here: Not all positive
    if (!allPositive(a, 4)) cout << "Not all positive\n";
// (e) Swap values.  Here -3 is printed.
    swap(a[2], x);
    cout << x << endl;
    return 0;
}
```

Answer:

(a)

```
int cube(int x) {
    return x * x * x;
}
```

(b)

```
int larger(int x, int y) {
    if (x > y) return x;
    return y;
}
```

(c)

```
int largest(int x[], int cap) {
    int ans = x[0];
    for (int i = 0; i < cap; i++)
        if (x[i] > ans) ans = x[i];
    return ans;
}
```

(d)

```
bool allPositive(int x[], int capacity) {
    for (int i = 0; i < capacity; i++)
        if (x[i] <= 0) return false;
    return true;
}
```

(e)

```
void swap(int &x, int &y) {
    int temp = x;
    x = y;
    y = temp;
}
```

Problem 76   Write blocks of code to perform the functions used in the following main program. Your blocks must match the given title lines. Each block should be a short function of only a few lines.

```
int main() {
    int a[4] = {1, 2 ,-3, -4};
    int x = 5, y = 6;
// (a) Return the cube. Here 8.0 is printed.
    cout << cube(2.0) << endl;
// (b) Print the larger number. Here 6 is printed.
    larger(x, y);
// (c) Return the first negative element, or 0 if there is none. Here -3 is printed.
    cout << firstNegative(a, 4) << endl;
// (d) Test whether array entries increase in size.  Here: Not increasing
    if (!increasing(a, 4)) cout << "Not increasing\n";
// (e) Swap values.  Here 6 is printed.
```

```
            swap(y, x);
            cout << x << endl;
            return 0;
}
```

Answer:

(a)

```
double cube(double x) {
        return x * x * x;
}
```

(b)

```
void larger(int x, int y) {
        if (x > y) cout << x << endl;
        else cout << y << endl;
}
```

(c)

```
int firstNegative(int x[], int cap) {
        for (int i = 0; i < cap; i++)
            if (x[i] < 0) return x[i];
        return 0;
}
```

(d)

```
bool increasing(int x[], int capacity) {
    for (int i = 1; i < capacity; i++)
        if (x[i - 1] >= x[i]) return false;
    return true;
}
```

(e)

```
void swap(int &x, int &y) {
    int temp = x;
    x = y;
    y = temp;
}
```

Problem 77   Write blocks of code to perform the functions used in the following main program. Your blocks must match the given title lines. Each block should be a short function of only a few lines.

```
int main() {
        int a[4] = {3, 2 ,-3, -4};
        double x = 5.0, y = 6.0;
// (a) Return the cube. Here 8.0 is printed.
        cout << cube(2.0) << endl;
// (b) Print the larger number. Here 6.0 is printed.
        larger(x, y);
// (c) Return the last positive element, or 0 if there is none. Here 2 is printed.
```

```
        cout << lastPositive(a, 4) << endl;
// (d) Test whether array entries decrease in size.  Here: decreasing
        if (decreasing(a, 4)) cout << "Decreasing\n";
// (e) Swap values.  Here 2 is printed.
        swap(a[0], a[1]);
        cout << a[0] << endl;
        return 0;
}
```

Answer:

(a)

```
double cube(double x) {
    return x * x * x;
}
```

(b)

```
void larger(double x, double y) {
    if (x > y) cout << x << endl;
    else cout << y << endl;
}
```

(c)

```
int lastPositive(int x[], int cap) {
    int ans = 0;
    for (int i = 0; i < cap; i++)
        if (x[i] > 0) ans = x[i];
    return ans;
}
```

(d)

```
bool decreasing(int x[], int capacity) {
    for (int i = 1; i < capacity; i++)
        if (x[i - 1] <= x[i]) return false;
    return true;
}
```

(e)

```
void swap(int &x, int &y) {
    int temp = x;
    x = y;
    y = temp;
}
```

Problem 78   Write blocks of code to perform the functions used in the following main program. Your blocks must match the given title lines. Each block should be a short function of only a few lines.

```
int main() {
        int a[4] = {3, 2 ,-3, -4};
        int x = 7, y = 6;
```

```
// (a) Return the cube. Here 8 is printed.
     cout << cube(2) << endl;
// (b) Is x larger than y?. Here YES is printed.
     if (larger(x, y)) cout << "YES" << endl;
// (c) Return the smallest element. Here -4 is printed.
     cout << smallest(a, 4) << endl;
// (d) Test whether all array entries are negative.  Here: Not all negative
     if (!allNegative(a, 4)) cout << "Not all negative\n";
// (e) Swap values.  Here -3 is printed.
     swap(a[2], x);
     cout << x << endl;
     return 0;
}
```

Answer:

(a)

```
int cube(int x) {
    return x * x * x;
}
```

(b)

```
bool larger(int x, int y) {
   return x > y;
}
```

(c)

```
int smallest(int x[], int cap) {
    int ans = x[0];
    for (int i = 0; i < cap; i++)
       if (x[i] < ans) ans = x[i];
    return ans;
}
```

(d)

```
bool allNegative(int x[], int capacity) {
   for (int i = 0; i < capacity; i++)
      if (x[i] >= 0) return false;
   return true;
}
```

(e)

```
void swap(int &x, int &y) {
   int temp = x;
   x = y;
   y = temp;
}
```

Problem 79   Write a function called *evenCols* that returns the number of columns of a 2-dimensional array that have an even sum. The array contains integers and has 5 columns.

For example, a program that uses the function *evenCols* follows. The output is 2 because only columns 1 and 4 have even sum.

```
int main() {
    int x[2][5] = {{1, 2, 3, 5, 4}, {2, 2, 2, 2, 2}};
    cout << evenCols(x, 2, 5) << endl;        // prints 2
    return 0;
}
```

Answer:

```
int evenCols(int array[][5], int rows, int cols) {
    int ans = 0;
    for (int c = 0; c < cols; c++) {
        int total = 0;
        for (int r = 0; r < rows; r++)
            total += array[r][c];
        if (total % 2  == 0) ans++;
    }
    return ans;
}
```

Problem 80   Write a function called *positiveCols* that returns the number of columns of a 2-dimensional array that have a positive sum. The array contains doubles and has 6 columns.

For example, a program that uses the function *positiveCols* follows. The output is 2 because only columns 1 and 3 have positive sum.

```
int main() {
    double x[2][6] = {{1.0, 6.0, 3.0, 5.0, 4.0, 2.0},
                      {-4.0, -4.0, -4.0, -4.0, -4.0, -4.0}};
    cout << positiveCols(x, 2, 6) << endl;        // prints 2
    return 0;
}
```

Answer:

```
int positiveCols(double array[][6], int rows, int cols) {
    int ans = 0;
    for (int c = 0; c < cols; c++) {
        double total = 0;
        for (int r = 0; r < rows; r++)
            total += array[r][c];
        if (total > 0) ans++;
    }
    return ans;
}
```

Problem 81   Write a function called *largestCol* that returns the largest sum of the entries in a single column of a 2-dimensional array. The array contains integers and has 5 columns.

For example, a program that uses the function *largestCol* follows. The output is 7 because this is the sum for columns 0 and 4 and the other columns have a smaller sum.

```
int main() {
    int x[2][5] = {{1, 2, 3, 5, 4}, {6, 0, 0, 0, 3}};
    cout << largestCol(x, 2, 5) << endl;        // prints 7
    return 0;
}
```

Answer:

```
int largestCol(int array[][5], int rows, int cols) {
    int ans;
    for (int c = 0; c < cols; c++) {
        int total = 0;
        for (int r = 0; r < rows; r++)
            total += array[r][c];
        if (c == 0 || total > ans) ans = total;
    }
    return ans;
}
```

Problem 82   Write a function called *smallestCol* that returns the smallest sum of the entries in a single column of a 2-dimensional array. The array contains doubles and has 6 columns.

For example, a program that uses the function *smallestCol* follows. The output is 7.0 because this is the sum for columns 0 and 4 and the other columns have a larger sum.

```
int main() {
    double x[2][6] = {{1.0, 9.0, 8.0, 6.0, 4.0, 8.0},
                      {6.0, 0.0, 0.0, 3.0, 3.0, 3.0}};
    cout << smallestCol(x, 2, 6) << endl;       // prints 7.0
    return 0;
}
```

Answer:

```
double smallestCol(double array[][6], int rows, int cols) {
    double ans;
    for (int c = 0; c < cols; c++) {
        double total = 0;
        for (int r = 0; r < rows; r++)
            total += array[r][c];
        if (c == 0 || total < ans) ans = total;
    }
    return ans;
}
```

Problem 83   Write a function called *not7s* that counts how many digits are not equal to 7 in a positive integer parameter.

For example, a program that uses the function *not7s* follows.

```
int main() {
    cout << not7s(747) << endl;          // prints 1
    cout << not7s(176) << endl;          // prints 2
    cout << not7s(12345) << endl;        // prints 5
    cout << not7s(77777) << endl;        // prints 0
    return 0;
}
```

Answer:

```
int not7s(int x) {
    if (x == 0) return 0;
    if (x % 10 == 7) return not7s(x/10);
    return not7s(x/10) + 1;
}
```

Problem 84   Write a function called *sixesAndSevens* that counts how many digits are equal to 6 or 7 in a positive integer parameter.

For example, a program that uses the function *sixesAndSevens* follows.

```
int main() {
   cout << sixesAndSevens(747) << endl;        // prints 2
   cout << sixesAndSevens(176) << endl;        // prints 2
   cout << sixesAndSevens(666) << endl;        // prints 3
   cout << sixesAndSevens(12345) << endl;      // prints 0
   return 0;
}
```

Answer:

```
int sixesAndSevens(int x) {
   if (x == 0) return 0;
   if (x % 10 == 7 || x% 10 == 6) return sixesAndSevens(x/10) + 1;
   return sixesAndSevens(x/10);
}
```

Problem 85   Write a function called *diff2* that returns the absolute value of the difference of the first two digits in an integer parameter that is at least 10.

For example, a program that uses the function *diff2* follows.

```
int main() {
   cout << diff2(747) << endl;          // prints 3
   cout << diff2(176) << endl;          // prints 6
   cout << diff2(10101) << endl;        // prints 1
   cout << diff2(77777) << endl;        // prints 0
   return 0;
}
```

Answer:

```
int diff2(int x) {
   if (x < 100) {
      int ans = x/10 - x % 10;
      if (ans >= 0) return ans;
      return -ans;
   }
   return diff2(x/10);
}
```

Problem 86   Write a function called *sum3* that returns the sum of the first three digits in an integer parameter that is at least 100.

For example, a program that uses the function *sum3* follows.

```
int main() {
   cout << sum3(747) << endl;          // prints 18
   cout << sum3(176) << endl;          // prints 14
   cout << sum3(10199) << endl;        // prints  2
   cout << sum3(77777) << endl;        // prints 21
   return 0;
}
```

Answer:

```
int sum3(int x) {
    if (x == 0) return 0;
    if (x < 1000) return sum3(x/10) + x%10;
    return sum3(x/10);
}
```

Problem 87   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It asks the user to enter an integer n that is between 1 and 23.

2. It repeatedly reads n from the user until the supplied value of n is legal.

3. It prints out a rectangular picture with $2n - 1$ rows and n columns that makes a large 5 as displayed by a digital clock.

Here is an example of how the program should work:

```
Give me an integer between 1 and 23:    4
****
*
*
****
   *
   *
****
```

Answer:

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

int main() {
    int n;
    cout << "Give me an integer between 1 and 23:   ";
    cin >> n;
    while (n < 1 || n > 23) {
        cout << "Give me an integer between 1 and 23:   ";
        cin >> n;
    }

    for (int r = 1; r < 2*n; r++) {
        for (int c = 1; c <= n; c++)
            if (r ==1 || r == 2*n - 1 || r == n) cout << "*";
            else if (r < n && c == 1) cout << "*";
            else if (r > n && c == n) cout << "*";
            else cout << " ";
        cout << endl;
    }

    return 0;
}
```

Problem 88   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It asks the user to enter an integer n that is between 1 and 17.

2. It repeatedly reads n from the user until the supplied value of n is legal.

3. It prints out a rectangular picture with $2n - 1$ rows and n columns that makes a large 2 as displayed by a digital clock.

Here is an example of how the program should work:

```
Give me an integer between 1 and 17:    5
*****
```

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

Answer:

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

int main() {
   int n;
   cout << "Give me an integer between 1 and 17:   ";
   cin >> n;
   while (n < 1 || n > 17) {
      cout << "Give me an integer between 1 and 17:   ";
      cin >> n;
   }

   for (int r = 1; r < 2*n; r++) {
      for (int c = 1; c <= n; c++)
         if (r ==1 || r == 2*n - 1 || r == n) cout << "*";
         else if (r > n && c == 1) cout << "*";
         else if (r < n && c == n) cout << "*";
         else cout << " ";
      cout << endl;
   }

   return 0;
}
```

Problem 89   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It asks the user to enter an integer n that is between 1 and 23.

2. It repeatedly reads n from the user until the supplied value of n is legal.

3. It prints out a rectangular picture with $2n - 1$ rows and n columns that makes a large 3 as displayed by a digital clock.

Here is an example of how the program should work:

```
Give me an integer between 1 and 23:    5
*****
    *
    *
    *
*****
    *
    *
    *
*****
```

Answer:

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

int main() {
   int n;
   cout << "Give me an integer between 1 and 23:   ";
   cin >> n;
   while (n < 1 || n > 23) {
```

```
            cout << "Give me an integer between 1 and 23:   ";
            cin >> n;
        }

    for (int r = 1; r < 2*n; r++) {
        for (int c = 1; c <= n; c++)
            if (r ==1 || r == 2*n - 1 || r == n) cout << "*";
            else if (c == n) cout << "*";
            else cout << " ";
        cout << endl;
    }

    return 0;
}
```

Problem 90   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It asks the user to enter an integer n that is between 1 and 17.

2. It repeatedly reads n from the user until the supplied value of n is legal.

3. It prints out a rectangular picture with $2n - 1$ rows and n columns that makes a large 4 as displayed by a digital clock.

Here is an example of how the program should work:

```
Give me an integer between 1 and 17:   5
*   *
*   *
*   *
*****
    *
    *
    *
```

Answer:

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

int main() {
    int n;
    cout << "Give me an integer between 1 and 17:   ";
    cin >> n;
    while (n < 1 || n > 17) {
        cout << "Give me an integer between 1 and 17:   ";
        cin >> n;
    }

    for (int r = 1; r < 2*n; r++) {
        for (int c = 1; c <= n; c++)
            if (r == n) cout << "*";
            else if (r < n && c == 1) cout << "*";
            else if (c == n) cout << "*";
            else cout << " ";
        cout << endl;
    }

    return 0;
}
```

Problem 91   Write the best **title lines** for the functions that are called by the following main program. **Do not supply blocks for the functions.**

```
int main() {
    int x = 0, y = 1, z = 2;
    double b[2] = {1.1, 2.2};
    int d[2][2] = {{2,2},{3,4}};

    x = multiply(z, y);                    // (a) sets x to product 2
    copy(x, y);                            // (b) replaces x by value of y
    bigCol(d, 2, 2);                       // (c) prints biggest column: 2 4
    cout << printAll(b, 2) << endl;        // (d) prints array: 1.1 2.2
    cout << add(b[1], b[1]) << endl;       // (e) prints the sum 4.4
    return 0;
}
```

(a) Title line for **multiply**.

Answer:

```
int multiply(int z, int y)
```

(b) Title line for **copy**.

Answer:

```
void copy(int &x, int y)
```

(c) Title line for **bigCol**.

Answer:

```
void bigCol(int d[][2], int r, int c)
```

(d) Title line for **printAll**.

Answer:

```
string printAll(double b[], int cap)
```

(e) Title line for **add**.

Answer:

```
double add(double x, double y)
```

Problem 92   Write the best **title lines** for the functions that are called by the following main program. **Do not supply blocks for the functions.**

```
int main() {
    int x = 0, y = 1, z = 2;
    double b[2] = {1.1, 2.2};
    int d[2][2] = {{0,1},{3,4}};

    d[0][0] = sum(x, y);                   // (a) sets d[0][0] to the sum 1
    swap(x, y);                            // (b) swaps x and y
    cout << biggest(d, 2, 2);              // (c) prints biggest entry 4
    printAll(b, 2);                        // (d) prints 1.1 2.2
    cout << summit(b[0], b[0]) << endl;    // (e) prints the sum 2.2
    return 0;
}
```

(a) Title line for **sum**.

Answer:

```
int sum(int x, int y)
```

(b) Title line for **swap**.

Answer:

```
void swap(int &x, int &y)
```

(c) Title line for **biggest**.

Answer:

```
int biggest(int d[][2], int r, int c)
```

(d) Title line for **printAll**.

Answer:

```
void printAll(double b[], int cap)
```

(e) Title line for **summit**.

Answer:

```
double summit(double x, double y)
```

Problem 93   Consider the following C++ program.

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

double down(int x[], int cap, int gap) {
  double ans = 0.0;
  for (int i = 0; i < cap; i+= gap)
    ans += x[i];
  return ans / 10;
}

int main() {
    int x[4] = {2, 1, 3, 0};
    cout << x[2] << endl;                    // line (a)
    cout << x[5/3] << endl;                  // line (b)
    cout << x[x[3]] << endl;                 // line (c)
    cout << down(x, 4, 1) << endl;           // line (d)
    cout << down(x, 4, 3) << endl;           // line (e)
}
```

(a) What is the output at line (a)?

Answer:

3

(b) What is the output at line (b)?

Answer:

1

(c) What is the output at line (c)?

Answer:

2

(d) What is the output at line (d)?

Answer:

```
0.6
```

(e) What is the output at line (e)?

Answer:

```
0.2
```

Problem 94   Consider the following C++ program.

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

double down(int x[], int cap, int gap) {
  double ans = 0.0;
  for (int i = 0; i < cap; i+= gap)
    ans += x[i];
  return ans / 10;
}

int main() {
    int x[4] = {3, 2, 0, 1};
    cout << x[2] << endl;                    // line (a)
    cout << x[5/3] << endl;                  // line (b)
    cout << x[x[3]] << endl;                 // line (c)
    cout << down(x, 4, 1) << endl;           // line (d)
    cout << down(x, 4, 3) << endl;           // line (e)
}
```

(a) What is the output at line (a)?

Answer:

```
0
```

(b) What is the output at line (b)?

Answer:

```
2
```

(c) What is the output at line (c)?

Answer:

```
2
```

(d) What is the output at line (d)?

Answer:

```
0.6
```

(e) What is the output at line (e)?

Answer:

```
0.4
```

Problem 95   Write blocks of code to perform the functions used in the following main program. Your blocks must match the given title lines. Each block should be a short function of only a few lines.

```
int main() {
    int i = 2;
    int x[5] = {3, 1, 4, 1, 5};
// (a) Is i even?  Here YES is printed.
    if (isEven(i)) cout << "YES" << endl;
// (b) Return the bigger. Here 4 is printed.
    cout << bigger(i, 4) << endl;
// (c) Are all entries in the array x positive? Here YES is printed.
    if (allPositive(x, 5)) cout << "YES" << endl;
// (d) Print the array with spaces between entries. Here 3 1 4 1 5.
    printArray(x, 5);
// (e) Print the number of digits. Here 3.
    cout << numDigits(729) << endl;
    return 0;
}
```

Answer:

(a)

```
bool isEven(int x) {
    return x % 2 == 0;
}
```

(b)

```
int bigger(int x, int y) {
    if (x > y) return x;
    return y;
}
```

(c)

```
bool allPositive(int x[], int cap) {
    for (int i = 0; i < cap; i++)
        if (x[i] <= 0) return false;
    return true;
}
```

(d)

```
void printArray(int x[], int cap) {
    for (int i = 0; i < cap; i++) cout << x[i] << " ";
    cout << endl;
}
```

(e)

```
int numDigits(int x) {
    if (x < 10) return 1;
    return 1 + numDigits(x / 10);
}
```

Problem 96   Write blocks of code to perform the functions used in the following main program. Your blocks must match the given title lines. Each block should be a short function of only a few lines.

```
int main() {
    double i = 2.5;
    string x = "Hello";
// (a) Is i positive?  Here YES is printed.
    if (isPositive(i)) cout << "YES" << endl;
// (b) Return the bigger. Here 4 is printed.
    cout << bigger(i, 4) << endl;
// (c) Does the string x start with an upper case character? Here YES.
    if (startsUpper(x)) cout << "YES" << endl;
// (d) Add on a second copy of the string. Here HelloHello is printed.
    cout << twice(x) << endl;
// (e) Print the first digit. Here 7.
    cout << firstDigit(729) << endl;
    return 0;
}
```

Answer:

(a)

```
bool isPositive(double x) {
    return x > 0;
}
```

(b)

```
double bigger(double x, double y) {
    if (x > y) return x;
    return y;
}
```

(c)

```
bool startsUpper(string x) {
    return x[0] >= 'A' && x[0] <= 'Z';
}
```

(d)

```
string twice(string x) {
    return x + x;
}
```

(e)

```
int firstDigit(int x) {
    if (x < 10) return x;
    return firstDigit(x / 10);
}
```

Problem 97   Write a function called *shorten* that shortens each element of an array of strings. Every string with more than two characters is cut down to its first two characters.

For example, a program that uses the function *shorten* follows.

```
int main() {
    string x[6] = {"CSCI", "1", "11", "Queens", "College", "CUNY"};
    shorten(x, 6);
    for (int i = 0; i < 6; i++) cout << x[i] << " ";
        // Output:   CS 1 11 Qu Co CU
    cout << endl;
    return 0;
}
```

Answer:

```
void shorten(string x[], int cap) {
    for (int i = 0; i < cap; i++)
        if (x[i].length() > 2)
            x[i] = x[i].substr(0, 2);
}
```

Problem 98   Write a function called *lengthen* that lengthens each element of an array of strings. Every string with at least two characters has a *XXX* added after its first character.

For example, a program that uses the function *lengthen* follows.

```
int main() {
    string x[3] = {"csci", "1", "11"};
    lengthen(x, 3);
    for (int i = 0; i < 3; i++) cout << x[i] << " ";
        // Output:   cXXXsci 1 1XXX1
    cout << endl;
    return 0;
}
```

Answer:

```
void lengthen(string x[], int cap) {
    for (int i = 0; i < cap; i++)
        if (x[i].length() > 1)
            x[i] = x[i].insert(1, "XXX");
}
```

Problem 99   Write a function called *allOdd* that reports whether all the digits in a positive integer parameter are odd.

For example, a program that uses the function *allOdd* follows.

```
int main() {
    if (allOdd(153)) cout << "All odd" << endl;         // prints: All odd
    if (!allOdd(153972)) cout << "Not" << endl;         // prints: Not
    if (!allOdd(222)) cout << "Not " << endl;           // prints: Not
    if (allOdd(5)) cout << "All odd" << endl;           // prints: All odd
    return 0;
}
```

Answer:

```
bool allOdd(int x) {
    if (x < 10) return x % 2 == 1;
    return allOdd(x / 10) && allOdd(x % 10);
}
```

Problem 100   Write a function called *evenToNine* that returns a result obtained by turning all the even digits in a positive integer parameter to nines.

For example, a program that uses the function *evenToNine* follows.

```
int main() {
   cout << evenToNine(1234) << endl;        // prints: 1939
   cout << evenToNine(1357) << endl;        // prints: 1357
   cout << evenToNine(22) << endl;          // prints: 99
   cout << evenToNine(1) << endl;           // prints: 1
   return 0;
}
```

Answer:

```
int evenToNine(int x) {
   if (x <= 0) return 0;
   if (x % 2 == 0)
      return 10 * evenToNine(x / 10) + 9;
   return 10 * evenToNine(x/ 10) + x % 10;
}
```

Problem 101   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It asks the user to enter 25 quiz scores each of which is an integer between 0 and 10.

2. It reads the 25 quiz scores.

3. It prints out the most common score (or scores).

For example if the scores 6 and 8 were the two most common scores, the output would be:

6 8

Answer:

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

int main() {
   int score, counts[11], maxCount = 0;
   for (int i = 0; i < 11; i++) counts[i] = 0;

   cout << "Enter 25 quiz scores: ";
   for (int i = 0; i < 25; i++) {
      cin >> score;
      counts[score] ++;
      if (counts[score] > maxCount)
         maxCount = counts[score];
   }

   for (int i = 0; i < 11; i++)
      if (counts[i] == maxCount)
         cout << i << " ";
   cout << endl;
   return 0;
}
```

Problem 102   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It asks the user to enter quiz scores of 25 students. Each score is an integer between 0 and 10.

2. It reads the 25 quiz scores.

3. It prints out the score obtained by the middle student. (The middle student is ranked 13th in the class.)

Answer:

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

int main() {
    int score, counts[11];
    for (int i = 0; i < 11; i++) counts[i] = 0;

    cout << "Enter 25 quiz scores: ";
    for (int i = 0; i < 25; i++) {
        cin >> score;
        counts[score] ++;
    }

    score = 10;
    int numberStudents = counts[score];
    while (numberStudents < 13) {
        score--;
        numberStudents += counts[score];
    }

    cout << score << endl;
    return 0;
}
```

Problem 103   Write the best **title lines** for the functions that are called by the following main program. **Do not supply blocks for the functions.**

```cpp
int main() {
    int x = 0, y = 1, z = 2;
    double b[2] = {1.1, 2.2};
    int d[2][2] = {{1,2},{3,4}};

    cout << diff(x, y) << endl;      // (a) prints difference: -1
    y = addUp(x, y);                 // (b) sets y to sum 0 + 1
    cout << lastElt(b, 2);           // (c) prints last element: 2.2
    b[0] = average(d, 2, 2);         // (d) sets as average 2.5
    setZero(y, z);                   // (e) sets both to 0
    return 0;
}
```

(a) Title line for **diff**.

Answer:

```cpp
int diff(int a, int b)
```

(b) Title line for **addUp**.

Answer:

```cpp
int addUp(int x, int y)
```

(c) Title line for **lastElt**.

Answer:

```cpp
double lastElt(double array[], int cap)
```

(d) Title line for **average**.

Answer:

```
double average(int array[][2], int r, int c)
```

(e) Title line for **setZero**.

Answer:

```
void setZero(int &x, int &y)
```

Problem 104   Consider the following C++ program.

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

double down(int x[], int cap, int gap) {
  double ans = 0.0;
  for (int i = 0; i < cap; i+= gap)
    ans += x[i];
  return ans / 10;
}

int main() {
    int x[4] = {1, 1, 3, 2};
    cout << x[2] << endl;                // line (a)
    cout << x[5/3] << endl;              // line (b)
    cout << x[x[3]] << endl;             // line (c)
    cout << down(x, 4, 1) << endl;       // line (d)
    cout << down(x, 4, 3) << endl;       // line (e)
}
```

(a) What is the output at line (a)?

Answer:

3

(b) What is the output at line (b)?

Answer:

1

(c) What is the output at line (c)?

Answer:

3

(d) What is the output at line (d)?

Answer:

0.7

(e) What is the output at line (e)?

Answer:

0.3

Problem 105   Write blocks of code to perform the functions used in the following main program. Your blocks must match the given title lines. Each block should be a short function of only a few lines.

```
int main() {
    int i = 2;
    string x = "Hello";
// (a) Does the number end in a 0?  Here YES is printed.
    if (endInZero(100)) cout << "YES" << endl;
// (b) Return the smaller. Here 2 is printed.
    cout << smaller(i, 4) << endl;
// (c) Return the first character of the string.  Here  H  is printed.
    cout << firstCharacter(x) << endl;
// (d) Print first two characters in reverse order. Here  eH  is printed.
    swapFirstTwo(x);   cout << endl;
// (e) Print the sum of the digits. Here 18.
    cout << sumDigits(729) << endl;
    return 0;
}
```

Answer:

(a)

```
bool endInZero(int x) {
    return x % 10 == 0;
}
```

(b)

```
int smaller(int x, int y) {
    if (x < y) return x;
    return y;
}
```

(c)

```
char firstCharacter(string x) {
    return x[0];
}
```

(d)

```
void swapFirstTwo(string x) {
    cout << x[1] << x[0];
}
```

(e)

```
int sumDigits(int x) {
    if (x < 10) return x;
    return sumDigits(x / 10) + x % 10;
}
```

Problem 106   Write a function called *setRandom* that assigns a random value between 21 and 40 to each element of a 2-dimensional array of integers (with 3 columns). (You must use a standard C++ function to generate random numbers.)

For example, a program that uses the function *setRandom* follows.

```
int main() {
    int x[2][3];
    setRandom(x, 2, 3);
    for (int c = 0; c < 3; c++) cout << x[1][c] << " ";
        // The output would be something like:  30 21 29
    cout << endl;
    return 0;
}
```

Answer:

```
#include <cstdlib>

void setRandom(int x[][3], int r, int c) {
    for (int i = 0; i < r; i++)
        for (int j = 0; j < c; j++)
            x[i][j] = rand() % 20 + 21;
}
```

Problem 107   Write a function called *startsWith* that returns a result of *even* or *odd* that describes the first digit of a positive integer parameter.

For example, a program that uses the function *startsWith* follows.

```
int main() {
    cout << startsWith(1234) << endl;          // prints: odd
    cout << startsWith(2345) << endl;          // prints: even
    cout << startsWith(22) << endl;            // prints: even
    cout << startsWith(1) << endl;             // prints: odd
    return 0;
}
```

Answer:

```
string startsWith(int x) {
    if (x > 10) return startsWith(x / 10);
    if (x % 2 == 0) return "even";
    return "odd";
}
```

Problem 108   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It asks the user to enter quiz scores of 24 students. Each score is an integer between 0 and 10.

2. It reads the 24 quiz scores.

3. It prints out the lowest score obtained by a student in the first quartile. (This is the score of the student ranked 6th in the class.)

Answer:

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

int main() {
    int score, counts[11];
    for (int i = 0; i < 11; i++) counts[i] = 0;

    cout << "Enter 24 quiz scores: ";
    for (int i = 0; i < 24; i++) {
```

```
        cin >> score;
        counts[score] ++;
    }

    score = 10;
    int numberStudents = counts[score];
    while (numberStudents < 6) {
        score--;
        numberStudents += counts[score];
    }

    cout << score << endl;
    return 0;
}
```

Problem 109   Write the best **title lines** for the functions that are called by the following main program. **Do not supply blocks for the functions.**

```
int main() {
    int x = 0, y = 1, z = 2;
    double b[3] = {1.9, 2.3, 3.0};
    int d[2][2] = {{1,2},{3,4}};

    x = sum(z, y);                       // (a) sets x to the sum: 3
    reset(d[1][1], z);                   // (b) replaces d[1][1] by the value of z
    diagonal(d, 2, 2);                   // (c) prints diagonal: 1 4
    cout << printAll(d, 2, 2) << endl;   // (d) prints array: 1 2 3 4
    cout << add(b[2], d[0][0]) << endl;  // (e) prints the sum: 4
    return 0;
}
```

(a) Title line for **sum**.

Answer:

```
int sum(int z, int y)
```

(b) Title line for **reset**.

Answer:

```
void reset(int &x, int y)
```

(c) Title line for **diagonal**.

Answer:

```
void diagonal(int d[][2], int r, int c)
```

(d) Title line for **printAll**.

Answer:

```
string printAll(int d[][2], int r, int c)
```

(e) Title line for **add**.

Answer:

```
double add(double x, int y)
```

Problem 110   Write the best **title lines** for the functions that are called by the following main program. **Do not supply blocks for the functions.**

```
int main() {
   double d = 2;
   string x[5] = {"3", "1", "4", "1", "5"};
   d =  average(x, 5);                        // (a) sets d to 2.8
   d = max(d, x[4], 3); cout << d << endl;    // (b) prints 5.0
   cout << inWords(x[1]) << endl;             // (c) prints one
   cout << f(f(x[0],d), 1.0) << endl;         // (d) mystery function prints 1.0
   percentage(8.0, x[2]);                     // (e) prints 200%
   return 0;
}
```

(a) Title line for **average**.

Answer:

```
double average(string y[], int cap)
```

(b) Title line for **max**.

Answer:

```
double max(double x, string y, int z)
```

(c) Title line for **inWords**.

Answer:

```
string inWords(string x)
```

(d) Title line for **f**.

Answer:

```
string f(string x, double y)
```

(e) Title line for **percentage**.

Answer:

```
void percentage(double x, string y)
```

Problem 111   Consider the following C++ program.

```
#include <iostream>
using namespace std;
int recursive (int x) {
   if (x < 5) return 3;
   return recursive (x / 3) + x % 6;
}

char swap (int x, int y) {
   x = y;
   y = x;
   cout << x << y;
   return 's';
}

void set (int arr []) {
   arr[0] = 1; arr[1] = 9; arr[2] = 6; arr[3] = 8; arr[4] = 3;
}
```

```
int main() {
  int x[5];
  set(x);
  swap(1, 2);  cout << endl;                           //line (a)
  set(x);
  cout << x[0 + 2] << x[0] + 2 << endl;                //line (b)
  cout << swap(1, 2) << endl;                          //line (c)
  for (int i = 1; i < 4; i++) cout << x[i];  cout << endl; //line (d)
  int e = 21;
  cout << recursive(e) << endl;                        //line (e)
  return 0;
}
```

(a) What is the output at line (a)?

Answer:

22

(b) What is the output at line (b)?

Answer:

63

(c) What is the output at line (c)?

Answer:

22s

(d) What is the output at line (d)?

Answer:

968

(e) What is the output at line (e)?

Answer:

7

Problem 112   Consider the following C++ program.

```
#include <iostream>
using namespace std;
int recursive (int x) {
   if (x < 5) return 4;
   return recursive (x / 4) + x % 6;
}

char swap (int x, int y) {
   y = x;
   x = y;
   cout << x << y;
   return '0';
}

void set (int arr []) {
```

```
    arr[0] = 5; arr[1] = 9; arr[2] = 0; arr[3] = 4; arr[4] = 9;
}

int main() {
  int x[5];
  set(x);
  swap(1, 2);  cout << endl;                              //line (a)
  set(x);
  cout << x[0 + 2] << x[0] + 2 << endl;                   //line (b)
  cout << swap(1, 2) << endl;                             //line (c)
  for (int i = 1; i < 4; i++) cout << x[i];  cout << endl; //line (d)
  int e = 21;
  cout << recursive(e) << endl;                           //line (e)
  return 0;
}
```

(a) What is the output at line (a)?

Answer:

11

(b) What is the output at line (b)?

Answer:

07

(c) What is the output at line (c)?

Answer:

110

(d) What is the output at line (d)?

Answer:

904

(e) What is the output at line (e)?

Answer:

12

Problem 113   Write blocks of code to perform the functions used in the following main program. Your blocks must match the given title lines. Each block should be a short function of only a few lines.

```
int main() {
   int i = 2;
   int x[5] = {3, 1, 4, 1, 5};
// (a) Return the sum.  Here 4 is printed.
   cout << add(i, 2) << endl;
// (b) Return number of odd entries. Here 4 is printed.
   cout << numOdd(x, 5) << endl;
// (c) Multiply i by 2. Here 4 is printed.
   doubleIt(i); cout << i << endl;
// (d) Find the index of the largest entry. Here 4 is printed.
   cout << findIndexMax(x, 5) << endl;
// (e) Is it a lower case character? Here 4 is printed.
   if (isLowerCase('h')) cout << "4" << endl;
   return 0;
}
```

Answer:

(a)

```
int add(int x, int y) {
    return x + y;
}
```

(b)

```
int numOdd(int array[], int cap) {
   int ans = 0;
   for (int i = 0; i < cap; i++)
      if (array[i] % 2 != 0) ans++;
   return ans;
}
```

(c)

```
void doubleIt(int &x) {
   x *= 2;
}
```

(d)

```
int findIndexMax(int array[], int cap) {
   int ans = 0;
   for (int i = 0; i < cap; i++)
      if (array[i] > array[ans]) ans = i;
   return ans;
}
```

(e)

```
bool isLowerCase(char x) {
   return 'a' <= x && x <= 'z';
}
```

Problem 114   Write blocks of code to perform the functions used in the following main program. Your blocks must match the given title lines. Each block should be a short function of only a few lines.

```
int main() {
   int i = 2;
   int x[5] = {3, 1, 4, 1, 5};
// (a) Return the absoluteValue.  Here 2 is printed.
   cout << absoluteValue(i) << endl;
// (b) Return number of even entries, here 1 is printed.
   cout << numEven(x, 5) << endl;
// (c) Cube i. Here 8 is printed.
   cubeIt(i); cout << i << endl;
// (d) Find the (first) index of the smallest entry. Here 1 is printed.
   cout << findIndexMin(x, 5) << endl;
// (e) Is it a digit? Here print nothing.
   if (isDigit('h')) cout << "Digit" << endl;
   return 0;
}
```

Answer:

(a)

```
int absoluteValue(int x) {
    if (x < 0) return -x;
    return x;
}
```

(b)

```
int numEven(int array[], int cap) {
   int ans = 0;
   for (int i = 0; i < cap; i++)
      if (array[i] % 2 == 0) ans++;
   return ans;
}
```

(c)

```
void cubeIt(int &x) {
   x = x * x * x;
}
```

(d)

```
int findIndexMin(int array[], int cap) {
   int ans = 0;
   for (int i = 0; i < cap; i++)
      if (array[i] < array[ans]) ans = i;
   return ans;
}
```

(e)

```
bool isDigit(char x) {
   return '0' <= x && x <= '9';
}
```

Problem 115   Write a function called *noEl* that returns the number of elements that do not contain the letter *l* in a 2-dimensional array of strings (that has 3 columns).

For example, a program that uses the function *noEl* follows.

```
int main() {
   string x[2][3] = {{"CSCI", "One", "eleven"}, {"Queens", "College", "CUNY"}};
   cout << noEl(x, 2, 3) << endl;    // prints:  4
   return 0;
}
```

Answer:

```
int noEl(string data[][3], int rows, int cols) {
   int count = 0;
   for (int r = 0; r < rows; r++)
      for (int c = 0; c < cols; c++)
         if ((int) data[r][c].find("l") < 0) count++;
   return count;
}
```

Problem 116   Write a function called *cString* that returns a comma separated list of all elements that start with the letter *C* in an array of strings.

For example, a program that uses the function *cString* follows.

```
int main() {
   string x[6] = {"Computer", "Science", "111", "Queens", "College", "CUNY"};
   cout << cString(x, 6) << endl;    // prints:  Computer,College,CUNY
   return 0;
}
```

Answer:

```
string cString(string data[], int cap) {
   string ans = "";
   for (int c = 0; c < cap; c++)
      if (data[c].find("C") == 0) {
          if (ans != "") ans = ans + ",";
          ans = ans + data[c];
      }
   return ans;
}
```

Problem 117   Write a function called *removeDuplicates* that replaces any sequence of copies of a digit in a positive integer parameter by a single copy of that digit.

For example, a program that uses the function *removeDuplicates* follows.

```
int main() {
   cout << removeDuplicates(55511) << endl;        // prints 51
   cout << removeDuplicates(51155) << endl;        // prints 515
   cout << removeDuplicates(551155) << endl;       // prints 515
   cout << removeDuplicates(515) << endl;          // prints 515
   return 0;
}
```

Answer:

```
int removeDuplicates(int x) {
   if (x < 10) return x;
   int y = removeDuplicates(x / 10);
   if (y % 10 == x % 10) return y;
   return 10 * y + x % 10;
}
```

Problem 118   Write a function called *makeDecreasing* that makes a result with decreasing digits from a positive integer parameter. It selects the leftmost digit of the parameter and then later digits that are smaller than all that have already been selected.

For example, a program that uses the function *makeDecreasing* follows.

```
int main() {
   cout << makeDecreasing(89321) << endl;          // prints 8321
   cout << makeDecreasing(892321) << endl;         // prints 821
   cout << makeDecreasing(1995) << endl;           // prints 1
   cout << makeDecreasing(7) << endl;              // prints 7
   return 0;
}
```

Answer:

```
int makeDecreasing(int x) {
    if (x < 10) return x;
    int y = makeDecreasing(x / 10);
    if (y % 10 <= x % 10) return y;
    return 10 * y + x % 10;
}
```

Problem 119   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It asks the user to enter 25 integers and it reads the numbers that the user gives.

2. It calculates the average of the entered numbers.

3. It reports all entered numbers that are greater than the average, by printing them to a file called output6.txt.

Answer:

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

int main() {
    ofstream out;
    out.open("output6.txt");
    int x[25];
    cout << " Enter 25 integers: ";
    for (int i = 0; i < 25; i++) cin >> x[i];
    int sum = 0;
    for (int i = 0; i < 25; i++) sum += x[i];
    double average = sum / 25.0;
    for (int i = 0; i < 25; i++)
        if (x[i] > average) out << x[i] << endl;
    out.close();
    return 0;
}
```

Problem 120   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It asks the user to enter 25 integers and it reads the numbers that the user gives.

2. It calculates the smallest of the entered numbers.

3. It reports all entered numbers that are greater than the square of the smallest one. This output is to be printed to a file called output6.txt (and not to the user's screen).

Answer:

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

int main() {
    ofstream out;
    out.open("output6.txt");
    int x[25];
    cout << " Enter 25 integers: ";
    for (int i = 0; i < 25; i++) cin >> x[i];
    int smallest = x[0];
```

```
      for (int i = 0; i < 25; i++)
         if (x[i] < smallest) smallest = x[i];
      for (int i = 0; i < 25; i++)
         if (x[i] > smallest * smallest) out << x[i] << endl;
      out.close();
      return 0;
}
```

Problem 121   Write the best **title lines** for the functions that are called by the following main program. **Do
not supply blocks for the functions.**

```
int main() {
   int a[3] = {1, 1, 1}, i = 7, j = 8, k = 9;
   int b[5] = {1, 9, 6, 8, 3};
   int x[2][2] = {{2, 0}, {4, 8}};
   cout << max(i, j, k) << endl;    // (a) prints: 9
   printMax(b, 5);                  // (b) prints: 9
   cout << max2d(x, 2, 2) << endl;  // (c) prints: 8
   swap (i, j);                     // (d) swaps i and j
   swapArrays (a, b, 2); // (e) swaps first 2 elements of arrays a and b
   return 0;
}
```

(a) Title line for **max**.

Answer:

```
int max(int x, int y, int z)
```

(b) Title line for **printMax**.

Answer:

```
void printMax(int x[], int capacity)
```

(c) Title line for **max2d**.

Answer:

```
int max2d(int x[][2], int r, int c)
```

(d) Title line for **swap**.

Answer:

```
void swap(int &x, int &y)
```

(e) Title line for **swapArrays**.

Answer:

```
void swapArrays(int x[], int y[], int number)
```

Problem 122   Write the best **title lines** for the functions that are called by the following main program. **Do
not supply blocks for the functions.**

```
int main() {
   double a[3] = {1.0, 1.0, 1.0}, i = 7.0, j = 8.0, k = 9.9;
   double b[5] = {1.9, 9.9, 6.9, 8.9, 3.9};
   double x[2][2] = {{2.9, 0.9}, {4.9, 8.9}};
```

```
   cout << max(i, j, k) << endl;    // (a) prints: 9.9
   printMax(b, 5);                  // (b) prints: 9.9
   cout << max2d(x, 2, 2) << endl;  // (c) prints: 8.9
   swap (i, j);                     // (d) swaps i and j
   swapArrays (a, b, 2); // (e) swaps first 2 elements of arrays a and b
   return 0;
}
```

(a) Title line for **max**.

Answer:

```
double max(double x, double y, double z)
```

(b) Title line for **printMax**.

Answer:

```
void printMax(double x[], int capacity)
```

(c) Title line for **max2d**.

Answer:

```
double max2d(double x[][2], int r, int c)
```

(d) Title line for **swap**.

Answer:

```
void swap(double &x, double &y)
```

(e) Title line for **swapArrays**.

Answer:

```
void swapArrays(double x[], double y[], int number)
```

Problem 123   Consider the following C++ program.

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

void yesNo(bool ans) {
   if (ans) cout << "Y";
   else cout << "N";
   cout << endl;
}

int main() {
    int x = 3, y = 4, z = 5, a[4] = {0, 1, 2, 3};
    if (x == y) cout << "Y\n"; else cout << "N\n";        // line (a)
    if (x == a[x]) cout << "Y\n"; else cout << "N\n";     // line (b)
    if (!(x != y)) cout << "Y\n"; else cout << "N\n";     // line (c)
    yesNo((y < z) && (z < x));                            // line (d)
    yesNo((x < y) || (z < y));                            // line (e)
}
```

(a) What is the output at line (a)?

Answer:

```
N
```

(b) What is the output at line (b)?

Answer:

Y

(c) What is the output at line (c)?

Answer:

N

(d) What is the output at line (d)?

Answer:

N

(e) What is the output at line (e)?

Answer:

Y

Problem 124   Consider the following C++ program.

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

void yesNo(bool ans) {
   if (ans) cout << "Y";
   else cout << "N";
   cout << endl;
}

int main() {
    int x = 3, y = 5, z = 4, a[4] = {3, 2, 1, 0};
    if (x == y) cout << "Y\n";                        // line (a)
    if (x == a[0]) cout << "Y\n";                     // line (b)
    if (!(y < x)) cout << "Y\n"; else cout << "N\n";  // line (c)
    yesNo((x < z) && (y < z));                        // line (d)
    yesNo((x < z) || (y < z));                        // line (e)
}
```

(a) What is the output at line (a)?

Answer:

(b) What is the output at line (b)?

Answer:

Y

(c) What is the output at line (c)?

Answer:

Y

(d) What is the output at line (d)?

Answer:

N

(e) What is the output at line (e)?

Answer:

Y

Problem 125   Write blocks of code to perform the functions used in the following main program. Your blocks must match the given title lines. Each block should be a short function of only a few lines.

```
int main() {
      double a[4] = {1.0, 2.0, -3.0, -4.0};
      double b[4] = {0.5, 1.5, 2.5, 3.5};
// (a) Return the absolute value (ignoring sign).  Here 7 is printed.
      cout << absoluteValue(-7) << endl;
// (b) Return x/2 if x is even, otherwise 3*x+1: Here 22 is printed.
      cout << collatz(7) << endl;
// (c) Return the least factor. (Assume input at least 2.)  Here 5 is printed.
      cout << leastFactor(35) << endl;
// (d) Test whether all array entries are positive.  Here: Not all positive
      if (!allPositive(a, 4)) cout << "Not all positive\n";
// (e) Swap entries of the two arrays.
      swapArrays(a, b, 4);
      return 0;
}
```

Answer:

(a)

```
int absoluteValue(int x) {
    if (x < 0) return  - x;
    return x;
}
```

(b)

```
int collatz(int x) {
    if (x % 2 == 0) return x / 2;
    return 3 * x + 1;
}
```

(c)

```
int leastFactor(int x) {
    int ans = 2;
    while (x % ans != 0) ans++;
    return ans;
}
```

(d)

```
bool allPositive(double x[], int capacity) {
   for (int i = 0; i < capacity; i++)
      if (x[i] <= 0) return false;
   return true;
}
```

(e)

```
void swapArrays(double x[], double y[], int capacity) {
   for (int i = 0; i < capacity; i++) {
      double temp = x[i];
      x[i] = y[i];
      y[i] = temp;
   }
}
```

Problem 126   Write blocks of code to perform the functions used in the following main program. Your blocks must match the given title lines. Each block should be a short function of only a few lines.

```
int main() {
      int x = 5;
      double e = 2.718;
      double a[4] = {1.0, 2.0, -3.0, -4.0};
      double b[2] = {5.5, 4.5};
// (a) Changes the sign. Here to -5
      changeSign(x);
// (b) Return first digit after decimal point. Here 7 is printed.
      cout << firstDecimal(e) << endl;
// (c) Return the number of negative entries.  Here 2 is printed.
      cout << numberNeg(a, 4) << endl;
// (d) Test whether the first argument is a factor of the second.  Here: Yes
      if (isFactor(7, 14)) cout << "Yes\n";
// (e) print average of all entries both arrays:  Here 1.0 is printed.
      averageArrays(a, 4, b, 2);
      return 0;
}
```

Answer:

(a)

```
void changeSign(int &x) {
   x =  -x;
}
```

(b)

```
int firstDecimal(double x) {
   int tenX = (int) (x * 10);
   return tenX % 10;
}
```

(c)

```
int numberNeg(double x[], int capacity) {
```

```
       int ans = 0;
       for (int i = 0; i < capacity; i++)
            if (x[i] < 0) ans++;
       return ans;
}
```

(d)

```
bool isFactor(int x, int y) {
    return y % x == 0;
}
```

(e)

```
void averageArrays(double x[], int capacityX, double y[], int capacityY) {
    double sum = 0.0;
    for (int i = 0; i < capacityX; i++) sum += x[i];
    for (int i = 0; i < capacityY; i++) sum += y[i];
    cout << sum / (capacityX + capacityY) << endl;
}
```

Problem 127   Write a function called *longestString* that returns the longest element in a 2-dimensional array of strings (that is known to have 2 columns).

For example, a program that uses the function *longestString* follows.

```
int main() {
    string x[3][2] = {{"This", "is"}, {"an", "easy"}, {"question", ""}} ;
    cout << longestString(x, 3, 2) << endl;    // prints:  question
    return 0;
}
```

Answer:

```
string longestString(string x[][2], int rows, int cols) {
    string ans = "";
    for (int i = 0; i < rows; i++)
       for (int j = 0; j < cols; j++)
            if (x[i][j].length() > ans.length()) ans = x[i][j];
    return ans;
}
```

Problem 128   Write a function called *print3* that prints the elements of an array of integers, separated by commas and with 3 elements on each output line.

For example, a program that uses the function *print3* follows.

```
int main() {
    int x[8] = {1,2,3,4,5,6,7,8};
    print3(x, 8);
    return 0;
}
```

The output should be exactly:

```
1,2,3
4,5,6
7,8
```

Answer:

```
void print3(int x[], int capacity) {
   for (int i = 0; i < capacity; i++) {
      cout << x[i];
      if (i < (capacity - 1) && i % 3 != 2) cout << ",";
      else cout << endl;
   }
}
```

Problem 129   Write a function called *become5* that has two inputs – the first input is a positive integer and the second input is a single-digit integer. (You may assume that the two inputs have these forms.) The function has an integer output. The output is identical to the first input, except that every digit that matches the second input is replaced with a 5.

For example, a program that uses the function *become5* follows.

```
int main() {
   cout << become5(232, 2) << endl;       // prints 535
   cout << become5(232, 3) << endl;       // prints 252
   cout << become5(232, 4) << endl;       // prints 232
   return 0;
}
```

Answer:

```
int become5(int n, int digit) {
   if (n == digit) return 5;
   if (n < 10) return n;
   return 10 * become5(n/10, digit) + become5(n % 10, digit);
}
```

Problem 130   Write a function called *change5* that has two inputs – the first input is a positive integer and the second input is a single-digit integer. (You may assume that the two inputs have these forms.) The function has an integer output. The output is identical to the first input, except that every digit equal to 5 is replaced by the digit given by the second parameter.

For example, a program that uses the function *change5* follows.

```
int main() {
   cout << change5(535, 2) << endl;       // prints 232
   cout << change5(252, 3) << endl;       // prints 232
   cout << change5(232, 4) << endl;       // prints 232
   return 0;
}
```

Answer:

```
int change5(int n, int digit) {
   if (n == 5) return digit;
   if (n < 10) return n;
   return 10 * change5(n/10, digit) + change5(n % 10, digit);
}
```

Problem 131 Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It opens an input file called input14a.txt that contains only integers, including at least one negative integer. (You may assume that the file has exactly this content.)

2. It reads integers from the file until a negative integer is found.

3. It reports how many integers were read (upto and including the first negative value).

For example if the file input14a.txt has the following content:

```
12 16 29
17 10001
2 -34
-1 35 -3
11
```

The first negative entry in the file is its 7th number -34 and the program would output: 7

Answer:

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

int main() {
  ifstream f;
  f.open("input14a.txt");
  int x = 0, count = 0;

  while (x >= 0) {
     f >> x;
     count++;
  }
  cout << count << endl;
  f.close();
  return 0;
}
```

Problem 132 Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It opens an input file called input14b.txt that contains only strings, including at least one that starts with the letter X. (You may assume that the file has exactly this content.)

2. It reads strings from the file until one beginning with X is found.

3. It reports how many strings were read (upto and including the first that begins with X).

For example if the file input14b.txt has the following content:

```
A BBB Cat

Dog
XYZ E   XXX
```

The first X-word in the file is its 5th string XYZ and the program would output: 5

Answer:

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

```
int main() {
  ifstream f;
  f.open("input14b.txt");
  int count = 0;
  string x = "A";

  while (x[0] != 'X') {
     f >> x;
     count++;
  }
  cout << count << endl;
  f.close();
  return 0;
}
```

Problem 133   Write **title lines** for the functions that are called by the following main program. **Do not supply blocks for the functions.**

```
int main() {
   int i = 2;
   int x[5] = {3, 1, 4, 1, 5};
   cout << max(2.1, i, i) << endl;                // (a) prints 2.1
   cout << min(x[2], x[3]) << endl;               // (b) prints 1
   doubleIt(i); cout << i << endl;                // (c) prints 4
   printIt(x, 3);                                 // (d) prints 314
   cout << sum(sum(2,6), sum(x[0],x[1])) << endl; // (e) prints 12
   return 0;
}
```

(a) Title line for **max**.

Answer:

```
double max(double x, int y, int z)
```

(b) Title line for **min**.

Answer:

```
int min(int x, int y)
```

(c) Title line for **doubleIt**.

Answer:

```
void doubleIt(int &x)
```

(d) Title line for **printIt**.

Answer:

```
void printIt(int x[], int n)
```

(e) Title line for **sum**.

Answer:

```
int sum(int x, int y)
```

Problem 134   Write **title lines** for the functions that are called by the following main program. **Do not supply blocks for the functions.**

```
int main() {
   int i = 3;
   int x[5] = {2, 7, 1, 8, 2};
   cout << min(i, 2.1, i) << endl;              // (a) prints 2.1
   cout << max(x[2], 3) << endl;                // (b) prints 3
   cout << doubleIt(i) << endl;                 // (c) prints the following:  2 x 3
   cout << sum(sum(2,6,i), i, i) << endl;       // (d) prints 17
   sortIt(x, 3);                                // (e) sorts array x by selection sort
   return 0;
}
```

(a) Title line for **min**.

Answer:

```
double min(int x, double y, int z)
```

(b) Title line for **max**.

Answer:

```
int max(int x, int y)
```

(c) Title line for **doubleIt**.

Answer:

```
string doubleIt(int x)
```

(d) Title line for **sum**.

Answer:

```
int sum(int x, int y, int z)
```

(e) Title line for **sortIt**.

Answer:

```
void sortIt(int x[], int n)
```

Problem 135   Write **title lines** for the functions that are called by the following main program. **Do not supply blocks for the functions.**

```
int main() {
   int i = 2;
   double x[5] = {3, 1, 4, 1, 5};
   cout << max(4.1, x[i], i) << endl;              // (a) prints 4.1
   cout << min(x[2], x[3]) << endl;                // (b) prints 1
   doubleIt(i); cout << i << endl;                 // (c) prints 4
   printIt(x, 3);                                  // (d) prints 314
   cout << sum(sum(2.1,6), sum(x[0],x[1])) << endl; // (e) prints 12.1
   return 0;
}
```

(a) Title line for **max**.

Answer:

```
double max(double x, double y, int z)
```

(b) Title line for **min**.

Answer:

```
double min(double x, double y)
```

(c) Title line for **doubleIt**.

Answer:

```
void doubleIt(int &x)
```

(d) Title line for **printIt**.

Answer:

```
void printIt(double x[], int n)
```

(e) Title line for **sum**.

Answer:

```
double sum(double x, double y)
```

Problem 136   Write **title lines** for the functions that are called by the following main program. **Do not supply blocks for the functions.**

```
int main() {
    double i = 3;
    double x[5] = {2, 7, 1, 8, 2};
    cout << min(i, 2.1, i) << endl;              // (a) prints 2.1
    cout << max(x[2], 3.1) << endl;              // (b) prints 3.1
    cout << doubleIt(i) << endl;                 // (c) prints the following:  2 x 3
    cout << sum(sum(2.1,6,i), i, i) << endl;     // (d) prints 17.1
    sortIt(x, 3);                                // (e) sorts array x by selection sort
    return 0;
}
```

(a) Title line for **min**.

Answer:

```
double min(double x, double y, double z)
```

(b) Title line for **max**.

Answer:

```
double max(double x, double y)
```

(c) Title line for **doubleIt**.

Answer:

```
string doubleIt(double x)
```

(d) Title line for **sum**.

Answer:

```
double sum(double x, double y, double z)
```

(e) Title line for **sortIt**.

Answer:

```
void sortIt(double x[], int n)
```

Problem 137   Write **title lines** for the functions that are called by the following main program. **Do not supply blocks for the functions.**

```
int main() {
   int i = 2;
   int x[5] = {3, 1, 4, 1, 5};
   cout << add(i, i) << endl;                // (a) prints 4
   cout << numOdd(x, 5) << endl;             // (b) prints 4
   doubleIt(x[1]); cout << x[1] << endl;     // (c) prints 2
   cout << diff(diff(3,1), 1) << endl;       // (d) prints 1
   cout << percentage(i, x[2]) << endl;      // (e) prints 50%
   return 0;
}
```

(a) Title line for **add**.

Answer:

```
int add(int y, int z)
```

(b) Title line for **numOdd**.

Answer:

```
int numOdd(int x[], int y)
```

(c) Title line for **doubleIt**.

Answer:

```
void doubleIt(int &x)
```

(d) Title line for **diff**.

Answer:

```
int diff(int x, int y)
```

(e) Title line for **percentage**.

Answer:

```
string percentage(int x, int y)
```

Problem 138   Write **title lines** for the functions that are called by the following main program. **Do not supply blocks for the functions.**

```
int main() {
   int i = 2;
   int x[5] = {3, 1, 4, 1, 5};
   cout << average(x, 5) << endl;            // (a) prints 2.8
   cout << max(i, i, 3) << endl;             // (b) prints 3
   cout << doubleIt(x[1]) << endl;           // (c) prints 2
   cout << total(total(3,1,1), 1, 1) << endl; // (d) prints 7
   percentage(i, x[2]);                      // (e) prints 50%
   return 0;
}
```

(a) Title line for **average**.

Answer:

```
double average(int y[], int cap)
```

(b) Title line for **max**.

Answer:

```
int max(int x, int y, int z)
```

(c) Title line for **doubleIt**.

Answer:

```
int doubleIt(int x)
```

(d) Title line for **total**.

Answer:

```
int total(int x, int y, int z)
```

(e) Title line for **percentage**.

Answer:

```
void percentage(int x, int y)
```

Problem 139   Write **title lines** for the functions that are called by the following main program. **Do not supply blocks for the functions.**

```
int main() {
   double i = 2.5;
   int x[5] = {3, 1, 4, 1, 5};
   cout << add(i, i) << endl;                    // (a) prints 5.0
   if (oddSum(x, 5)) cout << "true" << endl; // (b) prints true
   doubleIt(i); cout << i << endl;               // (c) prints 5.0
   cout << diff(diff(3.0,i), i) << endl;      // (d) prints -2.0
   cout << percentage(x[1], x[2]) << endl;    // (e) prints 25%
   return 0;
}
```

(a) Title line for **add**.

Answer:

```
double add(double y, double z)
```

(b) Title line for **oddSum**.

Answer:

```
bool oddSum(int x[], int y)
```

(c) Title line for **doubleIt**.

Answer:

```
void doubleIt(double &x)
```

(d) Title line for **diff**.

Answer:

```
double diff(double x, double y)
```

(e) Title line for **percentage**.

Answer:

```
string percentage(int x, int y)
```

Problem 140   Write **title lines** for the functions that are called by the following main program. **Do not supply blocks for the functions.**

```
int main() {
   double i = 2; int n = 2;
   double x[5] = {3, 1, 4, 1, 5};
   cout << average(x, 5) << endl;              // (a) prints 2.8
   cout << max(i, i, 3.0) << endl;            // (b) prints 3.0
   cout << doubleIt(x[1]) << endl;            // (c) prints 2.0
   cout << ratio(ratio(3,1), n) << endl;      // (d) prints 1.5
   percentage(i, x[2]);                        // (e) prints 50.0%
   return 0;
}
```

(a) Title line for **average**.

Answer:

```
double average(double y[], int cap)
```

(b) Title line for **max**.

Answer:

```
double max(double x, double y, double z)
```

(c) Title line for **doubleIt**.

Answer:

```
double doubleIt(double x)
```

(d) Title line for **ratio**.

Answer:

```
double ratio(double x, int y)
```

(e) Title line for **percentage**.

Answer:

```
void percentage(double x, double y)
```

Problem 141   Consider the following C++ program. It is compiled to **a.out** and executed with the command **./a.out abc 123**.

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

int main(int argc, char *argv[]) {
   string words[4] = {"An ", "easy ", "question ", ""};
   for (int i = 0; i <= 2; i++) cout << words[i];   cout << endl;      // line (a)
   for (int i = 0; i <= 2; i++) cout << words[i][i];  cout << endl;    // line (b)
   words[3] = argv[1];
   cout << words[3] << endl;                                           // line (c)
   cout << ++words[0][0] << endl;                                      // line (d)
   cout << argc << endl;                                               // line (e)
   return 0;
}
```

(a) What is the output at line (a)?

Answer:

```
An easy question
```

(b) What is the output at line (b)?

Answer:

```
Aae
```

(c) What is the output at line (c)?

Answer:

```
abc
```

(d) What is the output at line (d)?

Answer:

```
B
```

(e) What is the output at line (e)?

Answer:

```
3
```

Problem 142   Consider the following C++ program. It is compiled to **a.out** and executed with the command **./a.out 123**.

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

int main(int argc, char *argv[]) {
    string words[4] = {"An ", "easy ", "question ", ""};
    for (int i = 2; i >= 0; i--) cout << words[i];  cout << endl;      // line (a)
    for (int i = 2; i >= 0; i--) cout << words[i][i+1];  cout << endl;   // line (b)
    words[3] = argv[1];
    cout << words[3] << endl;                                     // line (c)
    cout << words[0][0]++ << endl;                                // line (d)
    cout << argc << endl;                                         // line (e)
    return 0;
}
```

(a) What is the output at line (a)?

Answer:

```
question easy An
```

(b) What is the output at line (b)?

Answer:

```
ssn
```

(c) What is the output at line (c)?

Answer:

```
123
```

(d) What is the output at line (d)?

Answer:

```
A
```

(e) What is the output at line (e)?

Answer:

```
2
```

Problem 143   Consider the following C++ program. It is compiled to **a.out** and executed with the command **./a.out xyz 987**.

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

int main(int argc, char *argv[]) {
    string words[4] = {"Not ", "very ", "difficult ", ""};
    for (int i = 0; i <= 2; i++) cout << words[i];   cout << endl;      // line (a)
    for (int i = 0; i <= 2; i++) cout << words[i][i];   cout << endl;   // line (b)
    words[3] = argv[1];
    cout << words[3] << endl;                                          // line (c)
    cout << ++words[0][0] << endl;                                     // line (d)
    cout << argc << endl;                                             // line (e)
    return 0;
}
```

(a) What is the output at line (a)?

Answer:

```
Not very difficult
```

(b) What is the output at line (b)?

Answer:

```
Nef
```

(c) What is the output at line (c)?

Answer:

```
xyz
```

(d) What is the output at line (d)?

Answer:

```
O
```

(e) What is the output at line (e)?

Answer:

```
3
```

Problem 144   Consider the following C++ program. It is compiled to **a.out** and executed with the command **./a.out 007**.

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

int main(int argc, char *argv[]) {
    string words[4] = {"Not ", "very ", "difficult ", ""};
    for (int i = 2; i >= 0; i--) cout << words[i];  cout << endl;        // line (a)
    for (int i = 2; i >= 0; i--) cout << words[i][i+1];  cout << endl;   // line (b)
    words[3] = argv[1];
    cout << words[3] << endl;                                           // line (c)
    cout << words[0][0]++ << endl;                                      // line (d)
    cout << argc << endl;                                              // line (e)
    return 0;
}
```

(a) What is the output at line (a)?

Answer:

```
difficult very Not
```

(b) What is the output at line (b)?

Answer:

```
fro
```

(c) What is the output at line (c)?

Answer:

```
007
```

(d) What is the output at line (d)?

Answer:

```
N
```

(e) What is the output at line (e)?

Answer:

```
2
```

Problem 145   Consider the following C++ program. It is compiled to **a.out** and executed with the command **./a.out a 1**.

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

int main(int argc, char *argv[]) {
    string words[4] = {"CS111 ", "Queens ", "College ", ""};
    for (int i = 1; i <= 3; i++) cout << words[i];  cout << endl;       // line (a)
    for (int i = 0; i <= 2; i++) cout << words[i][i];  cout << endl;    // line (b)
    words[3] = argv[2];
    cout << words[3] << endl;                                          // line (c)
    cout << ++words[0][0] << endl;                                     // line (d)
    cout << argc << endl;                                             // line (e)
    return 0;
}
```

(a) What is the output at line (a)?

Answer:

```
Queens College
```

(b) What is the output at line (b)?

Answer:

```
Cul
```

(c) What is the output at line (c)?

Answer:

```
1
```

(d) What is the output at line (d)?

Answer:

```
D
```

(e) What is the output at line (e)?

Answer:

```
3
```

Problem 146   Consider the following C++ program. It is compiled to **a.out** and executed with the command **./a.out CS111**.

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

int main(int argc, char *argv[]) {
    string words[4] = {"Queens ", "College ", "CUNY ", "NY"};
    for (int i = 3; i >= 0; i--) cout << words[i];   cout << endl;       // line (a)
    for (int i = 2; i >= 0; i--) cout << words[i][i+1];  cout << endl; // line (b)
    words[3] = argv[1];
    cout << words[3] << endl;                                  // line (c)
    cout << words[0][0]++ << endl;                            // line (d)
    cout << ++argc << endl;                                   // line (e)
    return 0;
}
```

(a) What is the output at line (a)?

Answer:

```
NYCUNY College Queens
```

(b) What is the output at line (b)?

Answer:

```
Ylu
```

(c) What is the output at line (c)?

Answer:

```
CS111
```

(d) What is the output at line (d)?

Answer:

Q

(e) What is the output at line (e)?

Answer:

3

Problem 147   Consider the following C++ program. It is compiled to **a.out** and executed with the command **./a.out out out**.

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

int main(int argc, char *argv[]) {
    string words[4] = {"CS ", "QC ", "CUNY ", "EDU "};
    for (int i = 0; i <= 2; i++) cout << words[i];  cout << endl;     // line (a)
    for (int i = 0; i <= 2; i++) cout << words[i][i];  cout << endl;   // line (b)
    words[3] = argv[1];
    cout << words[3] << endl;                                          // line (c)
    cout << ++words[0][0] << endl;                                     // line (d)
    cout << argc++ << endl;                                            // line (e)
    return 0;
}
```

(a) What is the output at line (a)?

Answer:

CS QC CUNY

(b) What is the output at line (b)?

Answer:

CCN

(c) What is the output at line (c)?

Answer:

out

(d) What is the output at line (d)?

Answer:

D

(e) What is the output at line (e)?

Answer:

3

Problem 148   Consider the following C++ program. It is compiled to **a.out** and executed with the command **./a.out 007**.

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

int main(int argc, char *argv[]) {
    string words[4] = {"Queens ", "College ", "Flushing ", "New York"};
    for (int i = 3; i >= 0; i--) cout << words[i];  cout << endl;      // line (a)
    for (int i = 3; i >= 0; i--) cout << words[i][i+1];  cout << endl;   // line (b)
    words[3] = argv[1];
    cout << words[3] << endl;                                          // line (c)
    cout << words[0][0]++ << endl;                                     // line (d)
    cout << --argc << endl;                                           // line (e)
    return 0;
}
```

(a) What is the output at line (a)?

Answer:

New YorkFlushing College Queens

(b) What is the output at line (b)?

Answer:

Yslu

(c) What is the output at line (c)?

Answer:

007

(d) What is the output at line (d)?

Answer:

Q

(e) What is the output at line (e)?

Answer:

1

Problem 149   Write blocks of code to perform the functions used in the following main program. Your blocks must match the given title lines. Each block should be a short function of only a few lines.

```cpp
int main() {
   int a = 2, b = 3, c = 4;
   ifstream f;
   string s = "HELLO";  char t[] = "HELLO";
   f.open("testFile.txt");
 // (a) Tests whether a number is even, here Even!
   if (isEven(c)) cout << "Even!" << endl;
 // (b) Removes first and last chars from a string, here ELL
   cout << removeEnds(s) << endl;
 // (c) Prints first word in the input file
   cout << firstWord(f) << endl;
 // (d) Print last character of a C-string, here O
   cout << lastChar(t) << endl;
 // (e) Rotate a,b,c so as to print 3,4,2
   rotate(a, b, c);
   cout   << a << b << c << endl;
   return 0;
}
```

Answer:

(a)

```
bool isEven(int x) {
    return x % 2 == 0;
}
```

(b)

```
string removeEnds(string x) {
    return x.substr(1, x.length() - 2);
}
```

(c)

```
string firstWord(ifstream &file) {
    string x;
    file >> x;
    return x;
}
```

(d)

```
char lastChar(char x[]) {
    return x[strlen(x) - 1];
}
```

(e)

```
void rotate(int &x, int &y, int &z) {
    int temp = x;
    x = y;
    y = z;
    z = temp;
}
```

Problem 150   Write blocks of code to perform the functions used in the following main program. Your blocks must match the given title lines. Each block should be a short function of only a few lines.

```
int main() {
    int a = 23, b = 3, c = 4;
    ifstream f;
    string s = "HELLO";   char t[] = "HELLO";
    f.open("testFile.txt");
 // (a) Tests whether a number has 2 digits, here Yes!
    if (is2digit(a)) cout << "Yes!" << endl;
 // (b) Doubles a string, here HELLOHELLO
    cout << doubleIt(s) << endl;
 // (c) The number of words read from the input file before eof() is true
    cout << countWords(f) << endl;
 // (d) Print middle character of a C-string that has a middle, here L
    cout << midChar(t) << endl;
 // (e) Rotate a,b,c so as to print 4,23,3
    rotate(a, b, c);
    cout   << a << "," << b << "," << c << endl;
    return 0;
}
```

Answer:

(a)

```
bool is2digit(int x) {
    return (x > 9) && (x < 100);
}
```

(b)

```
string doubleIt(string x) {
    return x + x;
}
```

(c)

```
int countWords(ifstream &file) {
    string x;
    int count = 0;
    while (!file.eof()) {
        file >> x;
        count++;
    }
    return count;
}
```

(d)

```
char midChar(char x[]) {
    return x[(strlen(x) - 1)/2];
}
```

(e)

```
void rotate(int &x, int &y, int &z) {
    int temp = x;
    x = z;
    z = y;
    y = temp;
}
```

Problem 151   Write blocks of code to perform the functions used in the following main program. Your blocks must match the given title lines. Each block should be a short function of only a few lines.

```
int main() {
    int a = 2, b = 3, c = 4;
    ifstream f;
    string s = "HELLO";   char t[] = "HELLO";
    f.open("testFile.txt");
// (a) Tests whether a number is seven, here No!
    if (!isSeven(c)) cout << "No!" << endl;
// (b) Removes the last char from a string, here HELL
    cout << removeLast(s) << endl;
// (c) Prints second word in the input file
    cout << secondWord(f) << endl;
```

```
    // (d) Print first character of a C-string, here H
      cout << firstChar(t) << endl;
    // (e) swap a with the biggest of a,b,c.   Here prints 4,3,2
      swapBig(a, b, c);
      cout   << a << b << c << endl;
      return 0;
}
```

Answer:

(a)

```
bool isSeven(int x) {
    return x == 7;
}
```

(b)

```
string removeLast(string x) {
    return x.substr(0, x.length() - 1);
}
```

(c)

```
string secondWord(ifstream &file) {
    string x;
    file >> x;
    file >> x;
    return x;
}
```

(d)

```
char firstChar(char x[]) {
    return x[0];
}
```

(e)

```
void swapBig(int &x, int &y, int &z) {
    int temp = x;
    if (x < y && z <= y) {
        x = y;
        y = temp;
    } else if (x < z) {
        x = z;
        z = temp;
    }
}
```

Problem 152   Write blocks of code to perform the functions used in the following main program. Your blocks must match the given title lines. Each block should be a short function of only a few lines.

```
int main() {
    int a = 123, b = 3, c = 4;
```

```
      ifstream f;
      string s = "HELLO";   char t[] = "HELLO";
      f.open("testFile.txt");
 // (a) Tests whether a number has 3 digits, here Yes!
      if (is3digit(a)) cout << "Yes!" << endl;
 // (b) Returns the part of a string before its midpoint, here HE
      cout << halfIt(s) << endl;
 // (c) The number of characters read from the input file before eof() is true
      cout << countChar(f) << endl;
 // (d) Print third character of a C-string that has a middle, here L
      cout << thirdChar(t) << endl;
 // (e) Replace a, b and c by their sum to print 130, 130, 130
      replace(a, b, c);
      cout  << a << "," << b << "," << c << endl;
      return 0;
}
```

Answer:

(a)

```
bool is3digit(int x) {
    return (x > 99) && (x < 1000);
}
```

(b)

```
string halfIt(string x) {
    return x.substr(0, x.length()/2);
}
```

(c)

```
int countChar(ifstream &file) {
    char x;
    int count = 0;
    while (!file.eof()) {
        x = file.get();
        count++;
    }
    return count;
}
```

(d)

```
char thirdChar(char x[]) {
    return x[2];
}
```

(e)

```
void replace(int &x, int &y, int &z) {
    x = x + y + z;
    y = x;
    z = x;
}
```

Problem 153   Write blocks of code to perform the functions used in the following main program. Your blocks must match the given title lines. Each block should be a short function of only a few lines.

```
int main() {
   string s = "HELLO", t = "GOODBYE";
 // (a) Tests whether a string has 5 or more letters
   if (isLong(s)) cout << "Long!" << endl;
 // (b) Tests whether a string contains the letter E
   cout << hasE(s) << endl;
 // (c) Returns a string with just the first 4 characters
   cout << first4(t) << endl;
 // (d) Prints the last character at or before the middle of the string
   cout << middle(t) << endl;
 // (e) swaps them
   swap(s, t);
   cout   << s << " " << t << endl;
   return 0;
}
```

Answer:

(a)

```
bool isLong(string x) {
    return x.length() > 4;
}
```

(b)

```
bool hasE(string x) {
    return x.find("E") >= 0;
}
```

(c)

```
string first4(string x) {
    return x.substr(0,4);
}
```

(d)

```
char middle(string x) {
   return x[x.length()/2];
}
```

(e)

```
void swap(string &x, string &y) {
   string temp = x;
   x = y;
   y = temp;
}
```

Problem 154   Write blocks of code to perform the functions used in the following main program. Your blocks must match the given title lines. Each block should be a short function of only a few lines.

```
int main() {
    string s = "HELLO", t = "GOODBYE";
 // (a) return number of characters
    cout << stringLength(s) << endl;
 // (b) Tests whether a string contains a target
    cout << contains(s, "HELL") << endl;
 // (c) Returns a string with just the last 4 characters
    cout << last4(t) << endl;
 // (d) Prints the first character
    cout << first(t) << endl;
 // (e) adds on the second string
    addOn(s, t);
    cout   << s << endl;
    return 0;
}
```

Answer:

(a)

```
int stringLength(string x) {
    return x.length();
}
```

(b)

```
bool contains(string x, string target) {
    return x.find(target) >= 0;
}
```

(c)

```
string last4(string x) {
    return x.substr(x.length() - 4, 4);
}
```

(d)

```
char first(string x) {
    return x[0];
}
```

(e)

```
void addOn(string &x, string y) {
    x = x + y;
}
```

Problem 155   Write blocks of code to perform the functions used in the following main program. Your blocks must match the given title lines. Each block should be a short function of only a few lines.

```
int main() {
    string s = "HELLO", t = "GOODBYE";
 // (a) Tests whether a string starts in upper case
    if (isUpper(s)) cout << "Upper Case!" << endl;
```

```
 // (b) Tests whether a string omits the letter E
    cout << hasNoE(s) << endl;
 // (c) Returns a string that drops the first character
    cout << dropFirst(t) << endl;
 // (d) Prints the last character
    cout << last(t) << endl;
 // (e) If t is shorter than s, swap the strings, otherwise do nothing
    sort(s, t);
    cout   << s << " " << t << endl;
    return 0;
}
```

Answer:

(a)

```
bool isUpper(string x) {
    return 'A' <= x[0] && x[0] <= 'Z';
}
```

(b)

```
bool hasNoE(string x) {
    return x.find("E") < 0;
}
```

(c)

```
string dropFirst(string x) {
    return x.substr(1);
}
```

(d)

```
char last(string x) {
   return x[x.length() - 1];
}
```

(e)

```
void sort(string &x, string &y) {
   if (x.length() <= y.length()) return;
   string temp = x;
   x = y;
   y = temp;
}
```

Problem 156   Write blocks of code to perform the functions used in the following main program. Your blocks must match the given title lines. Each block should be a short function of only a few lines.

```
int main() {
   string s = "HELLO", t = "GOODBYE";
 // (a) Do two strings have the same number of characters?
   cout << sameLength(s, t) << endl;
 // (b) Tests whether a string contains a target
```

```
   cout << contains("HELL", s) << endl;
// (c) Returns a string that drops the last character
   cout << dropLast(t) << endl;
// (d) Prints the third character
   cout << third(t) << endl;
// (e) Turns an upper case character to lower case
   lower(s[0]);
   cout  << s << endl;
   return 0;
}
```

Answer:

(a)

```
bool sameLength(string x, string y) {
    return x.length() == y.length();
}
```

(b)

```
bool contains(string target, string x) {
    return x.find(target) >= 0;
}
```

(c)

```
string dropLast(string x) {
    return x.substr(0, x.length() - 1);
}
```

(d)

```
char third(string x) {
   return x[2];
}
```

(e)

```
void lower(char &x) {
   if ('A' <= x && x <= 'Z') x = x + 'a' - 'A';
}
```

Problem 157   Write a function called *subtractAverage* that calculates the average of the entries in a 2-dimensional array (that is known to have 2 columns) and subtracts this average from every entry of the array.

For example, a program that uses the function *subtractAverage* follows.

```
int main() {
   double x[3][2] = {{1,3}, {1,3}, {1,3}} ;   // average is 2 here
   subtractAverage(x, 3, 2);
   cout << x[0][0] << " " << x[0][1] << endl;  // prints:  -1 1
   return 0;
}
```

Answer:

```
void subtractAverage(double x[][2], int rows, int cols) {
   double sum  = 0;
   for (int r = 0; r < rows; r++)
      for (int c = 0; c < cols; c++) sum += x[r][c];
   double average = sum / (rows * cols);
   for (int r = 0; r < rows; r++)
      for (int c = 0; c < cols; c++) x[r][c] -= average;


}
```

Problem 158   Write a function called *addMin* that calculates the minimum of the entries in a 2-dimensional array (that is known to have 2 columns) and adds this minimum to every entry of the array.

For example, a program that uses the function *addMin* follows.

```
int main() {
   int x[3][2] = {{1,3}, {1,3}, {1,3}} ;   // min is 1 here
   addMin(x, 3, 2);
   cout << x[0][0] << " " << x[0][1] << endl;   // prints:  2 4
   return 0;
}
```

Answer:

```
void addMin(int x[][2], int rows, int cols) {
   int min  = x[0][0];
   for (int r = 0; r < rows; r++)
      for (int c = 0; c < cols; c++)
         if (x[r][c] < min) min = x[r][c];
   for (int r = 0; r < rows; r++)
      for (int c = 0; c < cols; c++)
         x[r][c] += min;
}
```

Problem 159   Write a function called *subtractAverage* that calculates the average of the entries in an array and subtracts this average from every positive entry of the array.

For example, a program that uses the function *subtractAverage* follows.

```
int main() {
   double x[5] = {3, 1, 4, 1, 6} ;                    // average is 3 here
   subtractAverage(x, 5);
   cout << x[0] << " " << x[1] << x[2] << endl;   // prints:  0 -2 1
   return 0;
}
```

Answer:

```
void subtractAverage(double x[], int capacity) {
   double sum  = 0;
   for (int r = 0; r < capacity; r++) sum += x[r];
   double average = sum / capacity;
   for (int r = 0; r < capacity; r++)
      if (x[r] > 0) x[r] -= average;


}
```

Problem 160   Write a function called *addMin* that calculates the minimum of the entries in an array and adds this minimum to every odd entry of the array.

For example, a program that uses the function *addMin* follows.

```
int main() {
    int x[5] = {3, 1, 4, 1, 5} ;   // min is 1 here
    addMin(x, 5);
    cout << x[0] << " " << x[1] << " " << x[2] << endl;   // prints:  4 2 4
    return 0;
}
```

Answer:

```
void addMin(int x[], int cols) {
    int min  = x[0];
    for (int c = 0; c < cols; c++)
        if (x[c] < min) min = x[c];
    for (int c = 0; c < cols; c++)
        if (x[c] % 2 == 1)
            x[c] += min;
}
```

Problem 161   Write a function called *minGap* that calculates the smallest gap between adjacent entries of an array. (A gap between two numbers is the absolute value of their difference.)

For example, a program that uses the function *minGap* follows.

```
int main() {
    int x[5] = {3, 1, 4, 1, 5};
    cout << minGap(x, 5) << endl;    // prints 2 corresponding to the gap from 3 to 1.
    return 0;
}
```

Answer:

```
int minGap(int x[], int cap) {
    int ans = x[1] - x[0];
    if (ans < 0) ans = -ans;
    for (int i = 1; i < cap; i++) {
        if (x[i] > x[i-1]) {
            if ((x[i] - x[i-1]) < ans)
                ans = x[i] - x[i - 1];
        } else {
            if ((x[i- 1] - x[i]) < ans)
                ans = x[i - 1] - x[i];
        }
    }
    return ans;
}
```

Problem 162   Write a function called *gapSum* that calculates the sum of the gaps between adjacent entries of an array. (A gap between two numbers is the absolute value of their difference.)

For example, a program that uses the function *gapSum* follows.

```
int main() {
    int x[5] = {3, 1, 4, 1, 5};
    cout << gapSum(x, 5) << endl;    // prints 12
    // The gaps are 2, 3, 3, 4 and these add to 12
    return 0;
}
```

Answer:

```
int gapSum(int x[], int cap) {
    int ans = 0;
    for (int i = 1; i < cap; i++) {
        if (x[i] > x[i-1]) {
            ans = ans + x[i] - x[i - 1];
        } else {
            ans = ans + x[i - 1] - x[i];
        }
    }
    return ans;
}
```

Problem 163   Write a function called *maxGap* that calculates the biggest gap between adjacent entries of an array. (A gap between two numbers is the absolute value of their difference.)

For example, a program that uses the function *maxGap* follows.

```
int main() {
    int x[5] = {3, 1, 4, 1, 5};
    cout << maxGap(x, 5) << endl;   // prints 4 corresponding to the gap from 1 to 5.
    return 0;
}
```

Answer:

```
int maxGap(int x[], int cap) {
    int ans = 0;
    for (int i = 1; i < cap; i++) {
        if ((x[i] - x[i-1]) > ans)
            ans = x[i] - x[i - 1];
        if ((x[i- 1] - x[i]) > ans)
            ans = x[i - 1] - x[i];
    }
    return ans;
}
```

Problem 164   Write a function called *gapProd* that calculates the product of the gaps between adjacent entries of an array. (A gap between two numbers is the absolute value of their difference.)

For example, a program that uses the function *gapProd* follows.

```
int main() {
    int x[5] = {3, 1, 4, 1, 5};
    cout << gapProd(x, 5) << endl;   // prints 72
    // The gaps are 2, 3, 3, 4 and these multiply to 72
    return 0;
}
```

Answer:

```
int gapProd(int x[], int cap) {
    int ans = 1;
    for (int i = 1; i < cap; i++) {
        if (x[i] > x[i-1]) {
            ans = ans * (x[i] - x[i - 1]);
        } else {
```

```
            ans = ans * (x[i - 1] - x[i]);
        }
    }
    return ans;
}
```

Problem 165   Write a function called *roundOff* that returns the result of turning all digits (except the first) in a positive integer parameter to 0.

For example, a program that uses the function *roundOff* follows.

```
int main() {
    cout << roundOff(19683) << endl;   // prints 10000
    cout << roundOff(2) << endl;       // prints 2
    return 0;
}
```

Answer:

```
int roundOff(int x) {
    if (x < 10) return x;
    return 10* roundOff(x/10);
}
```

Problem 166   Write a function called *allFirst* that returns the result of turning all digits in a positive integer parameter to match the first digit.

For example, a program that uses the function *allFirst* follows.

```
int main() {
    cout << allFirst(19683) << endl;   // prints 11111
    cout << allFirst(2048) << endl;    // prints 2222
    return 0;
}
```

Answer:

```
int allFirst(int x) {
    if (x < 10) return x;
    int y = allFirst(x/10);
    return 10*y + y%10;
}
```

Problem 167   Write a function called *firstDown* that returns the result of decreasing the first digit in a positive integer by 1.

For example, a program that uses the function *firstDown* follows.

```
int main() {
    cout << firstDown(2048) << endl;       // prints 1048
    cout << firstDown(19683) << endl;      // prints 9683
    return 0;
}
```

Answer:

```
int firstDown(int x) {
    if (x < 10) return x - 1;
    return 10* firstDown(x/10) + x % 10;
}
```

Problem 168   Write a function called *firstUp* that returns the result of increasing the first digit of the parameter by 1, unless this first digit is 9 in which case it is not changed.

For example, a program that uses the function *firstUp* follows.

```
int main() {
   cout << firstUp(19683) << endl;   // prints 29683
   cout << firstUp(95) << endl;      // prints 95
   return 0;
}
```

Answer:

```
int firstUp(int x) {
   if (x < 9) return x + 1;
   if (x == 9) return x;
   return 10* firstUp(x/10) + x % 10;
}
```

Problem 169   Write a function called *oddOne* that returns the result of turning all odd digits in a positive integer parameter to 1.

For example, a program that uses the function *oddOne* follows.

```
int main() {
   cout << oddOne(19683) << endl;   // prints 11681
   cout << oddOne(2) << endl;       // prints 2
   return 0;
}
```

Answer:

```
int oddOne(int x) {
   if (x == 0) return 0;
   if (x % 2 == 0) return 10 * oddOne(x/10) + x % 10;
   return 10* oddOne(x/10) + 1;
}
```

Problem 170   Write a function called *oddOneOut* that returns the result of removing the rightmost odd digit in a positive integer parameter.

For example, a program that uses the function *oddOneOut* follows.

```
int main() {
   cout << oddOneOut(19682) << endl;   // prints 1682
   cout << oddOneOut(2) << endl;       // prints 2
   return 0;
}
```

Answer:

```
int oddOneOut(int x) {
   if (x == 0) return 0;
   if (x % 2 == 1) return x/10;
   return 10 * oddOneOut(x/10) + x % 10;
}
```

Problem 171   Write a function called *eveNine* that returns the result of turning all even digits in a positive integer parameter to 9.

For example, a program that uses the function *eveNine* follows.

```
int main() {
    cout << eveNine(19683) << endl;   // prints 19993
    cout << eveNine(3) << endl;       // prints 3
    return 0;
}
```

Answer:

```
int eveNine(int x) {
    if (x == 0) return 0;
    if (x % 2 != 0) return 10 * eveNine(x/10) + x % 10;
    return 10* eveNine(x/10) + 9;
}
```

Problem 172   Write a function called *evenOut* that returns the result of removing the rightmost even digit in a positive integer parameter.

For example, a program that uses the function *evenOut* follows.

```
int main() {
    cout << evenOut(19683) << endl;   // prints 1963
    cout << evenOut(2) << endl;       // prints 0
    return 0;
}
```

Answer:

```
int evenOut(int x) {
    if (x == 0) return 0;
    if (x % 2 == 0) return x/10;
    return 10 * evenOut(x/10) + x % 10;
}
```

Problem 173   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It reads the entries in a 2-dimensional array with 4 rows and 4 columns from the user.

2. It prints (all) rows that have the greatest sum.

Here is an example of how the program should work:

```
Give me the entries of a 4 x 4 array:
0 0 0 -1
1 2 3 4
1 1 1 1
2 3 3 2

Largest rows:
1 2 3 4
2 3 3 2
```

Answer:

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

int main() {
    int x[4][4];
    cout << "Give me the entries of a 4 x 4 array:" << endl;
```

```
    for (int i = 0; i < 4; i++)
       for (int j = 0; j < 4; j++) cin >> x[i][j];

    int sums[4] = {0, 0, 0 ,0 };
    for (int i = 0; i < 4; i++)
       for (int j = 0; j < 4; j++) sums[i] += x[i][j];

    int max = sums[0];
    for (int i = 1; i < 4; i++)
       if (sums[i] > max) max = sums[i];

    cout << "Largest rows\n";
    for (int i = 0; i < 4; i++) {
       if (sums[i] == max) {
          for (int j = 0; j < 4; j++) cout << x[i][j] << " ";
          cout << endl;
       }
    }
}
```

Problem 174   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It reads the entries in a 2-dimensional array with 5 rows and 3 columns from the user.

2. It prints the last row that has an even sum.

Here is an example of how the program should work:

```
Give me the entries of a 5 x 3 array:
0 0 0
1 2 3
1 1 1
3 3 3
1 1 1

Last row with even sum:
1 2 3
```

Answer:

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

int main() {
   int x[5][3];
   cout << "Give me the entries of a 5 x 3 array:" << endl;
   for (int i = 0; i < 5; i++)
      for (int j = 0; j < 3; j++) cin >> x[i][j];

   int sums[5] = {0, 0, 0, 0, 0};
   for (int i = 0; i < 5; i++)
      for (int j = 0; j < 3; j++) sums[i] += x[i][j];

   cout << "Last row with even sum: \n";
   for (int i = 4; i >= 0; i--) {
      if (sums[i] % 2 == 0) {
         for (int j = 0; j < 3; j++) cout << x[i][j] << " ";
         cout << endl;
         return 0;
```

```
        }
    }
    return 0;
}
```

Problem 175   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It reads the entries in a 2-dimensional array with 4 rows and 4 columns from the user.

2. It prints (all) columns that have the greatest sum.

Here is an example of how the program should work:

```
Give me the entries of a 4 x 4 array:
0 0 0 -1
1 2 3 4
1 1 1 1
2 3 3 2

Largest columns:
0 3 1 3
```

Answer:

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

int main() {
    int x[4][4];
    cout << "Give me the entries of a 4 x 4 array:" << endl;
    for (int i = 0; i < 4; i++)
        for (int j = 0; j < 4; j++) cin >> x[i][j];

    int sums[4] = {0, 0, 0 ,0 };
    for (int i = 0; i < 4; i++)
        for (int j = 0; j < 4; j++) sums[j] += x[i][j];

    int max = sums[0];
    for (int i = 1; i < 4; i++)
        if (sums[i] > max) max = sums[i];

    cout << "Largest columns\n";
    for (int j = 0; j < 4; j++) {
        if (sums[j] == max) {
            for (int i = 0; i < 4; i++) cout << x[i][j] << " ";
            cout << endl;
        }
    }
}
```

Problem 176   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It reads the entries in a 2-dimensional array with 5 rows and 3 columns from the user.

2. It prints the last column that has an even sum.

Here is an example of how the program should work:

```
Give me the entries of a 5 x 3 array:
```

```
0 0 0
1 2 3
1 1 1
3 3 3
1 2 0

Last column with even sum:
0 2 1 3 2
```

Answer:

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

int main() {
    int x[5][3];
    cout << "Give me the entries of a 5 x 3 array:" << endl;
    for (int i = 0; i < 5; i++)
        for (int j = 0; j < 3; j++) cin >> x[i][j];

    int sums[5] = {0, 0, 0, 0, 0};
    for (int i = 0; i < 5; i++)
        for (int j = 0; j < 3; j++) sums[j] += x[i][j];

    cout << "Last column  with even sum: \n";
    for (int i = 2; i >= 0; i--) {
        if (sums[i] % 2 == 0) {
            for (int j = 0; j < 5; j++) cout << x[j][i] << " ";
            cout << endl;
            return 0;
        }
    }
    return 0;
}
```

Problem 177   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It reads (from the user) the entries in a 2-dimensional array with 5 rows and 5 columns.

2. It prints (all) rows that have the property that entries increase as we move along their columns.

Here is an example of how the program should work:

```
Give me the entries of a 5 x 5 array:
0 0 0 0 0
1 2 3 4 5
1 5 6 7 99
2 -1 3 4 5
5 4 3 2 1

Increasing rows:
1 2 3 4 5
1 5 6 7 99
```

Answer:

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

```cpp
int main() {
   int x[5][5];
   cout << "Give me the entries of a 5 x 5 array:" << endl;
   for (int i = 0; i < 5; i++)
      for (int j = 0; j < 5; j++) cin >> x[i][j];

   cout << "Increasing rows\n";
   for (int i = 0; i < 5; i++) {
      bool ok = true;
      for (int j = 1; j < 5; j++)
         if (x[i][j] <= x[i][j - 1]) ok = false;
      if (ok) {
         for (int j = 0; j < 5; j++) cout << x[i][j] << " ";
         cout << endl;
      }
   }
}
```

Problem 178 Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It reads (from the user) the entries in a 2-dimensional array with 5 rows and 5 columns.

2. It prints (all) columns that have the property that entries increase as we move down their rows.

Here is an example of how the program should work:

```
Give me the entries of a 5 x 5 array:
0 1 5   10   10
0 2 4   11   20
0 3 3    9   21
0 4 2   12   41
0 5 1   13   99

Increasing columns:
1 2 3 4 5
10 20 21 41 99
```

Answer:

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

int main() {
   int x[5][5];
   cout << "Give me the entries of a 5 x 5 array:" << endl;
   for (int i = 0; i < 5; i++)
      for (int j = 0; j < 5; j++) cin >> x[i][j];

   cout << "Increasing columns\n";
   for (int j = 0; j < 5; j++) {
      bool ok = true;
      for (int i = 1; i < 5; i++)
         if (x[i][j] <= x[i -1][j]) ok = false;
      if (ok) {
         for (int i = 0; i < 5; i++) cout << x[i][j] << " ";
         cout << endl;
      }
   }
}
```

Problem 179   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It reads (from the user) the entries in a 2-dimensional array with 5 rows and 5 columns.

2. It prints (all) rows that have the property that entries decrease as we move along their columns.

Here is an example of how the program should work:

```
Give me the entries of a 5 x 5 array:
0 0 0 0 0
1 2 3 4 5
501 5 306 107 99
2 -1 -3 -4 -5
5 4 3 2 1

Decreasing rows:
2 -1 -3 -4 -5
5 4 3 2 1
```

Answer:

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

int main() {
   int x[5][5];
   cout << "Give me the entries of a 5 x 5 array:" << endl;
   for (int i = 0; i < 5; i++)
      for (int j = 0; j < 5; j++) cin >> x[i][j];

   cout << "Decreasing rows\n";
   for (int i = 0; i < 5; i++) {
      bool ok = true;
      for (int j = 1; j < 5; j++)
         if (x[i][j] >= x[i][j - 1]) ok = false;
      if (ok) {
         for (int j = 0; j < 5; j++) cout << x[i][j] << " ";
         cout << endl;
      }
   }
}
```

Problem 180   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It reads (from the user) the entries in a 2-dimensional array with 5 rows and 5 columns.

2. It prints (all) columns that have the property that entries decrease as we move down their rows.

Here is an example of how the program should work:

```
Give me the entries of a 5 x 5 array:
0 1 5   10  99
0 2 4   11  41
0 3 3    9  21
0 4 2   12  20
0 5 1   13  10

Decreasing columns:
5 4 3 2 1
99 41 21 20 10
```

Answer:

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

int main() {
    int x[5][5];
    cout << "Give me the entries of a 5 x 5 array:" << endl;
    for (int i = 0; i < 5; i++)
        for (int j = 0; j < 5; j++) cin >> x[i][j];

    cout << "Decreasing columns\n";
    for (int j = 0; j < 5; j++) {
        bool ok = true;
        for (int i = 1; i < 5; i++)
            if (x[i][j] >= x[i -1][j]) ok = false;
        if (ok) {
            for (int i = 0; i < 5; i++) cout << x[i][j] << " ";
            cout << endl;
        }
    }
}
```

Problem 181   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It asks the user to enter an integer n that is between 1 and 21.

2. It terminates if the user supplies an illegal value for n.

3. It prints out a triangular picture with n rows like the one shown in the example (below). The triangle has a vertical left edge and a horizontal bottom edge. Odd numbered rows of the triangle are made from the letter A and even numbered rows with the letter B, as in the example.

Here is an example of how the program should work:

```
Give me an integer between 1 and 21:    9
A
BB
AAA
BBBB
AAAAA
BBBBBB
AAAAAAA
BBBBBBBB
AAAAAAAAA
```

Answer:

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

int main() {
    int n;
    cout << "Give me an integer between 1 and 21:";
    cin >> n;

    if (n < 1 || n > 21) return 0;
    for (int r = 0; r < n; r++) {
        for (int c = 0; c <= r; c++)
            cout << (char) ('A' + r % 2);
```

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

Problem 182   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It asks the user to enter an integer n that is between 1 and 23.

2. It terminates if the user supplies an illegal value for n.

3. It prints out a triangular picture with n rows like the one shown in the example (below). The triangle has a vertical right edge and a horizontal top edge. Odd numbered rows of the triangle are made from the letter x and even numbered rows with the letter y, as in the example.

Here is an example of how the program should work:

```
Give me an integer between 1 and 23:    5
xxxxx
 yyyy
  xxx
   yy
    x
```

Answer:

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

int main() {
    int n;
    cout << "Give me an integer between 1 and 23:";
    cin >> n;

    if (n < 1 || n > 23) return 0;
    for (int r = 0; r < n; r++) {
        for (int c = 0; c < n; c++)
            if (c < r) cout << " ";
            else cout << (char) ('x' + r % 2);
        cout << endl;
    }
}
```

Problem 183   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It asks the user to enter an integer n that is between 1 and 16.

2. It terminates if the user supplies an illegal value for n.

3. It prints out a triangular picture with n rows like the one shown in the example (below). The triangle has a vertical left edge and a horizontal bottom edge. Odd numbered columns of the triangle are made from the letter A and even numbered columns with the letter B, as in the example.

Here is an example of how the program should work:

```
Give me an integer between 1 and 16:    6
A
AB
ABA
ABAB
ABABA
ABABAB
```

Answer:

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

int main() {
    int n;
    cout << "Give me an integer between 1 and 16:";
    cin >> n;

    if (n < 1 || n > 16) return 0;
    for (int r = 0; r < n; r++) {
        for (int c = 0; c <= r; c++)
            cout << (char) ('A' + c % 2);
        cout << endl;
    }
}
```

Problem 184   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It asks the user to enter an integer n that is between 1 and 18.

2. It terminates if the user supplies an illegal value for n.

3. It prints out a triangular picture with n rows like the one shown in the example (below). The triangle has a vertical right edge and a horizontal top edge. Odd numbered columns of the triangle are made from the letter x and even numbered columns with the letter y, as in the example.

Here is an example of how the program should work:

```
Give me an integer between 1 and 18:   5
xyxyx
 yxyx
  xyx
   yx
    x
```

Answer:

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

int main() {
    int n;
    cout << "Give me an integer between 1 and 18:";
    cin >> n;

    if (n < 1 || n > 18) return 0;
    for (int r = 0; r < n; r++) {
        for (int c = 0; c < n; c++)
            if (c < r) cout << " ";
            else cout << (char) ('x' + c % 2);
        cout << endl;
    }
}
```

Problem 185   Write **title lines** for the functions that are called by the following main program. **Do not supply the blocks for the functions.**

```
int main() {
    int x = 1, y = 10, z = 19;
    double b[5] = {1.9, 2.3, 3.0};
    int d[2][2] = {{1,2},{3,4}};

    b[1] = divide(z, y);                  // (a) sets b[1] to quotient 2
    reset(d[1][1], x);                    // (b) replaces d[1][1] by value of x
    cout << bigRow(d, 2, 2);              // (c) prints biggest row: 3 4
    printAll(b, 3);                       // (d) prints array: 1.9 2.3 3.0
    cout << add(d[0][0], b[2]) << endl;   // (e) prints the sum 4
    return 0;
}
```

(a) Title line for **divide**.

Answer:

```
double divide(int z, int y)
```

(b) Title line for **reset**.

Answer:

```
void reset(int &x, int y)
```

(c) Title line for **bigRow**.

Answer:

```
string bigRow(int d[][2], int r, int c)
```

(d) Title line for **printAll**.

Answer:

```
void printAll(double b[], int cap)
```

(e) Title line for **add**.

Answer:

```
int add(int x, double y)
```

Problem 186   Consider the following C++ program.

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

string fun(int x) {
    string ans = "9876543210";
    if (x <= 10) return "0";
    if ((x <= 30) || (x > 10000)) return ans.substr(x % 10);
    if ((x >= 0) && (x < 100)) return "x+1";
    return ans.substr(x%4, x%4);
}

int nuf(int &x) {
    cout << x << endl;
    x = x * x - 3;
    return x;
}
```

```
int main() {
    int x = 2;
    cout << fun(23) << endl;      // line (a)
    cout << fun(233) << endl;     // line (b)
    cout << fun(2333) << endl;    // line (c)
    nuf(x);                               // line (d)
    cout << nuf(x) << endl;       // line (e)
}
```

(a) What is the output at line (a)?

Answer:

6543210

(b) What is the output at line (b)?

Answer:

8

(c) What is the output at line (c)?

Answer:

8

(d) What is the output at line (d)?

Answer:

2

(e) What is the output at line (e)?

Answer:

1
-2

Problem 187   Write a function called *smallRow* that calculates and returns the smallest possible sum of entries of any row in a 2-dimensional array.

For example, a program that uses the function *smallRow* follows.

```
int main() {
    int x[2][3] = {{3, 1, 4}, {1, 5, 9}};
    cout << smallRow (x, 2, 3) << endl;
      // from the 2-d array x that has size 2 x 3, find the smallest row sum
      // output will be 8 since row #0 contains 3, 1 and 4 is smallest.
    return 0;
}
```

Answer:

```
int smallRow(int x[][3], int r, int c) {
    int ans;
    for (int row = 0; row < r; row++) {
        int sum = 0;
        for (int col = 0; col < c; col++)
            sum += x[row][col];
        if (row == 0 || sum < ans) ans = sum;
    }
    return ans;
}
```

Problem 188   Write a function called *bond* that changes any sequence of digits 006 to 007 in a positive integer parameter.

    For example, a program that uses the function *bond* follows.

```
int main() {
   cout << bond(4006) << endl;         // prints 4007
   cout << bond(4006006) << endl;      // prints 4007007
   cout << bond(106) << endl;          // prints 106
   cout << bond(1006) + 1 << endl;     // prints 1008
   return 0;
}
```

Answer:

```
int bond(int x) {
   if (x <= 0) return 0;
   if (x % 1000 == 6) return 1000 * bond(x / 1000) + 7;
   return 10 * bond(x / 10) + x % 10;
}
```

Problem 189   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It asks the user to enter an integer n that is between 1 and 24.

2. It terminates if the user supplies an illegal value for n.

3. It prints out a triangular picture with n rows like the one shown in the example (below). The triangle has a vertical right edge and a horizontal top edge. The right edge is formed from the letter A, next to it is a vertical line formed from the letter B, then one formed from the letter C and so on. The top edge is also formed from the letter A, just below it is a line formed from the letter B and so on as in the example.

Here is an example of how the program should work:

```
Give me an integer between 1 and 24:    8
AAAAAAAA
 BBBBBBA
  CCCCBA
   DDCBA
    DCBA
     CBA
      BA
       A
```

Answer:

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

int main() {
   int n;
   char picture[24][24];
   cout << "Give me an integer between 1 and 24:";
   cin >> n;

   if (n < 1 || n > 24) {
      cout << "Illegal." << endl;
      return 0;
   }
   int mid = (n + 1) / 2;
```

```
      char letter = 'A';
      for (int step = 0; step < mid; step++) {
         for (int r = step; r < n - step; r++)
            for (int c = step; c < n - step; c++)
               picture[r][c] = letter;
         letter++;
      }

      for (int r = 0; r <n; r++) {
         for (int c = 0; c < n; c++)
            if (r <= c) cout << picture[r][c];
            else cout << " ";
         cout << endl;
      }
}
```

Problem 190   Write **title lines** for the functions that are called by the following main program. **Do not supply the blocks for the functions.**

```
int main() {
   int x = 0, y = 1, z = 2;
   double b[3] = {1.9, 2.3, 3.0};
   int d[2][2] = {{1,2},{3,4}};

   x = diffTwo(y, b[0]);              // (a) sets x to approx difference 1
   swap(d[1][1], x);                  // (b) swaps x with value of d[1][1]
   cout << biggest(d, 2, 2);          // (c) prints biggest row: 3 4
   printThree(b);                     // (d) prints three entries: 1.9 2.3 3.0
   summit(b[2], d[0][0]);             // (e) prints the sum 4
   return 0;
}
```

(a) Title line for **diffTwo**.

Answer:

```
int diffTwo(int y, double z)
```

(b) Title line for **swap**.

Answer:

```
void swap(int &x, int &y)
```

(c) Title line for **biggest**.

Answer:

```
string biggest(int d[][2], int r, int c)
```

(d) Title line for **printThree**.

Answer:

```
void printThree(double b[])
```

(e) Title line for **summit**.

Answer:

```
void summit(double x, int y)
```

Problem 191   Consider the following C++ program.

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

string fun(int x) {
    string ans = "0123456789";
    if (x <= 0) return "0";
    if ((x <= 10) || (x > 10000)) return ans.substr(x % 10);
    if ((x >= 0) && (x < 100)) return "x+1";
    return ans.substr(x%4, x%4);
}

int nuf(int &x) {
  cout << x << endl;
  x = x * x;
  return x - 6;
}

int main() {
    int x = 4;
    cout << fun(3) << endl;      // line (a)
    cout << fun(32) << endl;     // line (b)
    cout << fun(323) << endl;    // line (c)
    nuf(x);                      // line (d)
    cout << nuf(x) << endl;      // line (e)
}
```

(a) What is the output at line (a)?

Answer:

3456789

(b) What is the output at line (b)?

Answer:

x+1

(c) What is the output at line (c)?

Answer:

345

(d) What is the output at line (d)?

Answer:

4

(e) What is the output at line (e)?

Answer:

16
250

Problem 192   Write a function called *smallCol* that calculates and returns the smallest possible sum of entries of any column in a 2-dimensional array.

For example, a program that uses the function *smallCol* follows.

```
int main() {
    int x[2][3] = {{3, 1, 4}, {1, 5, 9}};
    cout << smallCol (x, 2, 3) << endl;
      // from the 2-d array x that has size 2 x 3, find the smallest col sum
      // output will be 4  since col #0 contains 3 and 1 is smallest.
    return 0;
}
```

Answer:

```
int smallCol(int x[][3], int r, int c) {
    int ans;
    for (int col = 0; col < c; col++) {
        int sum = 0;
        for (int row = 0; row < r; row++)
            sum += x[row][col];
        if (col == 0 || sum < ans) ans = sum;
    }
    return ans;
}
```

Problem 193   Write a function called *bond* that inserts a digit 0 before any digit pair 07 in a positive integer parameter.

For example, a program that uses the function *bond* follows.

```
int main() {
    cout << bond(407) << endl;        // prints 4007
    cout << bond(401) << endl;        // prints 401
    cout << bond(40707) << endl;      // prints 4007007
    cout << bond(107) + 1 << endl;    // prints 1008
    return 0;
}
```

Answer:

```
int bond(int x) {
    if (x <= 0) return 0;
    if (x % 100 == 7) return 100 * bond(x / 10) + 7;
    return 10 * bond(x / 10) + x % 10;
}
```

Problem 194   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It asks the user to enter an integer n that is between 1 and 23.

2. It terminates if the user supplies an illegal value for n.

3. It prints out a triangular picture with n rows like the one shown in the example (below). The triangle has a vertical right edge and a horizontal bottom edge. The right edge is formed from the letter A, next to it is a vertical line formed from the letter B, then one formed from the letter C and so on. The bottom edge is also formed from the letter A, just above it is a line formed from the letter B and so on as in the example.

Here is an example of how the program should work:

```
Give me an integer between 1 and 23:    9
        A
       BA
      CBA
     DCBA
```

```
    EDCBA
   DDDCBA
  CCCCCBA
 BBBBBBBA
AAAAAAAAA
```

Answer:

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

int main() {
   int n;
   char picture[23][23];
   cout << "Give me an integer between 1 and 23:";
   cin >> n;

   if (n < 1 || n > 23) {
      cout << "Illegal." << endl;
      return 0;
   }
   int mid = (n + 1) / 2;

   char letter = 'A';
   for (int step = 0; step < mid; step++) {
      for (int r = step; r < n - step; r++)
         for (int c = step; c < n - step; c++)
            picture[r][c] = letter;
      letter++;
   }

   for (int r = 0; r <n; r++) {
      for (int c = 0; c < n; c++)
         if ((r + c) >= (n - 1)) cout << picture[r][c];
         else cout << " ";
      cout << endl;
   }
}
```

Problem 195   Write **title lines** for the functions that are called by the following main program. **Do not supply the blocks for the functions.**

```
int main() {
   int x = 0, y = 1, z = 2;
   double b[3] = {1.9, 2.3, 3.0};
   int d[2][2] = {{1,2},{3,4}};

   cout << twoD(y, b[0]) << endl;       // (a) prints difference: 0.9
   y = addUp(d[1][1], y);               // (b) sets y to sum 4 + 1
   cout << firstElt(d, 2, 2);           // (c) prints last element: 1
   b[2] = av(b, 3);                     // (d) sets as average
   setOne(b[2], d[0][0]);               // (e) sets both to 1
   return 0;
}
```

(a) Title line for **twoD**.

Answer:

```
double twoD(int a, double b)
```

(b) Title line for **addUp**.

Answer:

```
int addUp(int x, int y)
```

(c) Title line for **firstElt**.

Answer:

```
int firstElt(int d[][2], int r, int c)
```

(d) Title line for **av**.

Answer:

```
double av(double b[], int cap)
```

(e) Title line for **setOne**.

Answer:

```
void setOne(double &x, int &y)
```

Problem 196   Consider the following C++ program.

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

string fun(int x) {
   string ans = "0123456789";
   if (x <= 10) return "0";
   if ((x <= 30) || (x > 10000)) return ans.substr(x % 10);
   if ((x >= 0) && (x < 100)) return "x+1";
   return ans.substr(x%4, x%4);
}

int nuf(int &x) {
  cout << x << endl;
  x = x * x;
  return x;
}

int main() {
   int x = 2;
   cout << fun(2) << endl;      // line (a)
   cout << fun(22) << endl;     // line (b)
   cout << fun(222) << endl;    // line (c)
   nuf(x);                      // line (d)
   cout << nuf(x) << endl;      // line (e)
}
```

(a) What is the output at line (a)?

Answer:

0

(b) What is the output at line (b)?

Answer:

23456789

(c) What is the output at line (c)?

Answer:

23

(d) What is the output at line (d)?

Answer:

2

(e) What is the output at line (e)?

Answer:

4
16

Problem 197   Write a function called *bigRow* that calculates and returns the biigest possible sum of entries of any row in a 2-dimensional array.

For example, a program that uses the function *bigRow* follows.

```
int main() {
    int x[2][3] = {{3, 1, 4}, {1, 5, 9}};
    cout << bigRow (x, 2, 3) << endl;
        // from the 2-d array x that has size 2 x 3, find the biggest row sum
        // output will be 15 since row #1 contains 1, 5 and 9 is biggest.
    return 0;
}
```

Answer:

```
int bigRow(int x[][3], int r, int c) {
    int ans;
    for (int row = 0; row < r; row++) {
        int sum = 0;
        for (int col = 0; col < c; col++)
            sum += x[row][col];
        if (row == 0 || sum > ans) ans = sum;
    }
    return ans;
}
```

Problem 198   Write a function called *bond* that the insert the digit 7 after any pair of zero digits in a positive integer parameter.

For example, a program that uses the function *bond* follows.

```
int main() {
    cout << bond(400) << endl;        // prints 4007
    cout << bond(401) << endl;        // prints 41
    cout << bond(4007) << endl;       // prints 40077
    cout << bond(400) + 1 << endl;    // prints 4008
    return 0;
}
```

Answer:

```
int bond(int x) {
    if (x <= 0) return 0;
    if (x % 100 == 0) return 1000 * bond(x / 100) + 7;
    return 10 * bond(x / 10) + x % 10;
}
```

Problem 199   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It asks the user to enter an integer n that is between 1 and 22.

2. It terminates if the user supplies an illegal value for n.

3. It prints out a triangular picture with n rows like the one shown in the example (below). The triangle has a vertical left edge and a horizontal top edge. The left edge is formed from the letter A, next to it is a vertical line formed from the letter B, then one formed from the letter C and so on. The top edge is also formed from the letter A, just below it is a line formed from the letter B and so on as in the example.

Here is an example of how the program should work:

```
Give me an integer between 1 and 22:   8
AAAAAAAA
ABBBBBBB
ABCCCCC
ABCDD
ABCD
ABC
AB
A
```

Answer:

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

int main() {
    int n;
    char picture[22][22];
    cout << "Give me an integer between 1 and 22:";
    cin >> n;

    if (n < 1 || n > 22) {
        cout << "Illegal." << endl;
        return 0;
    }
    int mid = (n + 1) / 2;

    char letter = 'A';
    for (int step = 0; step < mid; step++) {
        for (int r = step; r < n - step; r++)
            for (int c = step; c < n - step; c++)
                picture[r][c] = letter;
        letter++;
    }

    for (int r = 0; r <n; r++) {
        for (int c = 0; c < n; c++)
            if ((r + c) < n) cout << picture[r][c];
            else cout << " ";
        cout << endl;
    }
}
```

Problem 200   Write **title lines** for the functions that are called by the following main program. **Do not supply the blocks for the functions.**

```
int main() {
   double x = 0, y = 1, z = 2;
   int b[3] = {1, 2, 3};
   double d[2][2] = {{1.9,2},{3.9,4}};

   cout << add3(b[0], y, d[0][0]) << endl;// (a) prints sum: 3.9
   y = addUp(d[1][1], x) + 1;              // (b) sets y to sum 4.0 + 0 + 1
   cout << col(d, 2, 2, 0);                // (c) prints column 0 as: 1.9,3.9
   b[0] = min(b, 3);                       // (d) sets as min element
   decrease(b[2], d[0][0]);                // (e) decreases both by 1
   return 0;
}
```

(a) Title line for **add3**.

Answer:

```
double add3(int a, double b, double c)
```

(b) Title line for **addUp**.

Answer:

```
double addUp(double x, double y)
```

(c) Title line for **col**.

Answer:

```
string col(double d[][2], int r, int c, int colNumber)
```

(d) Title line for **min**.

Answer:

```
int min(int b[], int cap)
```

(e) Title line for **decrease**.

Answer:

```
void decrease(int &x, double &y)
```

Problem 201   Consider the following C++ program.

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

string fun(int x) {
   string ans = "0123456789";
   if (x <= 10) return "0";
   if ((x <= 30) || (x > 10000)) return ans.substr(x % 10);
   if ((x >= 0) && (x < 100)) return "x+1";
   return ans.substr(x%4, x%4);
}

int nuf(int &x) {
  cout << x << endl;
```

```
    x = x * x;
    return x;
}

int main() {
    int x = 4;
    cout << fun(3) << endl;      // line (a)
    cout << fun(33) << endl;     // line (b)
    cout << fun(333) << endl;    // line (c)
    nuf(x);                      // line (d)
    cout << nuf(x) << endl;      // line (e)
}
```

(a) What is the output at line (a)?

Answer:

0

(b) What is the output at line (b)?

Answer:

x+1

(c) What is the output at line (c)?

Answer:

1

(d) What is the output at line (d)?

Answer:

4

(e) What is the output at line (e)?

Answer:

16
256

Problem 202   Write a function called *bigCol* that calculates and returns the biigest possible sum of entries of any column in a 2-dimensional array.

For example, a program that uses the function *bigCol* follows.

```
int main() {
    int x[2][3] = {{3, 1, 4}, {1, 5, 9}};
    cout << bigCol (x, 2, 3) << endl;
      // from the 2-d array x that has size 2 x 3, find the biggest col sum
      // output will be 13 since col #2 contains 4 and 9 is biggest.
    return 0;
}
```

Answer:

```
int bigCol(int x[][3], int r, int c) {
    int ans;
    for (int col = 0; col < c; col++) {
        int sum = 0;
        for (int row = 0; row < r; row++)
```

```
            sum += x[row][col];
        if (col == 0 || sum > ans) ans = sum;
    }
    return ans;
}
```

Problem 203   Write a function called *bond* that the insert the digits 07 after each digit 0 in a positive integer
parameter.

   For example, a program that uses the function *bond* follows.

```
int main() {
    cout << bond(40) << endl;        // prints 4007
    cout << bond(41) << endl;        // prints 41
    cout << bond(400) << endl;       // prints 4007007
    cout << bond(10) + 1 << endl;    // prints 1008
    return 0;
}
```

Answer:

```
int bond(int x) {
    if (x <= 0) return 0;
    if (x % 10 == 0) return 1000 * bond(x / 10) + 7;
    return 10 * bond(x / 10) + x % 10;
}
```

Problem 204   Write a complete C++ program that does the following. (Programs that correctly carry out some
of the tasks will receive partial credit.)

1. It asks the user to enter an integer n that is between 1 and 21.

2. It terminates if the user supplies an illegal value for n.

3. It prints out a triangular picture with n rows like the one shown in the example (below). The triangle has a
vertical left edge and a horizontal bottom edge. The left edge is formed from the letter A, next to it is a vertical line
formed from the letter B, then one formed from the letter C and so on. The bottom edge is also formed from the
letter A, just above it is a line formed from the letter B and so on as in the example.

Here is an example of how the program should work:

```
Give me an integer between 1 and 21:    9
A
AB
ABC
ABCD
ABCDE
ABCDDD
ABCCCCC
ABBBBBBB
AAAAAAAAA
```

Answer:

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

int main() {
    int n;
    char picture[21][21];
    cout << "Give me an integer between 1 and 21:";
```

```
      cin >> n;

      if (n < 1 || n > 21) {
         cout << "Illegal." << endl;
         return 0;
      }
      int mid = (n + 1) / 2;

      char letter = 'A';
      for (int step = 0; step < mid; step++) {
         for (int r = step; r < n - step; r++)
            for (int c = step; c < n - step; c++)
               picture[r][c] = letter;
         letter++;
      }

      for (int r = 0; r <n; r++) {
         for (int c = 0; c < n; c++)
            if (r >= c) cout << picture[r][c];
            else cout << " ";
         cout << endl;
      }
}
```

Problem 205   Write **title lines** for the functions that are called by the following main program. **Do not supply the blocks for the functions.**

```
int main() {
   int x = 0, y = 1, z = 2;
   int b[3] = {1, 2, 3};
   double d[2][2] = {{1.9,2},{3.9,4}};

   cout << sum3(b[0], y, d[0][0]) << endl;// (a) prints sum: 3.9
   y = addUp(x, d[1][1]) + 1;             // (b) sets y to sum 0 + 4.0 + 1
   cout << col0(d, 2, 2);                 // (c) prints column as: 1.9,3.9
   b[0] = max(b, 3);                      // (d) sets as max element
   increase(b[2], d[0][0]);               // (e) increases both by 1
   return 0;
}
```

(a) Title line for **sum3**.

Answer:

```
double sum3(int a, int b, double c)
```

(b) Title line for **addUp**.

Answer:

```
int addUp(int x, double y)
```

(c) Title line for **col0**.

Answer:

```
string col0(double d[][2], int r, int c)
```

(d) Title line for **max**.

Answer:

```
int max(int b[], int cap)
```

(e) Title line for **increase**.

Answer:

```
void increase(int &x, double &y)
```

Problem 206   Consider the following C++ program.

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

string fun(int x) {
    string ans = "012345";
    if (x <= 0) return "";
    if ((x >= 30) && (x < 1000)) return ans.substr(x % 5);
    if ((x >= 0) || (x < 100)) return "xyz";
    return ans;
}

int up(int &x) {
  x += 3;
  cout << x << endl;
  return x - 1;
}

int main() {
    int x = 7;
    cout << fun(0) << endl;    // line (a)
    cout << fun(33) << endl;   // line (b)
    cout << fun(3003) << endl; // line (c)
    up(x);                     // line (d)
    cout << up(x) << endl;     // line (e)
}
```

(a) What is the output at line (a)?

Answer:

(b) What is the output at line (b)?

Answer:

345

(c) What is the output at line (c)?

Answer:

xyz

(d) What is the output at line (d)?

Answer:

10

(e) What is the output at line (e)?

Answer:

Problem 207   Write a function called *rowProd* that calculates and returns the product of the entries of a specified row of a 2-dimensional array.

For example, a program that uses the function *rowProd* follows.

```
int main() {
   int x[2][3] = {{3, 1, 4}, {1, 5, 9}};
   cout << rowProd (x, 2, 3, 1) << endl;
     // from the 2-d array x that has size 2 x 3, find the product of row 1
     // output will be 45 since row #1 contains 1, 5 and 9.
   return 0;
}
```

Answer:

```
int rowProd(int x[][3], int r, int c, int row) {
   int ans = 1;
   for (int j = 0; j < c; j++) ans *= x[row][j];
   return ans;
}
```

Problem 208   Write a function called *numOdd* that the returns the number of digits in a positive integer parameter that are odd.

For example, a program that uses the function *numOdd* follows.

```
int main() {
   cout << numOdd(777) << endl;        // prints 3
   cout << numOdd(747) << endl;        // prints 2
   cout << numOdd(42) << endl;         // prints 0
   return 0;
}
```

Answer:

```
int numOdd(int x) {
   if (x <= 0) return 0;
   if (x % 2 != 0) return numOdd(x / 10) + 1;
   return numOdd(x / 10);
}
```

Problem 209   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It asks the user to enter an odd integer n that is between 1 and 19.

2. It repeatedly reads n from the user until the supplied value of n is legal.

3. It prints out a triangular picture (as shown in the diagram, but with n characters in the first row). Reading from the right, along each row the characters to be used is the sequence of uppercase letters A, B, C, ..., and so on.

Here is an example of how the program should work:

```
Give me an odd integer between 1 and 19:   7
GFEDCBA
 EDCBA
  CBA
   A
```

Answer:

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

int main() {
    int n;
    cout << "Give me an odd integer between 1 and 19:";
    cin >> n;

    while (n < 1 || n > 19 || (n % 2) != 1) {
        cout << "Illegal.  Try again: ";
        cin >> n;
    }

    int mid = n / 2;

    for (int r = mid; r >= 0; r--) {
        char out = 'A' + 2 * r;
        for (int c = 0; c < n; c++)
            if ((c >= mid - r) && (c <= mid + r)) {
                cout << out;
                out--;
            }
            else cout << " ";
        cout << endl;
    }
}
```

Problem 210   Write **title lines** for the functions that are called by the following main program. **Do not supply the blocks for the functions.**

```
int main() {
    int x = 0, y = 1, z = 2;
    double b[3] = {1.9, 2.3, 3.0};
    int d[2][2] = {{1,2},{3,4}};

    cout << twoD(b[0], y) << endl;       // (a) prints difference: 0.9
    y = addUp(x, d[1][1]);               // (b) sets y to sum 0 + 4
    cout << lastElt(d, 2, 2);            // (c) prints last element: 4
    b[0] = average(b, 3);                // (d) sets as average
    setZero(b[2], d[0][0]);             // (e) sets both to 0
    return 0;
}
```

(a) Title line for **twoD**.

Answer:

```
double twoD(double a, int b)
```

(b) Title line for **addUp**.

Answer:

```
int addUp(int x, int y)
```

(c) Title line for **lastElt**.

Answer:

```
int lastElt(int d[][2], int r, int c)
```

(d) Title line for **average**.

Answer:

```
double average(double b[], int cap)
```

(e) Title line for **setZero**.

Answer:

```
void setZero(double &x, int &y)
```


Problem 211   Consider the following C++ program.

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

string fun(int x) {
    string ans = "9876543210";
    if (x <= 0) return "5";
    if ((x >= 30) && (x < 1000)) return ans.substr(x % 10);
    if ((x >= 0) || (x < 100)) return "1+x";
    return ans + ans;
}

int up(int &x) {
  x++;
  cout << x << endl;
  return x - 2;
}

int main() {
    int x = 2;
    cout << fun(0) << endl;     // line (a)
    cout << fun(33) << endl;    // line (b)
    cout << fun(3003) << endl; // line (c)
    up(x);                      // line (d)
    cout << up(x) << endl;      // line (e)
}
```

(a) What is the output at line (a)?

Answer:

5

(b) What is the output at line (b)?

Answer:

6543210

(c) What is the output at line (c)?

Answer:

1+x

(d) What is the output at line (d)?

Answer:

(e) What is the output at line (e)?

Answer:

4
2

Problem 212   Write a function called *colProd* that calculates and returns the product of the entries of a specified column in a 2-dimensional array.

     For example, a program that uses the function *colProd* follows.

```
int main() {
   int x[2][3] = {{3, 2, 4}, {1, 5, 9}};
   cout << colProd (x, 2, 3, 1) << endl;
     // from the 2-d array x that has size 2 x 3, find the product of column 1
     // output will be 10 since col #1 contains 2 and 5.
   return 0;
}
```

Answer:

```
int colProd(int x[][3], int r, int c, int col) {
   int ans = 1;
   for (int i = 0; i < r; i++) ans *= x[i][col];
   return ans;
}
```

Problem 213   Write a function called *numBig* that the returns the number of digits in a positive integer parameter that are greater than or equal to 7.

     For example, a program that uses the function *numBig* follows.

```
int main() {
   cout << numBig(777) << endl;        // prints 3
   cout << numBig(747) << endl;        // prints 2
   cout << numBig(41) << endl;         // prints 0
   return 0;
}
```

Answer:

```
int numBig(int x) {
   if (x <= 0) return 0;
   if (x % 10 >= 7) return numBig(x / 10) + 1;
   return numBig(x / 10);
}
```

Problem 214   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It asks the user to enter an odd integer n that is between 1 and 23.

2. It repeatedly reads n from the user until the supplied value of n is legal.

3. It prints out a triangular picture (as shown in the diagram, but with n characters in the last row). Reading from the right, along each row the characters to be used is the sequence of uppercase letters A, B, C, ..., and so on.

Here is an example of how the program should work:

```
Give me an odd integer between 1 and 23:    7
   A
  CBA
 EDCBA
GFEDCBA
```

Answer:

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

int main() {
   int n;
   cout << "Give me an odd integer between 1 and 23:";
   cin >> n;

   while (n < 1 || n > 23 || (n % 2) != 1) {
      cout << "Illegal.  Try again: ";
      cin >> n;
   }

   int mid = n / 2;

   for (int r = 0; r <= mid; r++) {
      char out = 'A' + 2 * r;
      for (int c = 0; c < n; c++)
         if ((c >= mid - r) && (c <= mid + r)) {
            cout << out;
            out--;
         }
         else cout << " ";
      cout << endl;
   }
}
```

Problem 215   Write **title lines** for the functions that are called by the following main program. **Do not supply the blocks for the functions.**

```cpp
int main() {
   int x = 0, y = 1, z = 2;
   double b[3] = {1.9, 2.3, 3.0};
   int d[2][2] = {{1,2},{3,4}};

   x = diffTwo(b[0], y);                   // (a) sets x to approx difference 1
   swap(x, d[1][1]);                       // (b) swaps x with value of d[1][1]
   cout << biggest(d, 2, 2);               // (c) prints biggest row: 3 4
   printTwo(b);                            // (d) prints two entries: 1.9 2.3
   cout << summit(b[2], d[0][0]) << endl;  // (e) prints the sum 4
   return 0;
}
```

(a) Title line for **diffTwo**.

Answer:

```cpp
int diffTwo(double z, int y)
```

(b) Title line for **swap**.

Answer:

```
void swap(int &x, int &y)
```

(c) Title line for **biggest**.

Answer:

```
string biggest(int d[][2], int r, int c)
```

(d) Title line for **printTwo**.

Answer:

```
void printTwo(double b[])
```

(e) Title line for **summit**.

Answer:

```
double summit(double x, int y)
```

Problem 216   Consider the following C++ program.

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

string fun(int x) {
    string ans = "0123456789";
    if (x <= 0) return "4";
    if ((x >= 30) && (x < 1000)) return ans.substr(x % 7);
    if ((x >= 0) || (x < 100)) return "x11";
    return ans;
}

int up(int &x) {
  x--;
  cout << x << endl;
  return x - 1;
}

int main() {
    int x = 5;
    cout << fun(0) << endl;     // line (a)
    cout << fun(33) << endl;    // line (b)
    cout << fun(3003) << endl;  // line (c)
    up(x);                      // line (d)
    cout << up(x) << endl;      // line (e)
}
```

(a) What is the output at line (a)?

Answer:

4

(b) What is the output at line (b)?

Answer:

56789

(c) What is the output at line (c)?

Answer:

```
x11
```

(d) What is the output at line (d)?

Answer:

```
4
```

(e) What is the output at line (e)?

Answer:

```
3
2
```

Problem 217   The following C++ program has errors at the lines marked a,b,c,d, and e. For each answer write a single line of C++ that fixes the errors in the corresponding line.

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

void main(double x, string s[]) {    // line a

    ofstream f;
    f.open("outputFile");
    if (f == 0) return f;            // line b

    while (1 = 1) {                  // line c

       x -- 1;                       // line d

       if (x < 0) return 0;
       cout <<  s[x] endl;           // line e

    }

    return 0;
}
```

(a) Correct line (a):

Answer:

```cpp
int main(int x, char  *y[]) {        // line a
```

(b) Correct line (b):

Answer:

```cpp
    if (f == 0) return 0;            // line b
```

(c) Correct line (c):

Answer:

```cpp
    while (1 == 1) {                 // line c
```

(d) Correct line (d):

Answer:

```cpp
       x -= 1;                       // line d
```

(e) Correct line (e):

Answer:

```
    cout <<  y[x] << endl;          // line e
```

Problem 218   Write a function called *rowSum* that calculates and returns the sum of the entries of a specified row of a 2-dimensional array.

For example, a program that uses the function *rowSum* follows.

```
int main() {
   int x[2][3] = {{3, 1, 4}, {1, 5, 9}};
   cout << rowSum (x, 2, 3, 1) << endl;
     // from the 2-d array x that has size 2 x 3, find the sum of row 1
     // output will be 15 since row #1 contains 1, 5 and 9.
   return 0;
}
```

Answer:

```
int rowSum(int x[][3], int r, int c, int row) {
   int ans = 0;
   for (int j = 0; j < c; j++) ans += x[row][j];
   return ans;
}
```

Problem 219   Write a function called *numEven* that the returns the number of digits in a positive integer parameter that are even.

For example, a program that uses the function *numEven* follows.

```
int main() {
   cout << numEven(444) << endl;       // prints 3
   cout << numEven(414) << endl;       // prints 2
   cout << numEven(91) << endl;        // prints 0
   return 0;
}
```

Answer:

```
int numEven(int x) {
   if (x <= 0) return 0;
   if (x % 2 == 0) return numEven(x / 10) + 1;
   return numEven(x / 10);
}
```

Problem 220   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It asks the user to enter an odd integer n that is between 1 and 25.

2. It repeatedly reads n from the user until the supplied value of n is legal.

3. It prints out a triangular picture (as shown in the diagram, but with n characters in the first row). Along each row the characters to be used is the sequence of uppercase letters A, B, C, ..., and so on.

Here is an example of how the program should work:

```
Give me an odd integer between 1 and 25:   7
ABCDEFG
 ABCDE
  ABC
   A
```

Answer:

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

int main() {
   int n;
   cout << "Give me an odd integer between 1 and 25:";
   cin >> n;

   while (n < 1 || n > 25 || (n % 2) != 1) {
      cout << "Illegal.  Try again: ";
      cin >> n;
   }

   int mid = n / 2;

   for (int r = mid; r >= 0; r--) {
      char out = 'A';
      for (int c = 0; c < n; c++)
         if ((c >= mid - r) && (c <= mid + r)) {
            cout << out;
            out++;
         }
         else cout << " ";
      cout << endl;
   }
}
```

Problem 221   Write **title lines** for the functions that are called by the following main program. **Do not supply the blocks for the functions.**

```
int main() {
   int x = 0, y = 1, z = 2;
   double b[5] = {1.9, 2.3, 3.0};
   int d[2][2] = {{1,2},{3,4}};

   x = subtract(z, y);                    // (a) sets x to difference 1
   reset(x, d[1][1]);                     // (b) replaces x by value of d[1][1]
   bigRow(d, 2, 2);                       // (c) prints biggest row: 3 4
   cout << printAll(b, 3) << endl;        // (d) prints array: 1.9 2.3 3.0
   cout << add(b[2], d[0][0]) << endl;    // (e) prints the sum 4
   return 0;
}
```

(a) Title line for **subtract**.

Answer:

```
int subtract(int z, int y)
```

(b) Title line for **reset**.

Answer:

```
void reset(int &x, int y)
```

(c) Title line for **bigRow**.

Answer:

```
void bigRow(int d[][2], int r, int c)
```

(d) Title line for **printAll**.

Answer:

```
string printAll(double b[], int cap)
```

(e) Title line for **add**.

Answer:

```
double add(double x, int y)
```

Problem 222   Consider the following C++ program.

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

string fun(int x) {
    string ans = "0123456789";
    if (x <= 0) return "0";
    if ((x >= 30) && (x < 1000)) return ans.substr(x % 10);
    if ((x >= 0) || (x < 100)) return "x+1";
    return ans + ans;
}

int up(int &x) {
  x++;
  cout << x << endl;
  return x;
}

int main() {
    int x = 4;
    cout << fun(0) << endl;      // line (a)
    cout << fun(33) << endl;     // line (b)
    cout << fun(3003) << endl;   // line (c)
    up(x);                       // line (d)
    cout << up(x) << endl;       // line (e)
}
```

(a) What is the output at line (a)?

Answer:

0

(b) What is the output at line (b)?

Answer:

3456789

(c) What is the output at line (c)?

Answer:

x+1

(d) What is the output at line (d)?

Answer:

(e) What is the output at line (e)?

Answer:

Problem 223   The following C++ program has errors at the lines marked a,b,c,d, and e. For each answer write a single line of C++ that fixes the errors in the corresponding line.

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

int main(int x, string y[]) {         // line a

    while (0 < x < 5) {                // line b

        cout >> y[x - 1] >> end;       // line c

        x =- 1;                        // line d

    }
    ifstream f;
    f.open("inputFile");
    if (f = 0) return -1;              // line e

    return 0;
}
```

(a) Correct line (a):

Answer:

```cpp
int main(int x, char  *y[]) {         // line a
```

(b) Correct line (b):

Answer:

```cpp
    while (0 < x && x < 5) {           // line b
```

(c) Correct line (c):

Answer:

```cpp
        cout << y[x - 1] << endl;      // line c
```

(d) Correct line (d):

Answer:

```cpp
        x -= 1;                        // line d
```

(e) Correct line (e):

Answer:

```cpp
    if (f == 0) return -1;             // line e
```

Problem 224   Write a function called *colSum* that calculates and returns the sum of the entries of a specified column in a 2-dimensional array.

For example, a program that uses the function *colSum* follows.

```
int main() {
   int x[2][3] = {{3, 1, 4}, {1, 5, 9}};
   cout << colSum (x, 2, 3, 1) << endl;
     // from the 2-d array x that has size 2 x 3, find the sum of column 1
     // output will be 6 since col #1 contains 1 and 5.
   return 0;
}
```

Answer:

```
int colSum(int x[][3], int r, int c, int col) {
   int ans = 0;
   for (int i = 0; i < r; i++) ans += x[i][col];
   return ans;
}
```

Problem 225   Write a function called *num4* that the returns the number of digits in a positive integer parameter that are equal to 4.

For example, a program that uses the function *num4* follows.

```
int main() {
   cout << num4(444) << endl;        // prints 3
   cout << num4(414) << endl;        // prints 2
   cout << num4(81) << endl;         // prints 0
   return 0;
}
```

Answer:

```
int num4(int x) {
   if (x <= 0) return 0;
   if (x % 10 == 4) return num4(x / 10) + 1;
   return num4(x / 10);
}
```

Problem 226   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It asks the user to enter an odd integer n that is between 1 and 21.

2. It repeatedly reads n from the user until the supplied value of n is legal.

3. It prints out a triangular picture (as shown in the diagram, but with n characters in the last row). Along each row the characters to be used is the sequence of uppercase letters A, B, C, ..., and so on.

Here is an example of how the program should work:

```
Give me an odd integer between 1 and 21:   7
   A
  ABC
 ABCDE
ABCDEFG
```

Answer:

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

int main() {
   int n;
   cout << "Give me an odd integer between 1 and 21:";
   cin >> n;

   while (n < 1 || n > 21 || (n % 2) != 1) {
      cout << "Illegal.  Try again: ";
      cin >> n;
   }

   int mid = n / 2;

   for (int r = 0; r <= mid; r++) {
      char out = 'A';
      for (int c = 0; c < n; c++)
         if ((c >= mid - r) && (c <= mid + r)) {
            cout << out;
            out++;
         }
         else cout << " ";
      cout << endl;
   }
}
```

Problem 227   Write **title lines** for the functions that are called by the following main program. **Do not supply the blocks for the functions.**

```
int main() {
   double b[5] = {1.9, 2.3, 3.0, 4.4, 5.7};
   double d = 3.1415926;
   int x = 2;
   cout << decimalPart(b[1]) << endl;    // (a) prints 0.3
   medianPosition(b, 5);                  // (b) prints 2, the index of the median
   swap1(d, b[1]);                        // (c) swaps b[1] with d
   swap2(b, 3, x);                        // (d) swaps entry b[3] with b[x]
   cout << sqrt(d) << endl;               // (e) prints the square root of d
   return 0;
}
```

(a) Title line for **decimalPart** as called at the line marked (a).

Answer:

```
double decimalPart(double x)
```

(b) Title line for **medianPosition** as called at the line marked (b).

Answer:

```
void medianPosition(double x[], int cap)
```

(c) Title line for **swap1** as called at the line marked (c).

Answer:

```
void swap1(double &x, double &y)
```

(d) Title line for **swap2** as called at the line marked (d).

Answer:

```
void swap2(double x[], int y, int z)
```

(e) Title line for **sqrt** as called at the line marked (e).

Answer:

```
double sqrt(double x)
```

Problem 228   Consider the following C++ program.

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

string fun(int x) {
    if (x <= 0) return "";
    if (x >= 9 && x % 2 == 1) return "x+1";
    if (x >= 9 || x % 3 == 0) return "x+2";
    return "5";
}

int rec(int x) {
  if (x < 100) return x/5;
  return rec(x / 10) + rec(x % 100);
}

int main() {
    cout << fun(-3) << endl;    // line (a)
    cout << fun(33) << endl;    // line (b)
    cout << rec(36) << endl;    // line (c)
    cout << rec(-555) << endl;  // line (d)
    cout << rec(987) << endl;   // line (e)
}
```

(a) What is the output at line (a)?

Answer:

(b) What is the output at line (b)?

Answer:

x+1

(c) What is the output at line (c)?

Answer:

7

(d) What is the output at line (d)?

Answer:

-111

(e) What is the output at line (e)?

Answer:

Problem 229   Write a function called *dropEvens* that forms a new number from a positive integer parameter by dropping all even digits. In case all digits are even or a negative parameter is given an answer of 0 is to be returned.

For example, a program that uses the function *dropEvens* follows.

```
int main() {
   cout << dropEvens(1245);  // prints 15
   cout << dropEvens(19683); // prints 193
   cout << dropEvens(0);     // prints 0
   cout << dropEvens(-10);   // prints 0
   return 0;
}
```

Answer:

```
int dropEvens(int x) {
   if (x <= 0) return 0;
   if (x % 2 == 0) return dropEvens(x/10);
   return 10 * dropEvens(x/10) + x % 10;
}
```

Problem 230   Write a function called *randChange* that selects one entry at random in an array of integers and changes it to a random negative integer that lies between −99 and −1 inclusive. (You must use an appropriate standard C++ function to generate all random numbers.)

For example, a program that uses the function *randChange* follows.

```
int main() {
   int x[6] = {3, 1, 4, 1, 5, 9};
   randChange(x, 6);
   for (int i = 0; i <= 5; i++)
      cout << x[i] << " ";     // might print  3 1 -17 1 5 9
   cout << endl;
   return 0;
}
```

Answer:

```
void randChange(int x[], int cap) {
   int r = rand() % cap;
   x[r] = -(1 + rand() % 99);
}
```

Problem 231   Suppose that a C++ program called *prog.cpp* is compiled and correctly executed on venus with the instructions:

```
venus> g++ prog.cpp
venus> a.out file1 file2 file3
```

For each of the following short segments of the program *prog.cpp* write exactly what output is produced. Each answer should consist of those symbols printed by the given part of the program and nothing else.

(i)

```
   char a = 'b';
   cout << a << endl;
```

Answer:

```
b
```

(ii)

```
    char a = 'b';
    while (a <= 'f') {
        cout << a - 'a';
        a = a + 1;
    }
```

Answer:

```
12345
```

(iii)

```
int main(int argc, char *argv[]) {
    cout << argv[1];
```

Answer:

```
file1
```

(iv)

```
    string x = "Easy Question";
    cout << x.substr(1,2);
```

Answer:

```
as
```

(v)

```
    string x = "Easy Question";
    cout << x.rfind("E");
```

Answer:

```
0
```

Problem 232   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It asks the user to enter an integer n that is between 1 and 20.

2. It repeatedly reads n from the user until the supplied value of n is legal.

3. It prints out a square picture (as shown in the diagram, but with n rows) that uses the uppercase letters A, B, C, ... in sequence, to form an outer stepeter of As that contains a stepeter of Bs, that contains a permimeter of Cs, and so on.

Here is an example of how the program should work:

```
Give me an integer between 1 and 20:    7
AAAAAAA
ABBBBBA
ABCCCBA
ABCDCBA
ABCCCBA
ABBBBBA
AAAAAAA
```

Answer:

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

int main() {
    char picture[20][20];

    int n = 0;
    while (n < 1 || n > 20) {
        cout << "Give me an integer between 1 and 20:    ";
        cin >> n;
    }
    int mid = (n + 1) / 2;

    for (int step = 0; step <  mid; step++) {
        char x = 'A' + step;
        for (int r = step; r < n -step; r++)
         for (int c = step; c < n -step; c++)
            picture[r][c] = x;
    }

    for (int r = 0; r < n; r++) {
      for (int c = 0; c < n; c++)
          cout << picture[r][c];
      cout << endl;
    }
    return 0;
}
```

Problem 233   Write **title lines** for the functions that are called by the following main program. **Do not supply the blocks for the functions.**

```
int main() {
    bool b[5] = {true, true, false, true, true};
    int x = 2;
    cout << isTrue(b[1 + 2]) << endl;     // (a) prints true
    allTrue(b, 5);                        // (b) prints False
    swap1(b, 3, x);                       // (d) swaps entry b[3] with b[x]
    swap2(b[x], b[x+1]);                  // (d) swaps entries
    cout << sqrt(x) << endl;              // (e) prints the square root of x
    return 0;
}
```

(a) Title line for **isTrue** as called at the line marked (a).

Answer:

```
bool isTrue(bool x)
```

(b) Title line for **allTrue** as called at the line marked (b).

Answer:

```
void allTrue(bool x[], int cap)
```

(c) Title line for **swap1** as called at the line marked (c).

Answer:

```
void swap1(bool x[], int y, int z)
```

(d) Title line for **swap2** as called at the line marked (d).

Answer:

```
void swap2(bool &x, bool &y)
```

(e) Title line for **sqrt** as called at the line marked (e).

Answer:

```
double sqrt(int x)
```

Problem 234   Consider the following C++ program.

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

double fun(int x) {
    if (x <= 0) return sqrt((double) (-x));
    if (x >= 9 && x % 2 == 1) return x+1.0;
    if (x >= 9 || x % 3 == 0) return x+2.0;
    return 3.0;
}

int rec(int x) {
    if (x < 100) return x/3;
    return rec(x / 10) + rec(x % 100);
}

int main() {
    cout << fun(-3) << endl;    // line (a)
    cout << fun(33) << endl;    // line (b)
    cout << rec(36) << endl;    // line (c)
    cout << rec(-555) << endl;  // line (d)
    cout << rec(987) << endl;   // line (e)
}
```

(a) What is the output at line (a)?

Answer:

```
1.73205
```

(b) What is the output at line (b)?

Answer:

```
34
```

(c) What is the output at line (c)?

Answer:

```
12
```

(d) What is the output at line (d)?

Answer:

```
-185
```

(e) What is the output at line (e)?

Answer:

Problem 235   Write a function called *onlyEvens* that forms a new number from a positive integer parameter by dropping all odd digits. In case all digits are odd or a negative parameter is given an answer of 0 is to be returned.

For example, a program that uses the function *onlyEvens* follows.

```
int main() {
   cout << onlyEvens(1245);  // prints 24
   cout << onlyEvens(19683); // prints 68
   cout << onlyEvens(0);      // prints 0
   cout << onlyEvens(-10);   // prints 0
   return 0;
}
```

Answer:

```
int onlyEvens(int x) {
   if (x <= 0) return 0;
   if (x % 2 != 0) return onlyEvens(x/10);
   return 10*onlyEvens(x/10) + x% 10;
}
```

Problem 236   Write a function called *randChange* that selects one entry at random in a 2-dimensional array of integers and changes it to -17. (You must use an appropriate standard C++ function to generate all random numbers.)

For example, a program that uses the function *randChange* follows.

```
int main() {
   int x[2][3] = {{3, 1, 4}, {1, 5, 9}};
   randChange(x, 2, 3);
   for (int i = 0; i <= 1; i++)
    for (int j = 0; j <= 2; j++)
      cout << x[i][j] << " ";     // might print  3 1 -17 1 5 9
   cout << endl;
   return 0;
}
```

Answer:

```
void randChange(int x[][3], int rows, int cols) {
   int r = rand()%rows;
   int c = rand()%cols;
    x[r][c] = -17;
}
```

Problem 237   Suppose that a C++ program called *prog.cpp* is compiled and correctly executed on venus with the instructions:

```
venus> g++ prog.cpp
venus> a.out file1 file2 file3
```

For each of the following short segments of the program *prog.cpp* write exactly what output is produced. Each answer should consist of those symbols printed by the given part of the program and nothing else.

(i)

```
char a = 'a';
cout << a << endl;
```

Answer:

a

(ii)

```
char a = 'a';
while (a <= 'f') {
   cout << 'a' - a;
   a = a + 1;
}
```

Answer:

0-1-2-3-4-5

(iii)

```
int main(int argc, char *argv[]) {
   cout << argc;
```

Answer:

4

(iv)

```
string x = "Easy Question";
cout << x.substr(6, 0);
```

Answer:

(v)

```
string x = "Easy Question";
cout << x.rfind("s");
```

Answer:

8

Problem 238   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It asks the user to enter an integer n that is between 1 and 20.

2. It repeatedly reads n from the user until the supplied value of n is legal.

3. It prints out a square picture (as shown in the diagram, but with n rows) that uses the uppercase letters O and X in sequence, to form an outer perimeter of Os that contains a perimeter of Xs, that contains a permimeter of Os, and so on.

Here is an example of how the program should work:

```
Give me an integer between 1 and 20:   7
OOOOOOO
OXXXXXO
OXOOOXO
OXOXOXO
OXOOOXO
OXXXXXO
OOOOOOO
```

Answer:

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

int main() {
    char picture[20][20];

    int n = 0;
    while (n < 1 || n > 20) {
        cout << "Give me an integer between 1 and 20:    ";
        cin >> n;
    }
    int mid = (n + 1) / 2;

    for (int perim = 0; perim <  mid; perim++) {
        char x = 'O';
        if (perim % 2 == 1) x = 'X';
        for (int r = perim; r < n -perim; r++)
         for (int c = perim; c < n -perim; c++)
            picture[r][c] = x;
    }

    for (int r = 0; r < n; r++) {
      for (int c = 0; c < n; c++)
         cout << picture[r][c];
      cout << endl;
    }
    return 0;
}
```

Problem 239   Write **title lines** for the functions that are called by the following main program. **Do not supply the blocks for the functions.**

```cpp
int main() {
    string b[5] = {"1.9", "2.3", "3.0", "4.4", "5.7"};
    double d = 3.1415926;
    int x = 2;
    cout << decimalPart(b[1]) << endl;    // (a) prints 0.3
    medianPosition(b, 5);                 // (b) prints 2, the index of the median
    swap1(d, b[1]);                       // (c) changes b[1] and d
    swap2(b, 3, x);                       // (d) swaps entry b[3] with b[x]
    cout << sqrt(d) << endl;              // (e) prints the square root of d
    return 0;
}
```

(a) Title line for **decimalPart** as called at the line marked (a).
Answer:

```cpp
double decimalPart(string s)
```

(b) Title line for **medianPosition** as called at the line marked (b).
Answer:

```cpp
void medianPosition(string x[], int cap)
```

(c) Title line for **swap1** as called at the line marked (c).
Answer:

```
void swap1(double &d, string &s)
```

(d) Title line for **swap2** as called at the line marked (d).

Answer:

```
void swap2(string x[], int i, int j)
```

(e) Title line for **sqrt** as called at the line marked (e).

Answer:

```
double sqrt(double d)
```

Problem 240   Consider the following C++ program.

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

string fun(char x) {
   if (x <= 'k') return "";
   if (x >= 'l' && x <= 't') return "x++";
   if (x >= 'p') return "x-1";
   return "20";
}

int rec(int x) {
  if (x < 1000) return x/5;
  return rec(x / 10) + rec(x % 100);
}

int main() {
   cout << fun('m') << endl;   // line (a)
   cout << fun('p') << endl;   // line (b)
   cout << rec(666) << endl;   // line (c)
   cout << rec(-555) << endl; // line (d)
   cout << rec(2013) << endl;  // line (e)
}
```

(a) What is the output at line (a)?

Answer:

```
x++
```

(b) What is the output at line (b)?

Answer:

```
x++
```

(c) What is the output at line (c)?

Answer:

```
133
```

(d) What is the output at line (d)?

Answer:

```
-111
```

(e) What is the output at line (e)?

Answer:

Problem 241   Write a function called *upEvens* that forms a new number from a non-negative integer parameter by increasing all even digits. In case a negative parameter is given an answer of 0 is to be returned.

For example, a program that uses the function *upEvens* follows.

```
int main() {
   cout << upEvens(1245);  // prints 1355
   cout << upEvens(19683); // prints 19793
   cout << upEvens(0);     // prints 1
   cout << upEvens(-10);   // prints 0
   return 0;
}
```

Answer:

```
int upEvens(int x) {
   if (x < 0) return 0;
   if (x < 10)
      if (x % 2 == 0) return x + 1;
      else return x;
   return 10*upEvens(x/10) + upEvens(x%10);
}
```

Problem 242   Write a function called *randSelect* that selects one row at random in a 2-dimensional array of integers and returns the sum of the entries in that row. (You must use an appropriate standard C++ function to generate all random numbers.)

For example, a program that uses the function *randSelect* follows.

```
int main() {
   int x[2][3] = {{3, 1, 4}, {1, 5, 9}};
   cout << randSelect(x, 2, 3);  // might print 8 if the first row is selected
   cout << endl;
   return 0;
}
```

Answer:

```
int randSelect(int x[][3], int rows, int cols) {
   int r = rand() % rows;
   int ans = 0;
   for (int c = 0; c < cols; c++)
      ans += x[r][c];
   return ans;
}
```

Problem 243   Suppose that a C++ program called *prog.cpp* is compiled and correctly executed on venus with the instructions:

```
venus> g++ prog.cpp
venus> a.out file1 file2 file3
```

For each of the following short segments of the program *prog.cpp* write exactly what output is produced. Each answer should consist of those symbols printed by the given part of the program and nothing else.

(i)

```
    char a = 'a';
    cout << (char) (a + 2) << endl;
```

Answer:

c

(ii)

```
    char a = 'b';
    while ((a - 'a') <= 5) {
        cout << a;
        a = a + 1;
    }
```

Answer:

bcdef

(iii)

```
int main(int argc, char *argv[]) {
    cout << argv[2];
```

Answer:

file2

(iv)

```
    string x = "Easy Question";
    cout << x.substr(3,2);
```

Answer:

y

(v)

```
    string x = "Easy Question";
    cout << x.rfind("e");
```

Answer:

7

Problem 244   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It asks the user to enter an integer n that is between 1 and 20.

2. It exits if the user enters an illegal value for n.

3. It prints out a triangular picture (as shown in the diagram, but with n rows) that uses the uppercase letters A, B, C, ... in sequence, to form the diagonal sides of the triangle. The vertical straight side should be at the right.

Here is an example of how the program should work:

```
Give me an integer between 1 and 20:    7
      A
     AB
    ABC
   ABCD
  ABCDE
 ABCDEF
ABCDEFG
```

Answer:

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

int main() {
    int n = 0;
    cout << "Give me an integer between 1 and 20:   ";
    cin >> n;
    if (n < 1 || n > 20) return 0;

    for (int r = n; r >= 1; r--) {
        char x = 'A';
        for (int c = 1; c <= n; c++) {
            if (c < r) cout << " ";
            else {
                cout << x;
                x++;
            }
        }
        cout << endl;
    }
    return 0;
}
```

Problem 245   Write **title lines** for the functions that are called by the following main program. **Do not supply the blocks for the functions.**

```cpp
int main() {
    char b[5] = {'t', 't', 'f', 't', 't'};
    int x = 2;
    cout << isT(b[1 + 2]) << endl;      // (a) prints true
    allTrue(b, 5);                      // (b) prints false
    swap1(b, 3, x);                     // (d) swaps entry b[3] with b[x]
    swap2(b[x], b[x+1]);                // (d) swaps entries
    cout << sqrt(x) << endl;            // (e) prints the square root of x
    return 0;
}
```

(a) Title line for **isT** as called at the line marked (a).

Answer:

```cpp
bool isT(char x)
```

(b) Title line for **allTrue** as called at the line marked (b).

Answer:

```cpp
void allTrue(char b[], int cap)
```

(c) Title line for **swap1** as called at the line marked (c).

Answer:

```cpp
void swap1(char b[], int i, int j)
```

(d) Title line for **swap2** as called at the line marked (d).

Answer:

```
void swap2(char &x, char &y)
```

(e) Title line for **sqrt** as called at the line marked (e).

Answer:

```
double sqrt(int x)
```

Problem 246   Consider the following C++ program.

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

double fun(double x) {
   if (x <= 0.0) return sqrt(-x);
   if (x >= 9.0 && x <= 100.0) return x+1.0;
   if (x >= 90.0 || x >= 5.0) return x+2.0;
   return 3.0;
}

int rec(int x) {
  if (x < 100) return x/6;
  return rec(x / 10) + rec(x % 100);
}

int main() {
    cout << fun(-4.0) << endl;    // line (a)
    cout << fun(99.0) << endl;    // line (b)
    cout << fun(2.0)  << endl;    // line (c)
    cout << rec(-666) << endl;    // line (d)
    cout << rec(987) << endl;     // line (e)
}
```

(a) What is the output at line (a)?

Answer:

2

(b) What is the output at line (b)?

Answer:

100

(c) What is the output at line (c)?

Answer:

3

(d) What is the output at line (d)?

Answer:

-111

(e) What is the output at line (e)?

Answer:

30

Problem 247   Write a function called *downOdds* that forms a new number from a non-negative integer parameter by decreasing all odd digits. In case a negative parameter is given an answer of 0 is to be returned.

For example, a program that uses the function *downOdds* follows.

```
int main() {
   cout << downOdds(3245);  // prints 2244
   cout << downOdds(19683); // prints 8682
   cout << downOdds(1);     // prints 0
   cout << downOdds(-10);   // prints 0
   return 0;
}
```

Answer:

```
int downOdds(int x) {
   if (x <= 0) return 0;
   if (x < 10)
      if (x % 2 == 1) return x - 1;
      else return x;
   return 10*downOdds(x/10) + downOdds(x % 10);
}
```

Problem 248   Write a function called *randSelect* that selects one column at random in a 2-dimensional array of integers and returns the product of the entries in that row. (You must use an appropriate standard C++ function to generate all random numbers.)

For example, a program that uses the function *randSelect* follows.

```
int main() {
   int x[2][3] = {{3, 1, 4}, {1, 5, 9}};
   cout << randSelect(x, 2, 3);  // might print 36 if the last col is selected
   cout << endl;
   return 0;
}
```

Answer:

```
int randSelect(int x[][3], int rows, int cols) {
   int c = rand() % cols;
   int ans = 1;
   for (int r = 0; r < rows; r++)
      ans *= x[r][c];
   return ans;
}
```

Problem 249   Suppose that a C++ program called *prog.cpp* is compiled and correctly executed on venus with the instructions:

```
venus> g++ prog.cpp
venus> a.out file1 file2 file3
```

For each of the following short segments of the program *prog.cpp* write exactly what output is produced. Each answer should consist of those symbols printed by the given part of the program and nothing else.

(i)

```
   char c = 'a';
   cout << (char) (c + 3) << endl;
```

Answer:

d

(ii)

```
   char a = 'a';
   while (('a' - a) <= 3) {
      cout << 'a';
      a = a - 1;
   }
```

Answer:

aaaa

(iii)

```
int main(int argc, char *argv[]) {
   cout << argv[argc - 1];
```

Answer:

file3

(iv)

```
   string x = "Easy Question";
   cout << x.length();
```

Answer:

13

(v)

```
   string x = "Easy Question";
   cout << x.find("e");
```

Answer:

7

Problem 250   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It asks the user to enter an integer n that is between 1 and 25.

2. It exits if the user enters an illegal value for n.

3. It prints out a downward pointing triangular picture (as shown in the diagram, but with n rows) that uses the lowercase letters a, b, c, ... in sequence, to form the diagonal sides of the triangle.

Here is an example of how the program should work:

```
Give me an integer between 1 and 25:    7
abcdefg
 abcdef
  abcde
   abcd
    abc
     ab
      a
```

Answer:

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

int main() {
    int n = 0;
    cout << "Give me an integer between 1 and 25:  ";
    cin >> n;
    if (n < 1 || n > 20) return 0;

    for (int r = n; r >= 1; r--) {
        for (int c = 1; c <= n; c++) {
            if (c < r) cout << " ";
            else cout << (char) ('a' + c - r);
        }
        cout << endl;
    }
    return 0;
}
```

Problem 251   Write **title lines** for the functions that are called by the following main program. **Do not supply the blocks for the functions.**

```cpp
int main() {
    int b[5] = {9, 3, 0, 4, 7};
    int x = 17;
    cout << decimalPart(3.14159) << endl;    // (a) prints 0.14159
    median(b, 5);                            // (b) prints 4, the median entry
    swap1(x, b[1]);                          // (c) swaps b[1] with x
    swap2(b, 3, 4);                          // (d) swaps entry b[3] with b[4]
    cout << sqrt(5, 10, 12) << endl; // (e) prints "Hello" for any input values
    return 0;
}
```

(a) Title line for **decimalPart** as called at the line marked (a).

Answer:

```cpp
double decimalPart(double x)
```

(b) Title line for **median** as called at the line marked (b).

Answer:

```cpp
void median(int a[], int cap)
```

(c) Title line for **swap1** as called at the line marked (c).

Answer:

```cpp
void swap1(int &x, int &y)
```

(d) Title line for **swap2** as called at the line marked (d).

Answer:

```cpp
void swap2(int x[], int a, int b)
```

(e) Title line for **sqrt** as called at the line marked (e).

Answer:

```
string sqrt(int a, int b, int c)
```

Problem 252   Consider the following C++ program.

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

int fun(int x) {
   if (x <= 0) return 10;
   if (x >= 9 && x % 2 == 1) return x + 1;
   if (x >= 9 || x % 3 == 0) return x + 2;
   return 5;
}

int rec(int x) {
  if (x < 100) return x/10;
  return rec(x / 10) + rec(x % 100);
}

int main() {
    cout << fun(-3) << endl;    // line (a)
    cout << fun(33) << endl;    // line (b)
    cout << rec(36) << endl;    // line (c)
    cout << rec(-666) << endl; // line (d)
    cout << rec(987) << endl;   // line (e)
}
```

(a) What is the output at line (a)?

Answer:

10

(b) What is the output at line (b)?

Answer:

34

(c) What is the output at line (c)?

Answer:

3

(d) What is the output at line (d)?

Answer:

-66

(e) What is the output at line (e)?

Answer:

17

Problem 253   Write a function called *multiDigit* that prints a new number formed from a positive integer parameter by printing each odd digit once and each even digit twice. If a negative parameter is given, it should print the word *Idiot* and if 0 is entered it should do nothing.

For example, a program that uses the function *multiDigit* follows.

```
int main() {
   multiDigit(1245); cout << endl;   // prints 122445
   multiDigit(19683); cout << endl; // prints 1966883
   multiDigit(0); cout << endl;      // prints
   multiDigit(-10); cout << endl;    // prints Idiot
   return 0;
}
```

Answer:

```
void multiDigit(int n) {
   if (n < 0) cout << "Idiot";
   else if (n == 0) return;
   else {
      multiDigit(n / 10);
      if (n % 2 == 0) cout << n % 10;
      cout << n % 10;
   }
}
```

Problem 254   Write a function called *randFill* that fills the entries of an array with random negative integers that lie between -99 and -1 inclusive. (Use an appropriate C++ function to generate the random numbers.)

For example, a program that uses the function follows.

```
int main() {
   int x[4];
   randFill(x, 4);
   for (int i = 0; i <= 3; i++)
      cout << x[i] << endl;      // prints 4 random negative numbers
   return 0;
}
```

Answer:

```
void randFill(int a[], int c) {
   for (int i = 0; i < c; i++)
      a[i] = rand() % 99 - 99;
}
```

Problem 255   Suppose that a C++ program called *prog.cpp* is compiled and correctly executed on venus with the instructions:

```
venus> g++ prog.cpp
venus> a.out input1.txt input2 out.txt
```

For each of the following short segments of the program *prog.cpp* write exactly what output is produced. Each answer should consist of those symbols printed by the given part of the program and nothing else.

(i)

```
   int x = 4, y = 10;
   cout << (x/y + 1.0) << endl;
```

Answer:

1.0

(ii)

```
    char x = 'a';
    while (x <= 'f') {
        cout << (char) (x + 1);
        x = x + 1;
    }
```

Answer:

```
bcdefg
```

(iii)

```
    cout << 'a' - 'd';
```

Answer:

```
-3
```

(iv)

```
    string x = "Easy Question";
    cout << x.substr(1,2);
```

Answer:

```
as
```

(v)

```
int main(int argc, char *argv[]) {
    cout << argc;
```

Answer:

```
4
```

Problem 256   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It asks the user to enter an integer n that is between 1 and 20.

2. It repeatedly reads n from the user until the supplied value of n is legal.

3. It prints out a triangular picture (as shown in the diagram, but with n rows) that uses the uppercase letters A, B, C, ... in sequence, and if necessary returns to the letter A after any Z.

Here is an example of how the program should work:

```
Give me an integer between 1 and 20:    6
     A
    BC
   DEF
  GHIJ
 KLMNO
PQRSTU
```

Answer:

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

int main() {
    int n;
```

```
      cout << "Give me an integer between 1 and 20:   ";
      cin >> n;

      while (n < 1  || n > 20) {
         cout << "That is out of range. Give me an integer between 1 and 20:   ";
         cin >> n;
      }

      char x = 'A';
      for (int i = 1; i <= n; i++) {
         for (int j = 1; j <= n; j++)
            if ((i + j) <= n) cout << " ";
            else {
                cout << x;
                x = x + 1;
                if (x > 'Z') x = 'A';
            }
         cout << endl;
      }
}
```

Problem 257   Write **title lines** for the functions that are called by the following main program. **Do not supply the blocks for the functions.**

```
int main() {
   int a[5] = {9, 3, 0, 4, 7};
   int x = 17;
   cout << reducedFraction(2, 6) << endl;   // (a) prints 1/3
   swap1(a[1], a[2]);                         // (b) swaps a[1] with a[2]
   swap2(x, a, 3);                            // (c) swaps entry a[3] with x
   median(5, 4, 6);                           // (d) prints 5, the median entry
   cout << sqrt(5, 10, 12, 14) << endl; // (e) prints 25 for any input values
   return 0;
}
```

(a) Title line for **reducedFraction** as called at the line marked (a).
Answer:

```
string reducedFraction(int a, int b)
```

(b) Title line for **swap1** as called at the line marked (b).
Answer:

```
void swap1(int &x, int &y)
```

(c) Title line for **swap2** as called at the line marked (c).
Answer:

```
void swap2(int &x, int a[], int i)
```

(d) Title line for **median** as called at the line marked (d).
Answer:

```
void median(int a, int b, int c)
```

(e) Title line for **sqrt** as called at the line marked (e).
Answer:

```
int sqrt(int a, int b, int c, int d)
```

Problem 258 Consider the following C++ program.

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

int fun(int x) {
   if (x <= 0) return 10;
   if (x >= 9 && x % 2 == 1) return x + 1;
   if (x >= 9 || x % 3 == 0) return x + 2;
   return 5;
}

int rec(int x) {
  if (x < 100) return x/10;
  return rec(x / 10) + rec(x % 100);
}

int main() {
    cout << fun(-6) << endl;   // line (a)
    cout << fun(63) << endl;   // line (b)
    cout << rec(66) << endl;   // line (c)
    cout << rec(-747) << endl; // line (d)
    cout << rec(876) << endl;  // line (e)
}
```

(a) What is the output at line (a)?

Answer:

10

(b) What is the output at line (b)?

Answer:

64

(c) What is the output at line (c)?

Answer:

6

(d) What is the output at line (d)?

Answer:

-74

(e) What is the output at line (e)?

Answer:

15

Problem 259 Write a function called *multiDigit* that prints a new number formed from a positive integer parameter by printing each odd digit twice and each even digit once. If a negative parameter is given, it should print the word *Negative* and if 0 is entered it should do nothing.

For example, a program that uses the function *multiDigit* follows.

```
int main() {
   multiDigit(1245); cout << endl;   // prints 112455
   multiDigit(19683); cout << endl; // prints 11996833
   multiDigit(0); cout << endl;       // prints
   multiDigit(-10); cout << endl;    // prints Negative
   return 0;
}
```

Answer:

```
void multiDigit(int n) {
   if (n < 0) cout << "Negative";
   else if (n == 0) return;
   else {
      multiDigit(n / 10);
      if (n % 2 != 0) cout << n % 10;
      cout << n % 10;
   }
}
```

Problem 260   Write a function called *randFill* that fills the entries of an array with random integers between 1 and a specified maximum value. (Use an appropriate C++ function to generate the random numbers.)

For example, a program that uses the function follows.

```
int main() {
   int x[4];
   int max = 999;
   randFill(x, 4, max);
   for (int i = 0; i <= 3; i++)
      cout << x[i] << endl;      // prints 4 random numbers between 1 and 999
   return 0;
}
```

Answer:

```
void randFill(int a[], int c, int max) {
   for (int i = 0; i < c; i++)
      a[i] = rand() % max + 1;
}
```

Problem 261   Suppose that a C++ program called *prog.cpp* is compiled and correctly executed on venus with the instructions:

```
venus> g++ prog.cpp
venus> a.out input1.txt input2 out.txt
```

For each of the following short segments of the program *prog.cpp* write exactly what output is produced. Each answer should consist of those symbols printed by the given part of the program and nothing else.

(i)

```
   int x = 8, y = 10;
   cout << ((x + 1.0)/y) << endl;
```

Answer:

```
0.9
```

(ii)

```
char x = 'f';
while (x <= 'a') {
    cout << (char) (x + 1);
    x = x + 1;
}
```

Answer:

(iii)

```
cout << 'e' - 'd';
```

Answer:

1

(iv)

```
string x = "Easy Question";
cout << x.substr(2,1);
```

Answer:

s

(v)

```
int main(int argc, char *argv[]) {
    cout << argv[2];
```

Answer:

input2

Problem 262   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It asks the user to enter an integer n that is between 1 and 9.

2. It repeatedly reads n from the user until the supplied value of n is legal.

3. It prints out a triangular picture (as shown in the diagram, but with n rows) that uses the lowercase letters a, b, c, ... in sequence, and if necessary continues with uppercase letter starting at A after any z.

Here is an example of how the program should work:

```
Give me an integer between 1 and 9:    7
a
bc
def
ghij
klmno
pqrstu
vwxyzAB
```

Answer:

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

int main() {
    int n;
    cout << "Give me an integer between 1 and 9:  ";
    cin >> n;

    while (n < 1  || n > 9) {
        cout << "That is out of range. Give me an integer between 1 and 9:  ";
        cin >> n;
    }

    char x = 'a';
    for (int i = 1; i <= n; i++) {
        for (int j = 1; j <= i; j++) {
            cout << x;
            x = x + 1;
            if (x > 'z') x = 'A';
        }
        cout << endl;
    }
}
```

Problem 263   Write **title lines** for the functions that are called by the following main program. **Do not supply the blocks for the functions.**

```
int main() {
    int b[5] = {9, 3, 0, 4, 7};
    int x = 17;
    cout << integerPart(3.14159) << endl;    // (a) prints 3
    swap1(x, b[1]);                          // (b) swaps b[1] with x
    swap2(b, 1, x);                          // (c) swaps b[1] with x
    median(x +1, x, x+2);                    // (d) prints 18 the median value
    cout << sqrt(5, 10, 12) << endl;  // (e) prints "Error" for any input values
    return 0;
}
```

(a) Title line for **integerPart** as called at the line marked (a).
Answer:

```
int integerPart(double x)
```

(b) Title line for **swap1** as called at the line marked (b).
Answer:

```
void swap1(int &a, int &b)
```

(c) Title line for **swap2** as called at the line marked (c).
Answer:

```
void swap2(int a[], int i, int &b)
```

(d) Title line for **median** as called at the line marked (d).
Answer:

```
void median(int a, int b, int c)
```

(e) Title line for **sqrt** as called at the line marked (e).

Answer:

```
string sqrt(int a, int b, int c)
```

Problem 264   Consider the following C++ program.

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

int fun(int x) {
   if (x <= 0) return 100;
   if (x >= 9 && x % 2 == 1) return x + 1;
   if (x >= 9 || x % 3 == 0) return x + 2;
   return 5;
}

int rec(int x) {
  if (x < 100) return x/10;
  return rec(x / 10) + rec(x % 100);
}

int main() {
   cout << fun(-144) << endl;   // line (a)
   cout << fun(92) << endl;    // line (b)
   cout << rec(92) << endl;    // line (c)
   cout << rec(-144) << endl; // line (d)
   cout << rec(678) << endl;  // line (e)
}
```

(a) What is the output at line (a)?

Answer:

100

(b) What is the output at line (b)?

Answer:

94

(c) What is the output at line (c)?

Answer:

9

(d) What is the output at line (d)?

Answer:

-14

(e) What is the output at line (e)?

Answer:

13

Problem 265   Write a function called *multiDigit* that prints a new number formed from a positive integer parameter by printing each odd digit twice and omitting all even digits. If a negative parameter is given, it should print the word *Done* and if 0 is entered it should do nothing.

    For example, a program that uses the function *multiDigit* follows.

```
int main() {
   multiDigit(1245); cout << endl;  // prints 1155
   multiDigit(19683); cout << endl; // prints 119933
   multiDigit(220); cout << endl;   // prints
   multiDigit(-10); cout << endl;   // prints Done
   return 0;
}
```

Answer:

```
void multiDigit(int n) {
   if (n < 0) cout << "Done";
   else if (n == 0) return;
   else {
      multiDigit(n / 10);
      if (n % 2 != 0) {
         cout << n % 10;
         cout << n % 10;
      }
   }
}
```

Problem 266   Write a function called *randFill* that fills the entries of an array with random two digit integers. (Use an appropriate C++ function to generate the random numbers.)

     For example, a program that uses the function follows.

```
int main() {
   int x[4];
   randFill(x, 4);
   for (int i = 0; i <= 3; i++)
      cout << x[i] << endl;      // prints 4 random two digit numbers
   return 0;
}
```

Answer:

```
void randFill(int a[], int c) {
   for (int i = 0; i < c; i++)
      a[i] = rand() % 90 + 10;
}
```

Problem 267   Suppose that a C++ program called *prog.cpp* is compiled and correctly executed on venus with the instructions:

```
venus> g++ prog.cpp
venus> a.out input1.txt input2 out.txt
```

For each of the following short segments of the program *prog.cpp* write exactly what output is produced. Each answer should consist of those symbols printed by the given part of the program and nothing else.

(i)

```
   int x = 8, y = 10;
   cout << (x + 1.0/y) << endl;
```

Answer:

8.1

(ii)

```
    char x = 'f';
    while (x <= 'i') {
       cout << (char) (x - 1);
       x = x + 1;
    }
```

Answer:

efgh

(iii)

```
    cout << 'f' - 'c';
```

Answer:

3

(iv)

```
    string x = "Easy Question";
    cout << x.substr(4,1);
```

Answer:

(v)

```
int main(int argc, char *argv[]) {
    cout << argv[0];
```

Answer:

a.out

Problem 268   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It asks the user to enter an integer n that is between 1 and 25.

2. It immediately stops if the supplied value of n is not legal.

3. Otherwise it prints out a triangular picture (as shown in the diagram, but with n rows) that uses the lowercase letters a, b, c, ... in sequence, and if necessary returns to the letter a after any z.

Here is an example of how the program should work:

```
Give me an integer between 1 and 25:    6
abcdef
 ghijk
  lmno
   pqr
    st
     u
```

Answer:

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

int main() {
   int n;
   cout << "Give me an integer between 1 and 25:  ";
   cin >> n;

   while (n < 1  || n > 25) {
      cout << "That is out of range. Give me an integer between 1 and 25:  ";
      cin >> n;
   }

   char x = 'a';
   for (int i = n; i >= 1; i--) {
      for (int j = 1; j <= n; j++)
         if ((i + j) <= n) cout << " ";
         else {
            cout << x;
            x = x + 1;
            if (x > 'z') x = 'a';
         }
      cout << endl;
   }
}
```

Problem 269   Write **title lines** for the functions that are called by the following main program. **Do not supply the blocks for the functions.**

```
int main() {
   int a[5] = {9, 3, 0, 4, 7};
   int x = 17;
   cout << asFraction(2, 6) << endl;      // (a) prints 2/6
   swap1(x, a[2]);                        // (b) swaps x with a[2]
   swap2(a[1], a[3]);                     // (c) swaps entry a[1] with a[3]
   median(1, 5, 4, 6, 7);                 // (d) prints 5, the median entry
   cout << sqrt(5, 10, 12, 14) << endl; // (e) prints 0.5 for any input values
   return 0;
}
```

(a) Title line for **asFraction** as called at the line marked (a).

Answer:

```
string asFraction(int a, int b)
```

(b) Title line for **swap1** as called at the line marked (b).

Answer:

```
void swap1(int &a, int &b)
```

(c) Title line for **swap2** as called at the line marked (c).

Answer:

```
void swap2(int &a, int &b)
```

(d) Title line for **median** as called at the line marked (d).

Answer:

```
void median(int a, int b, int c, int d, int e)
```

(e) Title line for **sqrt** as called at the line marked (e).

Answer:

```
double sqrt(int a, int b, int c, int d)
```

Problem 270   Consider the following C++ program.

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

int fun(int x) {
   if (x <= 0) return 100;
   if (x >= 9 && x % 2 == 1) return x + 1;
   if (x >= 9 || x % 3 == 0) return x + 2;
   return 5;
}

int rec(int x) {
  if (x < 100) return x/10;
  return rec(x / 10) + rec(x % 100);
}

int main() {
   cout << fun(-144) << endl;    // line (a)
   cout << fun(71) << endl;    // line (b)
   cout << rec(71) << endl;    // line (c)
   cout << rec(-256) << endl; // line (d)
   cout << rec(729) << endl;    // line (e)
}
```

(a) What is the output at line (a)?

Answer:

100

(b) What is the output at line (b)?

Answer:

72

(c) What is the output at line (c)?

Answer:

7

(d) What is the output at line (d)?

Answer:

-25

(e) What is the output at line (e)?

Answer:

9

Problem 271   Write a function called *multiDigit* that prints a new number formed from an integer parameter by printing each odd digit and omitting all even digits. If a negative parameter is given, it should ignore the − sign and treat the parameter as if it was positive.

For example, a program that uses the function *multiDigit* follows.

```
int main() {
   multiDigit(1245); cout << endl;  // prints 15
   multiDigit(19683); cout << endl; // prints 193
   multiDigit(220); cout << endl;    // prints
   multiDigit(-132); cout << endl;  // prints 13
   return 0;
}
```

Answer:

```
void multiDigit(int n) {
   if (n < 0) multiDigit(-n);
   else if (n == 0) return;
   else {
      multiDigit(n / 10);
      if (n % 2 != 0) cout << n % 10;
   }
}
```

Problem 272   Write a function called *randFill* that fills the entries of an array with random integers between a specified pair of limits. (Use an appropriate C++ function to generate the random numbers.)

For example, a program that uses the function follows.

```
int main() {
   int x[4];
   int min = 20, max = 29;
   randFill(x, 4, min, max);
   for (int i = 0; i <= 3; i++)
      cout << x[i] << endl;      // prints 4 random numbers between 20 and 29
   return 0;
}
```

Answer:

```
void randFill(int a[], int c, int min, int max) {
   for (int i = 0; i < c; i++)
      a[i] = rand() % (max - min + 1) + min;
}
```

Problem 273   Suppose that a C++ program called *prog.cpp* is compiled and correctly executed on venus with the instructions:

```
venus> g++ prog.cpp
venus> a.out input1.txt input2 out.txt
```

For each of the following short segments of the program *prog.cpp* write exactly what output is produced. Each answer should consist of those symbols printed by the given part of the program and nothing else.

(i)

```
   int x = 7, y = 10;
   cout << (x/y + 2.0/y) << endl;
```

Answer:

```
0.2
```

(ii)

```
char x = 'f';
while (x >= 'a') {
    cout << x;
    x = x - 1;
}
```

Answer:

```
fedcba
```

(iii)

```
cout << 'Z' - 'A';
```

Answer:

```
25
```

(iv)

```
string x = "Easy Question";
cout << x.substr(4,2);
```

Answer:

```
Q
```

(v)

```
int main(int argc, char *argv[]) {
    cout << argv[2];
```

Answer:

```
input2
```

Problem 274   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It asks the user to enter an integer n that is between 1 and 9.

2. It immediately stops if the supplied value of n is not legal.

3. Otherwise it prints out a triangular picture (as shown in the diagram, but with n rows) that uses the lowercase letters a, b, c, ... in sequence, and if necessary continues with uppercase letter starting at A after any z.

Here is an example of how the program should work:

```
Give me an integer between 1 and 9:    7
abcdefg
hijklm
nopqr
stuv
wxy
zA
B
```

Answer:

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

int main() {
    int n;
    cout << "Give me an integer between 1 and 9:  ";
    cin >> n;
    if (n < 1  || n > 9) return 0;

    char x = 'a';
    for (int i = n; i >= 1; i--) {
        for (int j = 1; j <= i; j++) {
            cout << x;
            x = x + 1;
            if (x > 'z') x = 'A';
        }
        cout << endl;
    }
}
```

Problem 275   Write **title lines** for the functions most of which are called by the following main program. **Do not supply the blocks for the functions.**

```
int main() {
    cout << numSixes("19683") << endl;         // (a) prints 1
    printNumSixes(19683);                       // (b) prints 1
    cout << longest(961, 1961, 5) << endl;     // (c) prints 1961
    average(2.5, 3.4, 4.0);                     // (d) prints 3.3
    return 0;
}
```

(a) Title line for **numSixes**

Answer:

```
int numSixes(string a)
```

(b) Title line for **printNumSixes**

Answer:

```
void printNumSixes(int x)
```

(c) Title line for **longest**

Answer:

```
int longest(int a, int b, int c)
```

(d) Title line for **average**

Answer:

```
void average(double a, double b, double c)
```

(e) The required title line for a main program that uses arguments.

Answer:

```
int main(int argc, char *argv[])
```

Problem 276   Consider the following C++ program.

```cpp
#include <iostream>
#include <fstream>
using namespace std;
int main() {
  ifstream infile("file.txt");
  for (int line = 1; line <= 5; line++) {
     cout << "Line " << line << " ";
     int x;
     if (infile.eof()) cout << "Done";
     infile >> x;
     if (x > 10) cout << ++x;
     if (x >  5) cout << 2 * x;
     if (x >  0) cout << x;
     if (x < 0) {
        infile >> x;
        cout << x;
     }
     cout << endl;
  }
  return 0;
}
```

The file called *file.txt* exists in the directory in which the above program is run. The file consists of the following data:

```
0   2  22   -2   2  -2 -22 22 222 2222
```

(a) What is the output line that begins: Line 1?

Answer:

```
Line 1
```

(b) What is the output line that begins: Line 2?

Answer:

```
Line 2 2
```

(c) What is the output line that begins: Line 3?

Answer:

```
Line 3 234623
```

(d) What is the output line that begins: Line 4?

Answer:

```
Line 4 2
```

(e) What is the output line that begins: Line 5?

Answer:

```
Line 5 -22
```

Problem 277   Write a function called *sum3* that determines the sum of the first 3 digits in a parameter. If the parameter has fewer than 3 digits, the sum of whatever digits are present is reported. (Assume that the parameter always has a positive value.)

For example, a program that uses the function *sumSq* follows.

```
int main() {
    cout << sum3(3456) << endl;   // prints 12 as the sum 3 + 4 + 5
    cout << sum3(11113) << endl; // prints 3 as the sum 1 + 1 + 1
    cout << sum3(9) << endl;      // prints 9
    return 0;
}
```

Answer:

```
int sum3(int x) {
    if (x < 1000) return x / 100 + (x / 10) % 10 + x % 10;
    return sum3(x / 10);
}
```

Problem 278   Write a function called *numPositive* that finds the number of rows with positive sum in a 2-dimensional array of decimals that has 4 columns. The array and the capacities are parameters. (Note that 0 is not positive.)

For example, a program that uses the function follows.

```
int main() {
    double d[2][4] = {{2, 4, -6, -8}, {-1, -3, 5, 1.5}};
    cout << numPositive(d, 2, 4) << endl;
    // prints    1  because only one row, the 2nd has a positive sum
    return 0;
}
```

Answer:

```
int numPositive(double d[][4], int r, int c) {
    int count = 0;
    for (int i = 0; i < r; i++) {
        double rowSum = 0;
        for (int j = 0; j < c; j++)
            rowSum = rowSum + d[i][j];
        if (rowSum > 0) count++;
    }
    return count;
}
```

Problem 279   Write a function called *numX* that reports the number of elements in a array of strings that contain an uppercase letter *X*.

For example, a program that uses the function follows.

```
int main() {
    string data[4] = {"abcdXYZ", "Hello", "1234", "XXX"};
    cout << numX(data, 4);    // prints:  2 because 2 strings include an X
    return 0;
}
```

Answer:

```
int numX(string a[], int cap) {
    int ans = 0;
    for (int i = 0; i < cap; i++)
        if (((int) a[i].find("X")) >= 0) ans++;
    return ans;
}
```

Problem 280   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It asks the user to enter a positive integer n.

2. It repeatedly reads n from the user until the supplied value of n is positive.

3. It prints out a large letter N that has height n and width n. The locations of the printed characters should lie in the $n \times n$ square region that the letter occupies.

Here is an example of how the program should work:

```
Give me a positive integer:   5
N   N
NN  N
N N N
N  NN
N   N
```

Answer:

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

int main() {
    int n;
    cout << "Enter a value for n:";
    cin >> n;
    while (n <= 0) {
        cout << "No good. Give a positive value: ";
        cin >> n;
    }
    for (int i = 1; i <= n; i++) {
        for (int j = 1; j <= n; j++)
            if (j == 1 || j == n || i == j)
                cout << "N";
            else cout << " ";
        cout << endl;
    }
    return 0;
}
```

Problem 281   Write **title lines** for the functions that are called by the following main program. **Do not supply the blocks for the functions.**

```cpp
int main() {
    cout << numDigits(19683) << endl;              // (a) prints 5
    printNumDigits("19683");                       // (b) prints 5
    cout << longer("Hello", "Goodbye") << endl;    // (c) prints "Goodbye"
    biggest(3.14, 2.718, 1.5);                     // (d) prints 3.14
    cout << sqrt(5, 10, 12) << endl;               // (e) prints the sum as 27
    return 0;
}
```

(a) Title line for **numDigits**

Answer:

```cpp
int numDigits(int x)
```

(b) Title line for **printNumDigits**

Answer:

```
void printNumDigits(string x)
```

(c) Title line for **longer**

Answer:

```
string longer(string a, string b)
```

(d) Title line for **biggest**

Answer:

```
void biggest(double a, double b, double c)
```

(e) Title line for **sqrt** as called at the line marked (e).

Answer:

```
int sqrt(int a, int b, int c)
```


Problem 282   Consider the following C++ program.

```
#include <iostream>
#include <fstream>
using namespace std;
int main() {
  ifstream infile("file.txt");
  for (int line = 1; line <= 5; line++) {
    cout << "Line " << line << " ";
    int x;
    if (infile.eof()) cout << "Done";
    infile >> x;
    if (x > 10) cout << ++x;
    if (x >  5) cout << 2 * x;
    if (x >  0) cout << x;
    if (x < 0) {
      infile >> x;
      cout << x;
    }
    cout << endl;
  }
  return 0;
}
```

The file called *file.txt* exists in the directory in which the above program is run. The file consists of the following data:

```
0    4    6   14    -1    3   -2 -5 1 2 3
```

(a) What is the output line that begins: Line 1?

Answer:

```
Line 1
```

(b) What is the output line that begins: Line 2?

Answer:

```
Line 2 4
```

(c) What is the output line that begins: Line 3?

Answer:

```
Line 3 126
```

(d) What is the output line that begins: Line 4?

Answer:

```
Line 4 153015
```

(e) What is the output line that begins: Line 5?

Answer:

```
Line 5 3
```

Problem 283   Write a function called *sumSq* that determines the sum of the squares of the digits in a parameter.

For example, a program that uses the function *sumSq* follows.

```
int main() {
    cout << sumSq(34) << endl;    // prints 25 because this is 9 + 16
    cout << sumSq(11113) << endl; // prints 13 found as 1+1+1+1+9
    cout << sumSq(9) << endl;     // prints 81
    return 0;
}
```

Answer:

```
int sumSq(int n) {
    if (n < 10) return n * n;
    return sumSq(n/10) + sumSq(n%10);
}
```

Problem 284   Write a function called *smallestPositive* that finds the smallest positive entry in a 2-dimensional array of decimals that has 4 columns. The array and the capacities are parameters. If no entry in the array is positive, the function should return an answer of 0.0. (Note that 0 is not positive.)

For example, a program that uses the function follows.

```
int main() {
    double d[2][4] = {{2, 4, -6, 8}, {-1, -3, 5, 1.5}};
    cout << smallestPositive(d, 2, 4) << endl;
      // prints   1.5
    return 0;
}
```

Answer:

```
double smallestPositive(double d[][4], int r, int c) {
    double answer = d[0][0];
    for (int i = 0; i < r; i++)
        for (int j = 0; j < c; j++)
            if (d[i][j] > 0)
                if (answer <= 0 || d[i][j] < answer)
                    answer = d[i][j];
    if (answer > 0) return answer;
    return 0.0;
}
```

Problem 285   Write a function called *insertX* that inserts an *X* at the middle of each element of an array of strings. (If a string has even length, the X should be added exactly at its middle, otherwise the X should be added immediately before the middle.)

   For example, a program that uses the function follows.

```
int main() {
   string data[4] = {"abcd", "Hello", "1234", ""};
   insertX(data, 4);
   for (int i = 0; i < 4; i++)
      cout << data[i] << " ";     // output: abXcd HeXllo 12X34 X
   return 0;
}
```

Answer:

```
void insertX(string d[], int cap) {
   for (int i = 0; i < cap; i++)
      d[i].insert(d[i].length()/2, "X");
}
```

Problem 286   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It asks the user to enter a positive integer n.

2. It repeatedly reads n from the user until the supplied value of n is positive.

3. It prints out a large letter Z that has height n and width n. The locations of the printed characters should lie in the $n \times n$ square region that the letter occupies.

Here is an example of how the program should work:

```
Give me a positive integer:   5
ZZZZZ
    Z
   Z
  Z
ZZZZZ
```

Answer:

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

int main() {
   int n;
   cout << "Enter a value for n:";
   cin >> n;
   while (n <= 0) {
      cout << "No good. Give a positive value: ";
      cin >> n;
   }
   for (int i = 1; i <= n; i++) {
      for (int j = 1; j <= n; j++)
         if (i == 1 || i == n || (i + j) == (n + 1))
            cout << "Z";
         else cout << " ";
      cout << endl;
   }
   return 0;
}
```

Problem 287 Write **title lines** for the functions that are called by the following main program. **Do not supply the blocks for the functions.**

```
int main() {
    int a[10] = {3,1,4,1,5,9,2,6,5,3};
    int x[3][2] = {{0,1},{2,3},{4,5}};
    int n = 7, m = 2;
    int i = sum(n, m);                  // sets i as the sum
    swap(n, m);                         // swaps n and m
    printArray(a, 10);                  // prints content of a
    print2dArray(x, 3, 2);             // prints content of x
    cout << minElement(a, 10);          // minimum element of array
    cout << firstDigit(n*n + m*m);     // first digit
    return 0;
}
```

(a) Title line for **sum**

Answer:

```
int sum(int a, int b)
```

(b) Title line for **swap**

Answer:

```
void swap(int &a, int &b)
```

(c) Title line for **printArray**

Answer:

```
void printArray(int a[], int cap)
```

(d) Title line for **print2dArray**

Answer:

```
void print2dArray(int a[][2], int rows, int cols)
```

(e) Title line for **minElement**

Answer:

```
int minElement(int a[], int cap)
```

(f) Title line for **firstDigit**

Answer:

```
int firstDigit(int x)
```

Problem 288 Write a function called *array2F* that returns the largest entry in a 2-dimensional array (of integer values). The parameters are the array, its number of rows and its number of columns. For example, a program that uses the function *array2F* follows.

```
int main() {
    int a[3][4] = {{0, -2, 2, 4}, {10, -5, 1, 3}, {1, 4, 1, 0}};
    cout << array2F(a, 3, 4) << endl;   // output is 10
    return 0;
}
```

Answer:

```
int array2F(int a[][4], int rows, int cols) {
    int answer = a[0][0];
    for (int i = 0; i < rows; i++)
        for (int j = 0; j < cols; j++)
            if (a[i][j] > answer) answer = a[i][j];
    return answer;
}
```

Problem 289   Consider the following C++ program.

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

char recursive(char array[], int n) {
    char x = array[n];
    if ('a' <= x && x <= 'z') return x;
    cout << x;
    return recursive(array, n - 1);
}

int main() {
    char array[8] = {'a','b','c','d','0','1','2','3'};
    cout << array[1] << endl;                    // line a
    cout << (char) (array[1] + 1) << endl;   // line b
    cout << recursive(array, 0) << endl;     // line c
    cout << recursive(array, 4) << endl;     // line d
    cout << recursive(array, 7) << endl;     // line e
    cout << array[6] - array[7] << endl;     // line f
    return 0;
}
```

What is the output from the program at each of the following lines:

(a) line a:

b

(b) line b:

c

(c) line c:

a

(d) line d:

0d

(e) line e:

3210d

(f) line f:

-1

Problem 290   Write a function called *useRecursion* that returns the sum of the first two digits in a positive number. If there is only one digit, that digit is returned. For example, a program that uses the function *useRecursion* follows.

```
int main() {
   cout << useRecursion(567982) << endl;    // prints 11
   cout << useRecursion(107982) << endl;    // prints 1
   cout << useRecursion(7) << endl;         // prints 7
   return 0;
}
```

Answer:

```
int useRecursion(int x) {
   if (x < 100) return x % 10 + x / 10;
   return useRecursion(x / 10);
}
```

Problem 291   Write C++ statements to carry out the following tasks. **Do not write complete programs**, just give a single line, or a few lines of C++ instructions. Declare and initialize any variables that you use in each part.

(i) Print the number 7 to an output file whose system name is *out.txt*

```
ofstream f("out.txt");
f << 7 << endl;
```

(ii) Read the first line of text in an input file whose system name is *in.txt*. Store the line in an appropriate variable called *line*.

```
ifstream g("in.txt");
string line;
getline(g, line);
```

(iii) Write the title line for a main function that uses arguments.

```
int main(int argc, char *argv[])
```

(iv) Print the 5th character of a string variable called *line* to the output screen.

```
cout << line[4] << endl;
```

(v) Print the character after the first character equal to K in a string variable called *line* to the output screen. If there is no character K, print the first character of the string.

```
int x = line.find('K');
if (x >= 0 && x < line.size() - 1)
   cout << line[x + 1];
else cout << line[0];
```

(vi) Print a random 2 digit integer to the output screen.

```
cout << rand() % 90 + 10 << endl;
```

Problem 292   Write a complete C++ program that does the following.

1. It asks the user to enter a positive integer n that is at most 20. It continues asking until the user enters a correct input.

2. The program generates two random upper case letters (using the standard C++ random number generation function).

3. The program prints an $n \times n$ square that uses the two characters to make a checkerboard pattern.

For example, if the user enters 5 and the random letters are K and W the following square picture is printed.

```
KWKWK
WKWKW
KWKWK
WKWKW
KWKWK
```

Answer:

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

int main() {

    int n;
    cout << "Enter a positive value for n that is at most 20: ";
    cin >> n;
    while ( n <= 0  || n > 20 ) {
       cout << "That is not legal.  Try again: ";
       cin >> n;
    }

    char x = 'A' + rand() % 26;
    char y = 'B' + rand() % 26;

    for (int i = 0; i < n; i++) {
       for (int j = 0; j < n; j++) {
          if ((i + j) % 2 == 0) cout << x;
          else cout << y;
       }
       cout << endl;
    }

    return 0;
}
```

Problem 293   Write **title lines** for the functions that are called by the following main program. **Do not supply the blocks for the functions.**

```cpp
int main() {
   int a[10] = {3,1,4,1,5,9,2,6,5,3};
   int x[3][2] = {{0,1},{2,3},{4,5}};
   int n = 7, m = 2;
   int i = sum(n, m, n);              // sets i as the sum
   swap(n, m);                        // swaps n and m
   addToArray(a, 10, 5);              // adds 5 to every entry
   printArray(x, 3, 2);               // prints content of x
   cout << maxElement(a, 10);         // maximum element of array
   cout << firstDigit(n);             // first digit
   return 0;
}
```

(a) Title line for **sum**

Answer:

```cpp
int sum(int a, int b, int c)
```

(b) Title line for **swap**

Answer:

```
void swap(int &a, int &b)
```

(c) Title line for **addToArray**

Answer:

```
void addToArray(int a[], int cap, int x)
```

(d) Title line for **printArray**

Answer:

```
void printArray(int a[][2], int rows, int cols)
```

(e) Title line for **maxElement**

Answer:

```
int maxElement(int a[], int cap)
```

(f) Title line for **firstDigit**

Answer:

```
int firstDigit(int x)
```

Problem 294   Write a function called $array2F$ that returns the product of the negative entries in a 2-dimensional array (of integer values). The parameters are the array, its number of rows and its number of columns. For example, a program that uses the function $array2F$ follows.

```
int main() {
   int a[3][4] = {{0, -2, 2, 4}, {10, -5, 1, 3}, {1, 4, 1, 0}};
   cout << array2F(a, 3, 4) << endl;    // output is 10
   return 0;
}
```

Answer:

```
int array2F(int a[][4], int rows, int cols) {
   int answer = 1;
   for (int i = 0; i < rows; i++)
      for (int j = 0; j < cols; j++)
         if (a[i][j] < 0) answer *= a[i][j];
   return answer;
}
```

Problem 295   Consider the following C++ program.

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

char recursive(char array[], int n) {
   char x = array[n];
   if ('a' == x || x == 'b') return x;
   cout << x;
   return recursive(array, n - 1);
}

int main() {
   char array[8] = {'a','b','c','d','0','1','2','3'};
   cout << array[0] << endl;                    // line a
```

```
    cout << (char) (array[0] + 3) << endl;    // line b
    cout << recursive(array, 0) << endl;      // line c
    cout << recursive(array, 2) << endl;      // line d
    cout << recursive(array, 7) << endl;      // line e
    cout << array[7] - array[5] << endl;      // line f
    return 0;
}
```

What is the output from the program at each of the following lines:

(a) line a:

a

(b) line b:

d

(c) line c:

a

(d) line d:

cb

(e) line e:

3210dcb

(f) line f:

2

Problem 296   Write a function called *useRecursion* that returns the larger of the first two digits in a positive number. If there is only one digit, that digit is returned. For example, a program that uses the function *useRecursion* follows.

```
int main() {
    cout << useRecursion(567982) << endl;    // prints 6
    cout << useRecursion(107982) << endl;    // prints 1
    cout << useRecursion(7) << endl;         // prints 7
    return 0;
}
```

Answer:

```
int useRecursion(int x) {
    if (x < 100) {
        if (x / 10 > x % 10) return x / 10;
        return x % 10;
    }
    return useRecursion(x / 10);
}
```

Problem 297   Write C++ statements to carry out the following tasks. **Do not write complete programs**, just give a single line, or a few lines of C++ instructions. Declare and initialize any variables that you use in each part.

(i) Read the first line of text in an input file whose system name is *input.txt*. Store the line in an appropriate variable called *line*.

```
ifstream g("input.txt");
string line;
getline(g, line);
```

(ii) Print the number 2 to an output file whose system name is *output.txt*

```
ofstream f("output.txt");
f << 2 << endl;
```

(iii) Print the length of a string variable called *line* to the output screen.

```
cout << line.length() << endl;
```

(iv) Write the title line for a main function that uses arguments.

```
int main(int argc, char *argv[])
```

(v) Print the character before the first character equal K in a string variable called *line* to the output screen. If there is no character K, or no character before it print the first character of the string.

```
int x = line.find('K');
if (x <= 0) cout << line[0];
cout << line[x - 1];
```

(vi) Print a random 3 digit integer to the output screen.

```
cout << rand() % 900 + 100 << endl;
```

Problem 298   Write a complete C++ program that does the following.

1. It asks the user to enter a positive integer n that is at most 20. It continues asking until the user enters a correct input.

2. The program generates n^2 random upper case letters (using the standard C++ random number generation function).

3. The program prints an $n \times n$ square that is filled with its chosen random letters.

For example, if the user enters 5 the following square picture might be printed.

```
KWXDG
YKWQT
AGDKE
IEXVL
UGBLQ
```

Answer:

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

int main() {

    int n;
    cout << "Enter a positive value for n that is at most 20: ";
    cin >> n;
    while ( n <= 0  || n > 20 ) {
        cout << "That is not legal.  Try again: ";
        cin >> n;
    }
```

```
     char x[20][20];
     for (int i = 0; i < 20; i++)
        for (int j = 0; j < 20; j++)
           x[i][j] = 'A' + rand() % 26;

     for (int i = 0; i < n; i++) {
        for (int j = 0; j < n; j++) {
           cout << x[i][j];
        }
        cout << endl;
     }

     return 0;
}
```

Problem 299   Write **title lines** for the functions that are called by the following main program. **Do not supply the blocks for the functions.**

```
int main() {
   int a[10] = {3,1,4,1,5,9,2,6,5,3};
   int x[3][2] = {{0,1},{2,3},{4,5}};
   int n = 7, m = 2;
   int i = diff(n, m);                 // sets i as the difference
   swap(n, m);                         // swaps values of inputs
   printArray(a, 10);                  // prints content of a
   addToArray(x, 3, 2, 5);             // adds 5 to every entry in array
   cout << average(a, 10);             // average of array
   cout << first2Digits(n + m);        // first two digits
   return 0;
}
```

(a) Title line for **diff**

Answer:

```
int diff(int a, int b)
```

(b) Title line for **swap**

Answer:

```
void swap(int &a, int &b)
```

(c) Title line for **printArray**

Answer:

```
void printArray(int a[], int cap)
```

(d) Title line for **addToArray**

Answer:

```
void addToArray(int a[][2], int rows, int cols, int x)
```

(e) Title line for **average**

Answer:

```
double average(int a[], int cap)
```

(f) Title line for **first2Digits**

Answer:

```
string first2Digits(int x)
```

Problem 300   Write a function called *array2F* that returns the number of non-zero entries in a 2-dimensional array (of integer values). The parameters are the array, its number of rows and its number of columns. For example, a program that uses the function *array2F* follows.

```
int main() {
    int a[3][4] = {{0, -2, 2, 4}, {10, -5, 1, 3}, {1, 4, 1, 0}};
    cout << array2F(a, 3, 4) << endl;    // output is 10
    return 0;
}
```

Answer:

```
int array2F(int a[][4], int rows, int cols) {
    int answer = 0;
    for (int i = 0; i < rows; i++)
        for (int j = 0; j < cols; j++)
            if (a[i][j] != 0) answer++;
    return answer;
}
```

Problem 301   Consider the following C++ program.

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

char recursive(char array[], int n) {
    char x = array[n];
    if ('0' <= x && x <= '9') return x;
    cout << x;
    return recursive(array, n - 1);
}

int main() {
    char array[8] = {'0','1','2','3','a','b','c','d'};
    cout << array[1] << endl;                    // line a
    cout << (char) (array[1] + 1) << endl;    // line b
    cout << recursive(array, 0) << endl;       // line c
    cout << recursive(array, 4) << endl;       // line d
    cout << recursive(array, 7) << endl;       // line e
    cout << array[6] - array[7] << endl;       // line f
    return 0;
}
```

What is the output from the program at each of the following lines:

(a) line a:

1

(b) line b:

2

(c) line c:

0

(d) line d:

a3

(e) line e:

dcba3

(f) line f:

-1

Problem 302   Write a function called *useRecursion* that returns the second digit in a positive number. If there is only one digit, that digit is returned. For example, a program that uses the function *useRecursion* follows.

```
int main() {
   cout << useRecursion(567982) << endl;      // prints 6
   cout << useRecursion(107982) << endl;      // prints 0
   cout << useRecursion(7) << endl;           // prints 7
   return 0;
}
```

Answer:

```
int useRecursion(int x) {
   if (x < 100) return x % 10;
   return useRecursion(x / 10);
}
```

Problem 303   Write C++ statements to carry out the following tasks. **Do not write complete programs**, just give a single line, or a few lines of C++ instructions. Declare and initialize any variables that you use in each part.

(i) Write the title line for a main function that uses arguments.

```
int main(int argc, char *argv[])
```

(ii) Print the number 13 to an output file whose system name is *out.txt*

```
   ofstream f("out.txt");
   f << 13 << endl;
```

(iii) Read the first string in an input file whose system name is *in.txt*. Store the string in an appropriate variable called *data*.

```
   ifstream g("in.txt");
   string data;
   getline(g, data);
```

(iv) Print the 8th character of a string variable called *line* to the output screen.

```
   cout << line[7] << endl;
```

(v) Print the position of the first character equal to K in a string variable called *line* to the output screen. If there is no character K, print -1.

```
      int x = line.find('K');
      if (0 <= x && x < line.length())
          cout << x << endl;
      else cout << -1 << endl;
```

(vi) Print a random 5 digit integer to the output screen.

```
      cout << rand() % 90000 + 10000 << endl;
```

Problem 304   Write a complete C++ program that does the following.

1. It asks the user to enter a positive integer n that is at most 20. If an incorrect response is entered it exits.

2. The program generates a random upper case letter and a random lower case letter (using the standard C++ random number generation function).

3. The program prints an $n \times n$ square that uses the two characters to make a checkerboard pattern.

For example, if the user enters 5 and the random letters are K and w the following square picture is printed.

```
KwKwK
wKwKw
KwKwK
wKwKw
KwKwK
```

Answer:

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

int main() {

    int n;
    cout << "Enter a positive value for n that is at most 20: ";
    cin >> n;
    if ( n <= 0  || n > 20 ) {
       cout << "That is not legal.  " << endl;
       exit(0);
    }

    char x = 'A' + rand() % 26;
    char y = 'a' + rand() % 26;

    for (int i = 0; i < n; i++) {
       for (int j = 0; j < n; j++) {
          if ((i + j) % 2 == 0) cout << x;
          else cout << y;
       }
       cout << endl;
    }
    return 0;
}
```

Problem 305   Write **title lines** for the functions that are called by the following main program. **Do not supply the blocks for the functions.**

```
int main() {
   int a[4] = {3,1,4,1}, i = 3, j = 5, k = 4;
```

```
    int x[2][2] = {{0,1},{3,2}};
    printArray(a, 3);                    // outputs:  3,1,4
    printVals(i + j, a[0]);              // outputs: 8 3
    reverse(a, 0, 3);                    // changes a to 1,4,1,3
    cout << sumElements(x, 2 , 2);       // outputs: 6
    sort(i, j, k);
    cout << i << j << k << endl;         // prints 345
    return 0;
}
```

(a) Title line for **printArray**

Answer:

```
void printArray(int a[], int cap)
```

(b) Title line for **printVals**

Answer:

```
void printVals(int x, int y)
```

(c) Title line for **reverse**

Answer:

```
void reverse(int a[], int i, int j)
```

(d) Title line for **sumElements**

Answer:

```
int sumElements(int x[][2], int r, int c)
```

(e) Title line for **sort**

Answer:

```
void sort(int &a, int &b, int &c)
```

Problem 306   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It asks the user to enter a positive integer that is between 1 and 26.

2. The program reads a value n entered by the user. If the value is not legal, the program exits.

3. The program prints an $n \times n$ pattern of characters, in which the bottom right character is an 'A'. The bottom right 2×2 block is completed by three 'B' characters. The bottom right 3×3 block is completed by five 'C' characters, and so on.

For example, if the user enters 5 for n the program should print the following picture.

```
EEEEE
EDDDD
EDCCC
EDCBB
EDCBA
```

Answer:

```
#include <iostream>
using namespace std;
int main() {
    int n;
```

```
    cout << "Enter an integer between 1 and 26: ";
    cin >> n;
    if (n < 1 || n > 26) exit(1);

    for (int r = 1; r <= n; r++) {
        char k = (char) ('A' + n - r);
        for (int c = 1; c <= n; c++) {
            if (c < r) k = (char) ('A' + n - c);
            cout << k;
        }
        cout << endl;
    }
    return 0;
}
```

Problem 307   Write a function called *emergency* that detects whether a number contains the sequence of digits 911. For example, a program that uses the function *emergency* follows.

```
int main() {
    if (emergency(56791182)) cout << "Warning" << endl;   // prints warning
    if (emergency(56791212)) cout << "Warning" << endl;   // no print here
    if (emergency(91191191)) cout << "Warning" << endl;   // prints warning
    return 0;
}
```

Answer:

```
bool emergency(int x) {
    if (x <= 0) return false;
    if (x % 1000 = 911) return true;
    return emergency(x/10);
}
```

Problem 308   Consider the following C++ program.

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

string recursive(string x) {
    if (x.length() == 0) return ":";
    return x.substr(0,1) + "#" + recursive(x.substr(1));

}

int main(int argc, char *argv[]) {
  int i = 1, j = 2, k = 3;
  string array[2] = {"", "hello"};
  cout << ++k << endl;                    // line a
  k = ++i - j++;
  cout << i << j << k << endl;            // line b
  cout << recursive(array[0]) << endl;    // line c
  cout << recursive(array[1]) << endl;    // line d
  cout << argv[1]      << endl;           // line e
  return 0;
}
```

The program is compiled to produce a binary called a.out. The binary is run with the command:

```
venus>    ./a.out CS111 Final Exam
```

What is the output from the program at each of the following lines:

(a) line a:

```
4
```

(b) line b:

```
230
```

(c) line c:

```
:
```

(d) line d:

```
h#e#l#l#o#:
```

(e) line e:

```
CS111
```

Problem 309   Write C++ statements to carry out the following tasks. **Do not write complete programs**, just give a single line, or a few lines of C++ instructions. Assume that the following variables have been declared, and if necessary have values, for each part. All other necessary variables should be declared and initialized.

```
  int x, y, table[100][100];
  string name;
```

(i) Print the quotient when x is divided into y.

```
cout << y/x << endl;
```

(ii) Print *table*[2][2] to the file *out.txt*. (In this part you need to declare a variable to access the file.)

```
ofstream f("out.txt");
f << table[2][2];
```

(iii) Print HELLO if you can find the substring *Freddy* within *name*. Otherwise print HI.

```
if (name.find("Freddy") >= 0) cout << "HELLO";
else cout << "HI";
```

(iv) Print the sum of all the numbers in column number 17 of the 2-dimensional array called *table*. (The array *table* has 100 rows and 100 columns. As usual the array begins with row number 0.)

```
int ans = 0;
for (int r = 0; r <= 99; r++)
   ans += table[r][17];
cout << ans;
```

(v) Print a random integer value between 13 and 19 (inclusive) to the screen. (The random integer should be determined by using an appropriate C++ function.)

```
cout << rand() % 7 + 13;
```

Problem 310   Write a complete C++ program that does the following.

1. It asks the user to enter positive integers a and b that are each at most 100.

2. The program reads in a table of integers with a rows and b columns as entered by the user.

3. The program determines and prints the maximum entry in each column of the table.

4. The program then prints the smallest value among these maximum entries.

For example, the following represents one run of the program.

```
Enter integers for r and c (at most 100):     2 2
Enter 2 rows of 2 integers:
 1  4
 2  0
The maximum entries in the columns are:  2 4
The smallest of the printed maximum entries is :  2
```

Answer:

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

int main() {
   int a, b;
   int table[100][100];
   int max[100];
   int minMax;
   cout << "Enter integers for r and c (at most 100): ";
   cin >> a >> b;
   cout << "Enter " << a << " rows of " << b << " integers:\n";

   for (int r = 0; r < a; r++) {
      for (int c = 0; c < b; c++)
         cin >> table[r][c];
   }

   cout << "The maximum entries in the columns are:  ";
   for (int c = 0; c < b; c++) {
      max[c] = table[0][c];
      for (int r = 0; r < a; r++)
         if (table[r][c] > max[c]) max[c] = table[r][c];
      cout << max[c] << " ";
   }
   cout << "\nThe smallest of the printed maximum entries is : ";
   cout << endl;
   return 0;
}
```

Problem 311   Write title lines (header lines or prototypes) for the following functions. Do not supply the blocks for the functions.

(a) A function called **middleDigit** which returns the middle digit of an integer.
Answer:

```cpp
int middleDigit(int x)
```

(b) A function called **sqrt** that returns the square root of a double precision parameter.
Answer:

```cpp
double sqrt(double x)
```

(c) A function called **duplicateString** which returns a new copy of string.

Answer:

```
string duplicate(string original)
```

(d) A function called **randomFile** which is to return a randomly created name to use for an output file.

Answer:

```
string randomFile()
```

(e) A function called **selectionSort** which is to sort an array of strings into alphabetical order.

Answer:

```
void selectionSort(string data[], int length)
```

Problem 312   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It asks the user to enter a positive integer.

2. The program reads a value n entered by the user. If the value is not legal, the program repeatedly makes the user type in another value until a legal value of n has been entered.

3. The program prints an $n \times (2n - 1)$ pattern of $*$ symbols in the shape of a large solid triangle.

For example, if the user enters 4 for n the program should print the following picture.

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

Answer:

```
#include <iostream>
using namespace std;
int main() {
   int n;
   cout << "Enter a positive integer: ";
   cin >> n;
   while (n <= 0) {
      cout << "That is not positive. Try again: ";
      cin >> n;
   }

   for (int row = 1; row <= n; r++) {
      int rowSpace = n - row;
      int rowStars = 2 * row - 1;
      for (int c = 1; c <= rowSpace; c++) cout << " ";
      for (int c = 1; c <= rowStars; c++) cout << "*";
      cout << endl;
   }
   return 0;
}
```

Problem 313   Write a function called *removeFirst* that removes the first digit from a number. The answer should be returned as an integer. (Drop any leading 0 digits in the answer. So that as in the example below, removing the first from 1024 leaves 24.)

A program that uses the function *removeFirst* follows.

```
int main() {
    int n = 19683;
    int m = removeFirst(n);
    cout << m << endl;                      // output 9683
    cout << removeFirst(1024);              // output   24
    return 0;
}
```

Answer:

```
int removeFirst(int n) {
  if (n < 10) return 0;
  return removeFirst(n / 10) * 10 + n % 10;
}
```

Problem 314   Consider the following C++ program.

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

string recursive(string x) {
    if (x.length() <= 1) return x;
    return x.substr(0,2) + recursive(x.substr(1));

}

int main(int argc, char *argv[]) {
  int i = 1, j = 2, k = 3;
  string array[2] = {"A", "hello"};
  cout << ++argc << endl;                     // line a
  k = ++i * j++;
  cout << i << j << k << endl;                // line b
  cout << recursive(array[0]) << endl;        // line c
  cout << recursive(array[1]) << endl;        // line d
  cout << recursive(argv[3]) << endl;         // line e
  return 0;
}
```

The program is compiled to produce a binary called a.out. The binary is run with the command:

```
venus>   ./a.out CS111 Final Exam
```

What is the output from the program at each of the following lines:
(a) line a:

5

(b) line b:

234

(c) line c:

A

(d) line d:

heelllloo

(e) line e:

Exxaamm

Problem 315   Write C++ statements to carry out the following tasks. **Do not write complete programs**, just give a single line, or a few lines of C++ instructions. Include declarations for any variable that you use.

(i) Print the word *HELLO* to the file *out.txt*.

```
ofstream f("out.txt");
f << "HELLO";
```

(ii) Print a random upper case letter to the screen. (The random letter should be determined by using an appropriate C++ function.)

```
cout << (char) ('A' + rand() % 26);
```

(iii) Read a line of text from the user and print the word *NO* if it contains the string *Fred*.

```
string name;
cin >> name;
if (name.find("Freddy") >= 0) cout << "NO";
```

(iv) Print the first 4 characters of the string *s*. Assume that the string has length at least 4.

```
cout << s.substr(0, 4) << endl;
```

(v) Swap the values of integer variables called *p* and *q*.

```
int temp = p;
p = q;
q = temp;
```

Problem 316   Write a complete C++ program that does the following.

1. It asks the user to enter positive integers *a* and *b* that are each at most 20.

2. The program generates random integer values between 1 and 6 as the entries in a table with *a* rows and *b* columns.

3. The program then prints the table.

4. The program then prints the diagonal entries from the table.

For example, the following represents one run of the program.

```
Enter integers for r and c (at most 20):     2 2
The table has been generated as:
6 3
1 2
The diagonal is:  6 2
```

Answer:

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

int main() {
   int a, b, row, col;
   int table[21][21];
   cout << "Enter integers for r and c (at most 20): ";
   cin >> a >> b;
```

```
   for (row = 1; row <= a; row++)
      for (col = 1; col <= b; col++)
         table[row][col] = rand() % 6 + 1;

   cout << " The table has been generated as: " << endl;
   for (row = 1; row <= a; row++) {
      for (col = 1; col <= b; col++)
         cout << table[row][col] << " ";
      cout << endl;
   }

   cout << " The diagonal is: ";
   for (row = 1; row <= a && row <= b; row++)
      cout << table[row][row] << " ";
   cout << endl;

   return 0;
}
```

Problem 317   Write **title lines** for the functions that are called by the following main program. **Do not supply the blocks for the functions.**

```
int main() {
   string name = "Freddy", secondName = "Fred";
   cout << thirdChar(name);              // print the 3rd character
   if ( !isLegal(name) )                 // reject illegal names
      readName(name);                    // and reads a name entered by the user
   exchangeNames(name, secondName);      // Swap the two names
   cout << bothNames(name, secondName);  // print full name
   return 0;
}
```

(a) Title line for **thirdChar**

Answer:

```
char thirdChar(string name)
```

(b) Title line for **isLegal**

Answer:

```
bool isLegal(string name)
```

(c) Title line for **readName**

Answer:

```
void readName(string &name)
```

(d) Title line for **exchangeNames**

Answer:

```
void exchangeNames(string &name, string &otherName)
```

(e) Title line for **bothNames**

Answer:

```
string bothNames(string name, string otherName)
```

Problem 318   Write C++ statements to carry out the following tasks. **Do not write complete programs**, just give a single line, or a few lines of C++ instructions. Assume that the following variables have been declared, and if necessary have values, for each part. All other necessary variables should be declared and initialized.

```
int x, y, table[100][100];
string name;
```

(i) Print the remainder when x is divided into y.

```
cout << y % x;
```

(ii) Print *name* to the file *out.txt*. (In this part you need to declare a variable to access the file.)

```
ofstream fout("out.txt");
fout << name;
```

(iii) Read a line of text from the file *out.txt* into the variable *name*.

```
ifstream fin("out.txt");
getline(fin, name);
```

(iv) Print the average of all the numbers in row number 17 of the 2-dimensional array called *table*. (The array *table* has 100 rows and 100 columns. As usual the array begins with row number 0.)

```
int sum = 0;
for (int a = 0; a < 100; a++)
   sum += table[17][a];
cout << sum / 100.0;
```

(v) Print a sequence of 20 random integer values each between 1 and 20 (inclusive) to the screen. (The random integers should be determined by using an appropriate C++ function.)

```
for (int a = 0; a < 20; a++)
   cout << rand() % 20 + 1;
```

Problem 319   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It asks the user to enter a positive integer.

2. The program reads a value n entered by the user. If the value is not legal, the program repeatedly makes the user type in another value until a legal value of n has been entered.

3. The program prints an $n \times n$ pattern of $*$ symbols in the shape of an empty right triangle (with the point down).

For example, if the user enters 7 for n the program should print the following picture.

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

Answer:

```
#include <iostream>
using namespace std;
int main() {
   int n = -1;
   while (n < 0) {
```

```
        cout << "Enter a positive integer: ";
        cin >> n;
    }

    for (int r = 1; r <= n; r++) {
        for (int c = 1; c <= n; c++) {
            if (r == c || r == 1 || c == n) cout << "*";
            else cout << " ";
        }
        cout << endl;
    } //for r
} //main
```

Problem 320   Write a function called *evenUp* that uses an integer parameter and returns a result that is found by increasing each even digit in the parameter by 1. For example, if the parameter has value 19683 the returned result would be 19793.

A program that uses the function *evenUp* follows.

```
int main() {
    cout << evenUp(10) << endl;       // prints 11
    cout << evenUp(2662) << endl;     // prints 3773
    cout << evenUp(19683) << endl;    // prints 19793
    return 0;
}
```

Answer:

```
int evenUp(int x) {
    if (x < 10 && x % 2 == 0) return x + 1;
    if (x < 10 && x % 2 == 1) return x;
    return 10 * evenUp(x / 10) + evenUp(x % 10);
}
```

Problem 321   For each of the following short segments of a program write exactly what output is produced. Each answer should consist of those symbols printed by the given part of the program and nothing else.

(i)

```
    double x = 4, y = 8;
    bool z = (x <= y || y <= x);
    if (z) cout << y / x;
    else cout << x / y;
    cout << endl;
```

Answer:

2.0

(ii)

```
    char Int = 'C';
    Int = Int + 1;
    cout << Int << endl;
```

Answer:

D

(iii)

```
    int i = 1;
    while (i++ < 10) {
        cout << ++i << endl;
    }
```

Answer:

```
3
5
7
9
11
```

(iv)

```
    int x[3][3] = {{1,2,3}, {4,7,10}, {11,15,19}};
    for (int i = 0; i <= 2; i++)
        cout << x[i][i];
    cout << endl;
```

Answer:

```
1719
```

(v)

```
    string x[3] = {"Hello", "CS111", "Exam"};
    for (int j = 1; j <= 3; j++) for (int i = 2; i >= 0; i--)
        cout << x[i][j];
    cout << endl;
```

Answer:

```
xSea1lm1l
```

Problem 322   Write a complete C++ program that does the following.

1. It asks the user to enter a positive integer n that is at most 20.

2. The program then reads n words from the user. (You should assume that each word contains between 1 and 10 characters.)

3. The program then prints a summary giving the number of words with each length.

For example, the following represents one run of the program.

```
Enter an integer n (at most 20):     3
Enter 3 words:              Hello CS111 Exam
Length 4:   count 1
Length 5:   count 2
```

In the exam the words *Hello* and *CS111* have length 5, and give the count of 2 words with length 5. No counts are printed for word lengths other than 4 and 5 because no other word lengths are encountered in this example.
Answer:

```
#include <iostream>
using namespace std;
int main ()
{
    int n;
    cout << "Enter positive integer that is at most 20: ";
    cin >> n;
```

```
    string words[20];
    cout << "Enter " << n << " words: ";
    for (int a = 0; a < n; a++) cin >> words[a];

    int count [11]; //for lengths 1 thru 10 inclusive, nothing of length 0
    for (int a = 0; a < 11; a++) count[a] = 0;
    for (int a = 0; a < n; a++) {
        int len = words[a].length();
        count[len]++;
    } //for

    for (int a = 0; a < 11; a++)
        if (count[a] != 0)
            cout << "Length " << a << ": count " << count[a] << endl;
} //main
```

Problem 323   Write **title lines** for the functions that are called by the following main program. **Do not supply the blocks for the functions.**

```
int main() {
    string name = "Freddy", secondName = "Fred";
    fixThirdChar(name);                    // change the 3rd character to X
    if ( !isLegal(secondName) )            // reject illegal names
        secondName = readName();           // and reads a name entered by the user
    exchangeNames(name, secondName);       // Swap the two names
    printBothNames(name, secondName);      // print full name
    return 0;
}
```

(a) Title line for **fixThirdChar**

Answer:

```
void fixThirdChar(string &name)
```

(b) Title line for **isLegal**

Answer:

```
bool isLegal(string name)
```

(c) Title line for **readName**

Answer:

```
string readName()
```

(d) Title line for **exchangeNames**

Answer:

```
void exchangeNames(string &name, string &otherName)
```

(e) Title line for **printBothNames**

Answer:

```
void printBothNames(string name, string otherName)
```

Problem 324   Write C++ statements to carry out the following tasks. **Do not write complete programs**, just give a single line, or a few lines of C++ instructions. Assume that the following variables have been declared, and if necessary have values, for each part. All other necessary variables should be declared and initialized.

```
   int x, y, table[100][100];
   string name;
```

(i) Print the remainder when y is divided by x.

```
 cout << y % x;
```

(ii) Print $table[0][0]$ to the file *output.txt*. (In this part you need to declare a variable to access the file.)

```
 ofstream fout("output.txt");
 fout << table[0][0];
```

(iii) Read a line of text from the file *output.txt* into the variable *name*.

```
 ifstream fin("output.txt");
 getline(fin, name);
```

(iv) Print the average of all the numbers in column number 37 of the 2-dimensional array called *table*. (The array *table* has 100 rows and 100 columns. As usual the array begins with column number 0.)

```
 int sum = 0;
 for (int a = 0; a < 100; a++)
   sum += table[a][37];
 cout << sum / 100.0;
```

(v) Print a sequence of 10 random integer values each between 1 and 100 (inclusive) to the screen. (The random integers should be determined by using an appropriate C++ function.)

```
 for (int a = 0; a < 10; a++)
   cout << rand() % 100 + 1;
```

Problem 325   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It asks the user to enter a positive integer.

2. The program reads a value n entered by the user. If the value is not legal, the program repeatedly makes the user type in another value until a legal value of n has been entered.

3. The program prints an $n \times n$ pattern of $*$ symbols in the shape of an empty right triangle (with the point up).

For example, if the user enters 7 for n the program should print the following picture.

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

Answer:

```
#include <iostream>
using namespace std;
int main() {
   int n = -1;
   while (n < 0) {
      cout << "Enter positive integer: ";
      cin >> n;
   }
```

```
    for (int r = 1; r <= n; r++) {
        for (int c = 1; c <= n; c++) {
            if (r == n || c == n || r + c == n + 1) cout << "*";
            else cout << " ";
        }
        cout << endl;
    } //for r
} //main
```

Problem 326   Write a function called *bigDown* that uses an integer parameter. It returns a result that is found from the parameter by subtracting 1 from any digit that is 5 or larger. For example, if the parameter has value 19683 the returned result would be 18573.

A program that uses the function *bigDown* follows.

```
int main() {
    cout << bigDown(10) << endl;      // prints 10
    cout << bigDown(2654) << endl;    // prints 2544
    cout << bigDown(19683) << endl;   // prints 18573
    return 0;
}
```

Answer:

```
int bigDown(int x) {
    if (x < 5) return x;
    if (x < 10) return x - 1;
    return 10 * bigDown(x / 10) + bigDown(x % 10);
}
```

Problem 327   For each of the following short segments of a program write exactly what output is produced. Each answer should consist of those symbols printed by the given part of the program and nothing else.

(i)

```
    double x = 4, y = 8;
    bool z = (x <= y && y <= x);
    if (z) cout << y / x;
    else cout << x / y;
    cout << endl;
```

Answer:

```
0.5
```

(ii)

```
    char Int = 'D';
    Int = Int - 1;
    cout << Int << endl;
```

Answer:

```
C
```

(iii)

```
    int i = 1;
    while (++i < 10) {
        cout << i++ << endl;
    }
```

Answer:

```
2
4
6
8
```

(iv)

```
int x[3][3] = {{4,7,10}, {11,15,19}, {1,2,3}};
for (int i = 0; i <= 2; i++)
   cout << x[i][i];
cout << endl;
```

Answer:

```
4153
```

(v)

```
string x[3] = {"CS111", "Exam", "Hello"};
for (int j = 1; j <= 3; j++) for (int i = 2; i >= 0; i--)
   cout << x[i][j];
cout << endl;
```

Answer:

```
exS1a11m1
```

Problem 328   Write a complete C++ program that does the following.

1. It asks the user to enter a positive integer n that is at most 25.

2. The program then reads n words from the user. (You should assume that each word contains between 3 and 12 characters.)

3. The program then prints a summary giving the number of words with each length.

For example, the following represents one run of the program.

```
Enter an integer n (at most 20):     3
Enter 3 words:               Hello CS111 Exam
Length 4:   count 1
Length 5:   count 2
```

In the exam the words *Hello* and *CS111* have length 5, and give the count of 2 words with length 5. No counts are printed for word lengths other than 4 and 5 because no other word lengths are encountered in this example.
Answer:

```cpp
#include <iostream>
using namespace std;
int main() {
   int n;
   cout << "Enter positive integer that is at most 25: ";
   cin >> n;

   string words[25];
   cout << "Enter " << n << " words: ";
   for (int a = 0; a < n; a++) cin >> words[a];

   int count[13]; // lengths upto 12
   for (int a = 0; a < 13; a++) count[a] = 0;
```

```
    for (int a = 0; a < n; a++) {
        int len = words[a].length();
        count [len]++;
    } //for

    for (int a = 0; a < 13; a++)
        if (count[a] != 0)
            cout << "Length " << a << ": count " << count[a] << endl;
} //main
```

Problem 329   Write C++ statements to carry out the following tasks. **Do not write complete programs**, just give a single line, or a few lines of C++ instructions. Assume that the following variables have been declared, and if necessary have values, for each part. All other necessary variables should be declared and initialized.

```
int x, y, table[100][100];
string name;
```

(i) Print the remainder when x is divided by y.

```
cout << x % y;
```

(ii) Print $table[1][1]$ to the file *outfile.txt*. (In this part you need to declare a variable to access the file.)

```
ofstream fout ("outfile.txt");
fout << table[1][1];
```

(iii) Read a line of text from the file *infile.txt* into the variable *name*.

```
ifstream fin("outfile.txt");
getline(fin, name);
```

(iv) Print the average of all the numbers in row number 27 of the 2-dimensional array called *table*. (The array *table* has 100 rows and 100 columns. As usual the array begins with row number 0.)

```
int sum = 0;
for (int a = 0; a < 100; a++)
    sum += table[27][a];
cout << sum / 100.0;
```

(v) Print two random integer values each between 100 and 200 (inclusive) to the screen. (The random integers should be determined by using an appropriate C++ function.)

```
cout << rand() % 101 + 100;
cout << rand() % 101 + 100;
```

Problem 330   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It asks the user to enter a positive integer.

2. The program reads a value n entered by the user. If the value is not legal, the program repeatedly makes the user type in another value until a legal value of n has been entered.

3. The program prints an $n \times n$ pattern of $*$ symbols in the shape of an empty right triangle (with the point up).

For example, if the user enters 7 for n the program should print the following picture.

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

Answer:

```cpp
#include <iostream>
using namespace std;
int main(){
   int n = -1;
   while (n < 0) {
      cout << "Enter positive integer: ";
      cin >> n;
   }

   for (int r = 1; r <= n; r++) {
      for (int c = 1; c <= n; c++) {
         if (r == n || c == 1 || r == c) cout << "*";
         else cout << " ";
      }
      cout << endl;
   } //for r
} //main
```

Problem 331   Write C++ statements to carry out the following tasks. **Do not write complete programs**, just give a single line, or a few lines of C++ instructions. Assume that the following variables have been declared, and if necessary have values, for each part. All other necessary variables should be declared and initialized.

```cpp
int x, y, table[100][100];
string name;
```

(i) Print the remainder when y is divided into x.

```cpp
cout << x % y;
```

(ii) Print x and y to the file *out.txt*. (In this part you need to declare a variable to access the file.)

```cpp
ofstream fout("out.txt");
fout << x << y;
```

(iii) Read a word of text from the file *infile.txt* into the variable *name*.

```cpp
ifstream fin("infile.txt");
fin >> name;
```

(iv) Print the average of all the numbers in column number 27 of the 2-dimensional array called *table*. (The array *table* has 100 rows and 100 columns. As usual the array begins with column number 0.)

```cpp
(iv)
int sum = 0;
for (int a = 0; a < 100; a++)
   sum += table[a][27];
cout << sum / 100.0;
```

(v) Print two random integer values each between 10 and 99 (inclusive) to the screen. (The random integers should be determined by using an appropriate C++ function.)

```cpp
cout << rand() % 90 + 10;
cout << rand() % 90 + 10;
```

Problem 332   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It asks the user to enter a positive integer.

2. The program reads a value n entered by the user. If the value is not legal, the program repeatedly makes the user type in another value until a legal value of n has been entered.

3. The program prints an $n \times n$ pattern of $*$ symbols in the shape of an empty right triangle (with the point down). For example, if the user enters 7 for n the program should print the following picture.

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

Answer:

```cpp
#include <iostream>
using namespace std;
int main(){
   int n = -1;
   while (n < 0) {
      cout << "Enter positive integer: ";
      cin >> n;
   }

   for (int r = 1; r <= n; r++) {
      for (int c = 1; c <= n; c++) {
         if (r == 1 || c == 1 || r + c == n + 1) cout << "*";
         else cout << " ";
      }
      cout << endl;
   } //for r
} //main
```

Problem 333   For each of the following short segments of a program write exactly what output is produced. Each answer should consist of those symbols printed by the given part of the program and nothing else.

(i)

```cpp
double x = 4, y = 8;
bool z = (x > y || y > x);
if (z) cout << y / x;
else cout << x / y;
cout << endl;
```

Answer:

2.0

(ii)

```cpp
char Int = 'd';
Int = Int + 1;
cout << Int << endl;
```

Answer:

e

(iii)

```
int i = 1;
while (i++ < 10) {
   cout << i++ << endl;
}
```

Answer:

```
2
4
6
8
10
```

(iv)

```
int x[3][3] = {{1,2,3}, {4,7,10}, {11,15,19}};
for (int i = 0; i <= 2; i++)
   cout << x[i][2 - i];
cout << endl;
```

Answer:

```
3711
```

(v)

```
string x[3] = {"Hello", "CS111", "Exam"};
for (int j = 1; j <= 3; j++) for (int i = 0; i <= 2; i++)
   cout << x[i][j];
cout << endl;
```

Answer:

```
eSxl1al1m
```

Problem 334   For each of the following short segments of a program write exactly what output is produced. Each answer should consist of those symbols printed by the given part of the program and nothing else.

(i)

```
double x = 4, y = 8;
bool z = (x > y && y > x);
if (z) cout << y / x;
else cout << x / y;
cout << endl;
```

Answer:

```
0.5
```

(ii)

```
char Int = 'b';
Int = Int - 1;
cout << Int << endl;
```

Answer:

a

(iii)

```
int i = 1;
while (++i < 10) {
   cout << i++ << endl;
}
```

Answer:

2
4
6
8

(iv)

```
int x[3][3] = {{4,7,10}, {11,15,19}, {1,2,3}};
for (int i = 0; i <= 2; i++)
   cout << x[i][2 - i];
cout << endl;
```

Answer:

10151

(v)

```
string x[3] = {"CS111", "Exam", "Hello"};
for (int j = 1; j <= 3; j++) for (int i = 0; i <= 2; i++)
   cout << x[i][j];
cout << endl;
```

Answer:

Sxe1al1ml

Problem 335   Write **title lines** for the functions that are called by the following main program. **Do not supply the blocks for the functions.**

```
int main() {
   string name;  int x, y, array[20];
   name = enterName();          // Reads a name entered by the user
   cout << lastChar(name);      // Print the last character
   enterNumbers(x, y);          // Ask for and read in values for x and y
   cout << power(x, y);         // x raised to the power y
                                // answer is decimal to allow for negative powers
   cout << reverse(name);       // Prints the name backwards
                                // so Fred would be printed as derF
   randomize(array, 20);        // fill the array with random numbers
   return 0;
}
```

(a) Title line for **lastChar**

```
char lastChar (string name)
```

(b) Title line for **enterNumbers**

```
void enterNumbers (int &a, int &b)
```

(c) Title line for **power**

```
double power (int a, int b)
```

(d) Title line for **reverse**

```
string reverse (string name)
```

(e) Title line for **randomize**

```
void randomize (int arr[], int cap)
```

Problem 336   Write C++ statements to carry out the following tasks. **Do not write complete programs**, just give a single line, or a few lines of C++ instructions. Assume that the following variables have been declared, and if necessary have values, for each part:

```
int x[10], z[10][10], r, c;
```

(i) Increase every entry of x by 1.

```
for (int i = 0; i < 10; i++) x[i]++;
```

(ii) Set r to be a random integer between c and c + 10. (The random integer should be determined by an appropriate C++ function.)

```
r = rand () % 11 + c;
```

(iii) Print the sum of all 100 entries of the 2-dimensional array z.

```
int sum = 0;
for (int i = 0; i < 10; i++)
  for (int j = 0; j < 10; j++)
    sum += z [i][j];
```

(iv) Print the last 5 entries of the array x.

```
for (int i = 5; i < 10; i++) cout << x [i];
```

(v) Swap column number 2 with column number 3 in the 2-dimensional array z.

```
for (int i = 0; i < 10; i++) {
  int temp = z [i][2];
  z [i][2] = z [i][3];
  z [i][3] = temp;
} //for
```

Problem 337   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It asks the user to enter a positive integer.

2. The program reads a value n entered by the user. If the value is not legal, the program repeatedly makes the user type in another value until a legal value of n has been entered.

3. The program prints the first n squares and their sum.

For example, if the user enters 4 for n the program should produce the following output.

```
1 4 9 16
sum to 30
```

Answer:

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

int main ()
{
  int a = -1;
  while (a < 0) {
     cout << "Give me a positive integer: ";
     cin >> a;
  } //while

  int sum = 0;
  for (int i = 1; i <= a; i++) {
     int temp = i * i;
     cout << temp << " ";
     sum += temp;
  } //for
  cout << endl << "sum to " << sum << endl;

  return 0;
} //main
```

Problem 338 Write a function called *boeing* that prints a parameter with additional digits of 7 before each digit and at the end of the number. (So that a parameter 4 would be printed as 747 and a parameter 666 would be printed as 7676767.)

For example, a program that uses the function *boeing* follows.

```cpp
int main() {
   boeing(4);     cout << endl;   // prints 747
   boeing(66);    cout << endl;   // prints 76767
   boeing(7);     cout << endl;   // prints 777
   boeing(1000);  cout << endl;   // prints 717070707
   return 0;
}
```

Answer:

```cpp
void boeing(int n) {
   if (n < 10) cout << 7 << n << 7;
   else {
      boeing(n / 10);
      cout << n % 10 << 7;
   }
}
```

Problem 339 Consider the following C++ program.

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

```
int recursive(int x[], int n) {
    if (n <= 0 || n > 10) return 0;
    if (n == 1) return x[0];
    if (n <= 3) return x[n - 1] + recursive(x, n - 1);
    x[0]++;
    return recursive(x, n - 3);
}

int main() {
    int x, a[10] = {1,2,3,4,5,6,7,8,9,10};
    cout << "Enter a number: ";
    cin >> x;
    cout << recursive(a, x) << endl;
    return 0;
}
```

What is the output from the program in response to the following user inputs.

(a) The user enters 0

Answer: 0

(b) The user enters 1

Answer: 1

(c) The user enters 3

Answer: 6

(d) The user enters 5

Answer: 4

(e) The user enters 10

Answer: 4

Problem 340   Write a complete C++ program that does the following.

1. It asks the user to enter positive integers a and b that are each at most 100.

2. The program reads in a table of integers with a rows and b columns as entered by the user.

3. The program determines and prints the minimum entry in each column of the table.

4. The program then prints the average value of these minimum entries.

For example, the following represents one run of the program.

```
Enter integers for r and c (at most 100):     2 2
Enter 2 rows of 2 integers:
 1  4
 2  0
The minimum entries in the columns are:  1 0
The average minimum entry is :  0.5
```

Answer:

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

int main () {
    int a, b, r, c, min, sumMin = 0;
    int table [100][100];

    cout << "Give me two integers, each at most 100: ";
    cin >> a >> b;
```

```
   cout << "Enter " << a << " rows of " <<  b << " integers: " << endl;
   for (r = 0; r < a; r++)
      for (c = 0; c < b; c++)
         cin >> table [r][c];

   cout << "The minimum entries in the columns are:  ";
   for (c = 0; c < b; c++) {
      min = table [0][c];
      for (r = 0; r < a; r++) if (table [r][c] < min) min = table[r][c];
      cout << min << " ";
      sumMin += min;
   } //for  c

   cout << "\nThe average minimum entry is :  ";
   cout << ((double) sumMin) / b << endl;

   return 0;
} //main
```

Problem 341   Write **title lines** for the functions that are called by the following main program. **Do not supply the blocks for the functions.**

```
int main() {
   string name;
   name = enterName();              // Reads a name entered by the user
   greet(name);                     // Says hello to the user
   cout << numberAs(name);          // Finds the number of As in the name
   string theClass[20];
   enterNames(theClass, 20);        // Enter the names of all students
   sort(theClass, 20, "decreasing"); // sort names into decreasing
                                    // alphabetical order
   printNames(theClass, 20);
   return 0;
}
```

(a) Title line for **enterName**

```
string enterName()
```

(b) Title line for **greet**

```
void greet(string name)
```

(c) Title line for **numberAs**

```
int numberAs(string name)
```

(d) Title line for **enterNames**

```
void enterNames(string names[], int cap)
```

(e) Title line for **sort**

```
void sort(string names[], int cap, string ordering)
```

Problem 342   Write C++ statements to carry out the following tasks. **Do not write complete programs**, just give a single line, or a few lines of C++ instructions. Assume that the following variables have been declared, and if necessary have values, for each part. All other necessary variables should be declared and initialized.

```
int x, y, table[100][100];
string name;
```

(i) Print the larger of integer variables called x and y.

```
int larger = x;
if (y > x) larger = y;
cout << larger;
```

(ii) Print the numbers *10 9 8* to the file *out.txt*. (In this part you need to declare a variable to access the file.)

```
ofstream fout ("out.txt");
fout << 10 << 9 << 8;
```

(iii) Read a line of text from the user and print the word *Yes* if it contains the substring *Freddy*.

```
cin >> name;
if (name.find ("Freddy") != -1) cout << "Yes";
```

(iv) Print the sum of all the numbers in column number 0 of a 2-dimensional array called *table*. (The array *table* has 100 rows and 100 columns.)

```
int sum = 0;
for (int i = 0; i < 100; i++)
   sum += table [i][0];
cout << sum;
```

(v) Print 8 random **negative** integers to the screen. (The random integers should be determined by using an appropriate C++ function.)

```
for (int i = 0; i < 8; i++) {
   int num = rand ();
   if (num > 0) num *= -1;
   cout << num << endl;
} //for
```

Problem 343 Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It asks the user to enter a positive integer.

2. The program reads a value n entered by the user. If the value is not legal, the program repeatedly makes the user type in another value until a legal value of n has been entered.

3. The program prints an $n \times (2n - 1)$ pattern of $*$ symbols in the shape of a large triangle.

For example, if the user enters 4 for n the program should print the following picture.

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

Answer:

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

int main() {
   int c, r, n;
```

```
        cout << "Enter a positive integer: ";
        cin >> n;
        while (n <= 0) {
           cout << "Illegal.  Try again: ";
           cin >> n;
        }
        for (r = n; r >= 1; r--) {
           for (c = 1; c <= 2 * n - 1; c++)
              if ( r == 1 || c == r || c + r == 2 * n ) cout << "*";
              else cout << " ";
           cout << endl;
        }
        return 0;
}
```

Problem 344   Write a function called *oddDigits* that determines the number of odd digits in an integer parameter. For example, a program that uses the function *oddDigits* follows. (In this example, the number 10 has one odd digit namely 1; the number 26 has no odd digits; the number 19683 has three odd digits namely 1, 9 and 3.)

```
int main() {
   cout << oddDigits(10) << endl;    // prints 1
   cout << oddDigits(26) << endl;    // prints 0
   cout << oddDigits(19683) << endl; // prints 3
   return 0;
}
```

Answer:

```
int oddDigits(int x) {
   if (x == 0) return 0;
   return oddDigits(x/10) + x % 2;
}
```

Problem 345   For each of the following short segments of a program write exactly what output is produced. Each answer should consist of those symbols printed by the given part of the program and nothing else.

(i)

```
   int x = 4, y = 5;
   if (x <= y && y <= x) cout << "Yes";
   else cout << "No";
```

Answer:

No

(ii)

```
   int x = 4, y = 5;
   cout << (x / y  + 1.0) << endl;
```

Answer:

1

(iii)

```
   for (int i = 1; i <= 10; i++) {
      cout << i << endl;
      i++;
   }
```

Answer:

```
1
3
5
7
9
```

(iv)

```
int x[3][3] = {{1,3,5}, {2,4,6}, {7,8,9}};
for (int i = 0; i <= 2; i++) for (int j = 0; j <= 2; j++)
   if (i == j) cout << x[i][j];
```

Answer:

```
149
```

(v)

```
int x[3][3] = {{1,3,5}, {2,4,6}, {7,8,9}};
for (int j = 0; j <= 2; j++) for (int i = 0; i <= 2; i++)
   cout << x[i][j];
cout << endl;
```

Answer:

```
127348569
```

Problem 346   Write a complete C++ program that does the following.

1. It asks the user to enter positive integers a and b that are each at most 20.

2. The program generates random integer values between 1 and 6 as the entries in a table with a rows and b columns.

3. The program then prints the table.

4. The program prints a picture with a rows and b columns. The character printed in row i and column j is X or O according as the entry of the table in row i and column j is even or odd.

For example, the following represents one run of the program.

```
Enter integers for r and c (at most 20):    2 2
The table has been generated as:
6 3
1 3
The picture is:
XO
OO
```

Answer:

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

int main ()
{
        int a, b;
        int table [20][20];

        cout << "Give me two integers, each at most 20: ";
        cin >> a >> b;
```

```
        for (int r = 0; r < a; r++)
                for (int c = 0; c < b; c++)
                        table [r][c] = rand () % 6 + 1;

        cout << "The table has been generated as:" << endl;
        for (int r = 0; r < a; r++)
        {
                for (int c = 0; c < b; c++)
                        cout << table [r][c] << " ";
                cout << endl;
        } //for

        cout << "The picture is:" << endl;
        for (int r = 0; r < a; r++)
        {
                for (int c = 0; c < b; c++)
                        if (table [r][c] % 2 == 0) cout << "X";
                        else cout << "O";
                cout << endl;
        } //for

        return 0;
} //main
```

Problem 347   Write C++ statements to carry out the following tasks. **Do not write complete programs**, just give a single line, or a few lines of C++ instructions. Include declarations for any variable that you use.

(i) Print the word *output* to the file *out.txt*.

Answer:

```
ofstream out("out.txt");
out << "output";
```

(ii) Print a random negative integer to the screen. (The random integer should be determined by using an appropriate C++ function.)

Answer:

```
int r = rand();
while (r == 0) r = rand();
if (r > 0) r = -r;
cout << r;
```

(iii) Read a line of text from the user and print the word *Yes* if it contains at most 7 characters.

Answer:

```
string line;
getline(cin, line);
if (line.length() <= 7) cout << "Yes";
```

(iv) Print the last but one character of the string *s*.

Answer:

```
cout << s[s.length() - 2];
```

(v) Print the average of integer variables called x and y.

Answer:

```
cout << (x + y) / 2.0;
```

Problem 348   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It asks the user to enter a positive integer.

2. The program reads a value n entered by the user. If the value is not legal, the program repeatedly makes the user type in another value until a legal value of n has been entered.

3. The program prints an $n \times (2n - 1)$ pattern of $*$ symbols in the shape of a large upside down triangle.

For example, if the user enters 4 for n the program should print the following picture.

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

Answer:

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

int main() {
   int c, r, n;
   cout << "Enter a positive integer: ";
   cin >> n;
   while (n <= 0) {
      cout << "Illegal.  Try again: ";
      cin >> n;
   }
   for (r = 1; r <= n; r++) {
     for (c = 1; c <= 2 * n - 1; c++)
        if ( r == 1 || c == r || c + r == 2 * n ) cout << "*";
        else cout << " ";
      cout << endl;
   }
   return 0;
}
```

Problem 349   Write a function called *reverse* that reverses the entries in an array.

   For example, a program that uses the function *reverse* follows.

```cpp
int main() {
   int a[5] = {3, 1, 4, 1, 5};
   reverse(a, 5);
   cout << a[0] << a[1] << a[2] << a[3] << a[4];   // prints 51413
   return 0;
}
```

Answer:

```cpp
void reverse(int a[], int cap) {
   for (int i = 0; i < cap / 2; i++) {
      int temp = a[i];
      a[i] = a[cap - 1 - i];
      a[cap - 1 - i] = temp;
   }
}
```

Problem 350   Write a complete C++ program that does the following.

1. It asks the user to enter positive integers r and c that are at most 100.

2. The program reads in a table of integers with r rows and c columns as entered by the user.

3. The program prints out all values of an integer x for which the entries in row x have a sum of 7.

For example, the following represents one run of the program.

```
Enter integers for r and c (at most 100):    3 2
Enter 3 rows of 2 integers:
 3  4
 1  0
 8 -1
The following rows add to 7:   0 2
```

Answer:

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

int main ()
{
        int table[100][100], r, c;
        cout << "Enter integers for r and c (at most 100):   ";
        cin >> r >> c;

        cout << "Enter " << r << " rows of " << c << " integers: ";
        for (int i = 0; i < r; i++)
                for (int j = 0; j < c; j++)
                        cin >> table[i][j];

        cout << "The following rows add to 7: ";
        for (int x = 0; x < r; x++)
        {
            int rowS = 0;
            for (int i = 0; i < c; i++) rowS += table[x][i];
            if (rowS == 7) cout << x << " ";
        } //for

        cout << endl << endl;

        return 0;
} //main
```

Problem 351   Consider the following C++ program.

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

string recursive(string s) {
   if (s.length() < 3) return s;
   if (s.length() < 5) return "a";
   return recursive(s.substr(3));
}

int main() {
  string x;
  cout << "Enter a string: ";
```

```
   cin >> x;
   cout << recursive(x) << endl;
   return 0;
}
```

What is the output from the program in response to the following user inputs.

(a) The user enters *Hi*

Answer:

```
Hi
```

(b) The user enters *Hello*

Answer:

```
lo
```

(c) The user enters *Goodbye*

Answer:

```
a
```

(d) The user enters *12345678*

Answer:

```
78
```

(e) The user enters *1234 5678*

Answer:

```
a
```

Problem 352   Suppose that a C++ program called *prog.cpp* is compiled and correctly executed on venus with the instructions:

```
venus> g++ prog.cpp
venus> a.out input1.txt input2 out.txt
```

For each of the following short segments of the program *prog.cpp* write exactly what output is produced. Each answer should consist of those symbols printed by the given part of the program and nothing else.

(i)

```
   int x = 4, y = 5;
   cout << ++x + y--;
```

Answer:

```
10
```

(ii)

```
int main(int argc, char *argv[]) {
   cout << argv[1];
```

Answer:

```
input1.txt
```

(iii)

```
    for (int i = 2; i >= 0; i--) {
        for (int j = 0; j < i; j++) cout << "*";
        cout << endl;
    }
```

Answer:

```
**
*
```

(iv)

```
    int c = 4, d = 5;
    c = d;
    d = c;
    cout << c << " " << d;
```

Answer:

```
5 5
```

(v)

```
    for (int i = 2; i >= 0; i--)
        for (int j = 0; j < i; j++) cout << "*";
    cout << endl;
```

Answer:

```
***
```

Problem 353   Write title lines (header lines or prototypes) for the following functions. Do not supply the blocks for the functions.

(a) A function called **firstChar** which returns the first character of a string.

Answer:

```
char firstChar(string s)
```

(b) A function called **power** that returns an integer power of a double precision decimal number.

Answer:

```
double power(double x, int n)
```

(c) A function called **As** which returns the number of times the letter A appears in a string.

Answer:

```
int As(string s)
```

(d) A function called **randomEven** which is to create and return a random even number.

Answer:

```
int randomEven()
```

(e) A function called **inOrder** which is to determine whether an array of strings is in alphabetical order.

Answer:

```
bool inOrder(string s[], int cap)
```

Problem 354   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It asks the user to enter a positive integer.

2. The program reads a value n entered by the user. If the value is not legal, the program repeatedly makes the user type in another value until a legal value of n has been entered.

3. The program prints an $n \times (2n - 1)$ pattern of $*$ symbols in the shape of a large letter V.

For example, if the user enters 4 for n the program should print the following picture.

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

Answer:

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

int main() {
   int c, r, n;
   cout << "Enter a positive integer: ";
   cin >> n;
   while (n <= 0) {
      cout << "Illegal.  Try again: ";
      cin >> n;
   }
   for (r = 1; r <= n; r++) {
     for (c = 1; c <= 2 * n - 1; c++)
        if ( c == r || c + r == 2 * n ) cout << "*";
        else cout << " ";
     cout << endl;
   }
   return 0;
}
```

Problem 355   Write a function called *sort* that sorts three integer parameters into decreasing order.

For example, a program that uses the function *sort* follows.

```cpp
int main() {
   int a = 2, b = 7, c = 1;
   sort(a, b, c);
   cout << a << b << c << endl;    // prints 721
   return 0;
}
```

Answer:

```cpp
void swap(int &a, int &b) {
    int temp = a;
    a = b;
    b = temp;
}

void order(int &a, int &b) {
   if (a < b) swap(a, b);
}
```

```
void sort(int &a, int &b, int &c) {
    order(a, b);
    order(a, c);
    order(b, c);
}
```

Problem 356   Write a complete C++ program that does the following.

1. It asks the user to enter positive integers r and c that are at most 100.

2. The program reads in a table of integers with r rows and c columns as entered by the user.

3. The program prints out all values of an integer x for which row x and column x of the table have the same sum.

For example, the following represents one run of the program.

```
Enter integers for r and c (at most 100):    3 2
Enter 3 rows of 2 integers:
 3  2
 1  0
 1  1
The row and column sums are equal at 0.
```

(Note the program prints 0 because row 0 sums to $3 + 2 = 5$ and column 0 sums to $3 + 1 + 1 = 5$.)

Answer:

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

int main ()
{
        int table[100][100], r, c;
        cout << "Enter integers for r and c (at most 100):    ";
        cin >> r >> c;

        cout << "Enter " << r << " rows of " << c << " integers: ";
        for (int i = 0; i < r; i++)
                for (int j = 0; j < c; j++)
                        cin >> table[i][j];

        for (int x = 0; x < r && x < c; x++)
        {
            int rowS = 0, colS = 0;
            for (int i = 0; i < c; i++) rowS += table[x][i];
            for (int i = 0; i < r; i++) colS += table[i][x];
            if (rowS == colS)
                cout << "The row and column sums are equal at " << x <<".\n";
        } //for

        cout << endl << endl;

        return 0;
} //main
```

Problem 357   Consider the following C++ program.

```
#include <iostream>
```

```
using namespace std;

string recursive(string s) {
    if (s.length() < 3) return s;
    if (s.length() < 6) return "a";
    return recursive(s.substr(4));
}

int main() {
    string x;
    cout << "Enter a string: ";
    cin >> x;
    cout << recursive(x) << endl;
    return 0;
}
```

What is the output from the program in response to the following user inputs.

(a) The user enters *Hi*

Answer:

Hi

(b) The user enters *5*

Answer:

5

(c) The user enters *five*

Answer:

a

(d) The user enters *string*

Answer:

ng

(e) The user enters *recursive*

Answer:

a

Problem 358   Suppose that a C++ program called *prog.cpp* is compiled and correctly executed on venus with the instructions:

```
venus> g++ prog.cpp
venus> a.out input1.txt input2 out.txt
```

For each of the following short segments of the program *prog.cpp* write exactly what output is produced. Each answer should consist of those symbols printed by the given part of the program and nothing else.

(i)

```
    int x = 4, y = 5;
    if (x < y || y < x) cout << "Yes";
    else cout << "No";
```

Answer:

Yes

(ii)

```
int main(int argc, char *argv[]) {
    cout << argc;
```

Answer:

4

(iii)

```
    for (int i = 2; i < 0; i--) {
        for (int j = 0; j < i; j++) cout << "*";
        cout << endl;
    }
```

Answer:

(iv)

```
    int c = 4, d = 5;
    if (++c < d) cout << "Yes";
    else cout << "No";
```

Answer:

No

(v)

```
    string s = "Hello";
    for (int i = s.length(); i > 0; i--) {
        for (int j = 0; j < i; j++) cout << (char) s[j];
        cout << endl;
    }
```

Answer:

```
Hello
Hell
Hel
He
H
```


Problem 359   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It asks the user to enter a positive integer n.

2. It repeatedly reads n from the user until the supplied value of n is positive.

3. It prints out a large letter X that has height n and width n. The locations of the printed characters should lie on the diagonals of the $n \times n$ square region that the letter occupies.

Here is an example of how the program should work:

```
Give me a positive integer:   7
X     X
 X   X
  X X
   X
  X X
 X   X
X     X
```

Answer:

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

int main() {
    int n;
    cout << "Give me a positive integer: ";
    cin >> n;

    while (n <= 0) {
        cout << "Enter a POSITIVE integer:   ";
        cin >> n;
    }

    for (int i = 1; i <= n; i++) {
        for (int j = 1; j <= n; j++)
            if ((i == j) || (i + j == n + 1)) cout << "X";
            else cout << " ";
        cout << endl;
    }
    return 0;
}
```

Problem 360   Write C++ statements to carry out the following tasks.

Do not write complete programs, just give a single line, or a few lines of C++ instructions. Assume that the following variables have been declared, and if necessary have values, for each part:

```cpp
string f, l;
```

Declare any other variables that you use.

(i) Write the strings f and l as the first two lines of the file *data.txt*.
Answer:

```cpp
ofstream out("data.txt");
out << f << endl << l << endl;
```

(ii) Print the message *Hello Freddy* if the input file *input.txt* begins with the string *Freddy*. Otherwise do nothing.
Answer:

```cpp
ifstream file("input.txt");
file >> f;
if (f == "Freddy") cout << "Hello Freddy" << endl;
```

(iii) Convert the string f to upper case letters and then print it.
Answer:

```cpp
for (int i = 0; i < f.size(); i++)
    f[i] = toupper(f[i]);
cout << f << endl;
```

(iv) Print the number of times that the uppercase letter F appears in the string f.
Answer:

```cpp
int count = 0;
for (int i = 0; i < f.size(); i++)
    if (f[i] == 'F') count++;
cout << count << endl;
```

(v) Swap the strings stored in the variables f and l.

Answer:

```
string temp = f;
f = l;
l = temp;
```

Problem 361   Consider the following C++ program.

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

int main(){

    int i;
    string words[4] = {"zero", "one", "two", "three"};

    for (i = 1; i <= 4; i++) cout << words[4 - i] << " ";        // line A
    cout << endl;

    i = 0;
    while( i + 1 < 4){ cout << words[i+1] << " "; i++; }          // line B
    cout << endl;

    for(i = 0; i < words[1].length(); i++) cout << (words[i])[0];  // line C
    cout << endl;

    return 0;
}
```

(a) What is the output from the loop at line A?

Answer:

```
three two one zero
```

(b) What is the output from the loop at line B?

Answer:

```
one two three
```

(c) What is the output from the loop at line C?

Answer:

```
zot
```

Problem 362   Write a function called *thirdDigit*. The function has an integer parameter and returns the third digit in its parameter. If the parameter is less than 100 the function returns 0 because there is no third digit.
For example, a program that uses the function follows.

```cpp
int main() {
    cout << thirdDigit(777) << " " << thirdDigit(2048) << " " << thirdDigit(500125) << endl;
    return 0;
}
```

It should print: 7 4 0

Answer:

```
int thirdDigit(int x) {
    if (x < 100) return 0;
    if (x < 1000) return x % 10;
    return thirdDigit(x/10);
}
```

Problem 363   Write a function called *sixCount* that returns a count of the number of entries that are equal to 6 in a 2-dimensional array with 6 columns. The function should use a parameter to specify the array and parameters for the row count and column count.

For example, a program that uses the function *sixCount* follows.

```
int main() {
    int arr[2][6] = {{6,4,3,1,2,2}, {6,6,5,2,3,6}};   // array has 4 entries of 6
    cout << sixCount(arr, 2, 6) << endl;              // prints 4
    return 0;
}
```

Answer:

```
int sixCount(int a[][6], int r, int c) {
    int count = 0;
    for (int i = 0; i < r; i++)
      for (int j = 0; j < c; j++)
          if (a[i][j] == 6) count++;
    return count;
}
```

Problem 364   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It asks the user to enter a positive integer n.

2. If n is not positive, it prints an error message and exits.

3. Otherwise it calculates and prints the product of the digits of n.

Here is an example of how the program should work:

```
Enter a positive integer n:   373
The product of its digits is 63
```

In this example the product is $3 \times 7 \times 3$ which is 63.

Answer:

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

int product(int x) {
    if (x < 10) return x;
    return (x % 10) * product(x/10);
}

int main() {
    int n;
    cout << "Enter a positive integer: ";
    cin >> n;

    if (n <= 0) {
```

```
            cout << "That is not POSITIVE." << endl;
            exit(0);
        }

        cout << "The product of its digits is " << product(n) << endl;
        return 0;
}
```

Problem 365   Write a complete C++ program that does the following.

1. It asks the user to enter a positive integer n.

2. It reads n from the user and exits if n is not positive.

3. It prints out an $n \times n$ checkerboard pattern made from the characters X and O.

Here is an example of how the program should work:

```
Give me a positive integer:   3
XOX
OXO
XOX
```

In a checkerboard pattern, the horizontal and vertical neighbors of each X are Os, and the horizontal and vertical neighbors of each O are Xs.

Answer:

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

int main() {
    int n;
    cout << "Give me a positive integer: ";
    cin >> n;

    for (int i = 0; i < n; i++) {
        for (int j = 0; j < n; j++)
            if (((i + j) % 2) == 0) cout << "X";
            else cout << "O";
        cout << endl;
    }
    return 0;
}
```

Problem 366   Write C++ statements to carry out the following tasks. **Do not write complete programs**, just give a single line, or a few lines of C++ instructions. Assume that the following variables have been declared, and if necessary have values, for each part:

```
  string f, l, name;
```

Declare any other variables that you use.

(i) From the input file *data.txt*, read a first name to f and a last name to l.

Answer:

```
    ifstream file("data.txt");
    file >> f >> l;
```

(ii) Print the second character in f to an output file *output.txt*.

Answer:

```
ofstream out("output.txt");
out << f[1] << endl;
```

(iii) Convert the string f to lower case letters and then print it.

Answer:

```
for (int i = 0; i < f.size(); i++)
    f[i] = tolower(f[i]);
cout << f << endl;
```

(iv) Check whether the string f contains the letters *Fred* as a substring. If it does, print the message *Hello Freddy* . Otherwise do nothing.

Answer:

```
if (f.find("Fred") >= 0)
    cout << "Hello Freddy" << endl;
```

(v) Concatenate the strings f and l separated by a space into the string *name*.

Answer:

```
name = f + " " + l;
```

Problem 367   Consider the following C++ program.

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

void mystery(int x[][4], int a, int b, int k) {
  for (int r = 0; r <= a; r++) for (int c = 0; c <= b; c++)
      x[r][c] = k;
}

void print(int x[][4], int s) {
  for (int r = 0; r < s; r++) {
      for (int c = 0; c < s; c++) cout << x[r][c];
      cout << endl;
  }
  cout << endl;
}

int main() {
  int x[4][4];
  mystery(x, 3, 3, 0); print(x, 4);
  mystery(x, 1, 2, 1); print(x, 4);
  mystery(x, 3, 1, 2); print(x, 3);
  mystery(x, 3, 2, 3); print(x, 1);
  return 0;
}
```

(a) What is the output from the first call to the function print?

Answer:

```
0000
0000
0000
0000
```

(b) What is the output from the second call to the function print?

Answer:

```
1110
1110
0000
0000
```

(c) What is the output from the third call to the function print?

Answer:

```
221
221
220
```

(d) What is the output from the fourth call to the function print?

Answer:

```
3
```

Problem 368   Write header lines (prototypes) for the following functions. **Do not attempt to supply the blocks for the functions**.

(a) A function called **lastChar** which uses a string as input and returns the last character in the string.

Answer:

```
char lastChar(string x)
```

(b) A function called **isSquare** that tests whether an integer is a perfect square. (For example, 16 is a perfect square, but -5 is not.)

Answer:

```
bool isSquare(int x)
```

(c) A function called **addTwo** which uses as input an array of integers. The task of the function is to add 2 to every element in the array.

Answer:

```
void addTwo(int a[], int capacity)
```

(d) A function called **exchangeArrays** which uses two arrays of integers that have the same capacity and exchanges the entries between them.

Answer:

```
void exchangeArrays(int a[], int b[], int capacity)
```

(e) A function called **exchange** which exchanges the values of two integers.

Answer:

```
void exchange(int &x, int &y)
```

Problem 369   Write a function called *sevenUp*. The function has an integer parameter and calculates an answer by turning any digit equal to 7 in the input to an 8.

For example, a program that uses the function follows.

```
int main() {
    cout << sevenUp(777) << " " << sevenUp(471) << " " << sevenUp(50) << endl;
    return 0;
}
```

It should print: 888 481 50

Answer:

```
int sevenUp(int x) {
    if (x == 7) return 8;
    if (x < 10) return x;
    return 10*sevenUp(x / 10) + sevenUp(x % 10);
}
```

Problem 370   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It asks the user to enter 9 integers as the entries of a 3×3 table.

2. The program reads the 9 entries, row by row and prints the table.

3. If every row and column of the table have the same sum then the program adds the message: *MAGIC*.

Here is an example of how the program should work:

```
Enter 9 entries of a 3 x 3 table:   10 14 18   15 16 11   17 12 13

10 14 18
15 16 11
17 12 13

MAGIC
```

This example is magic because each row and each column has a sum of 42.

Answer:

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

int main() {
    int table[3][3];
    cout << "Enter 9 entries of a 3 x 3 table: ";

    int r, c;
    for (r = 0; r < 3; r++) for (c = 0; c < 3; c++)
        cin >> table[r][c];

    for (r = 0; r < 3; r++) {
        cout << endl;
        for (c = 0; c < 3; c++) cout << table[r][c] << " ";
    }
    cout << endl;

    int sum = table[0][0] + table[0][1] + table[0][2];
    bool isMagic = true;
    for (int i = 0; i < 3; i++) {
        int rowSum = 0, colSum = 0;
        for (int j = 0; j < 3; j++) {
            rowSum += table[i][j];
```

```
            colSum += table[j][i];
        }
        if (sum != rowSum || sum != colSum) isMagic = false;
    }
    if (isMagic) cout << "MAGIC" << endl;
    return 0;
}
```

Problem 371   Write a complete C++ program that does the following.

1. It asks the user to enter some positive integers.

2. It reads positive integers from the user.

3. As soon as the user enters a non-positive integer, the program stops reading.

4. The program reports the sum of all the positive numbers that it read.

Here is an example of how the program should work:

```
Give me some positive integers:    1 12 1 100 -1000
sum: 114
```

Answer:

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

int main() {
    int sum = 0;
    int n = 1;
    cout << "Give me some positive integers: ";
    while (n > 0) {
        cin >> n;
        if (n > 0) sum += n;
    }
    cout << "sum: " << sum << endl;
    return 0;
}
```

Problem 372   Write C++ statements to carry out the following tasks. **Do not write complete programs**, just give a single line, or a few lines of C++ instructions. Assume that the following variables have been declared, and if necessary have values, for each part:

```
  string f, l;
```

(i) Read a first name to f and a last name to l. Then, print out the string f followed by the string l on another line.
Answer:

```
cin >> f >> l;
cout << f << endl << l << endl;
```

(ii) Print the second character in f.
Answer:

```
cout << f[1];
```

(iii) Convert the string f to upper case letters and then print it.
Answer:

```
for (int i = 0; i < f.size(); i++) f[i] = toupper(f[i]);
cout << f;
```

(iv) Read a word into f from a user. If the program can find the smaller string "reddy" within the string f, print the word "Hello", otherwise do nothing.

Answer:

```
cin >> f;
if (f.find("reddy") >= 0) cout << "Hello";
```

(v) Print the last character of l.

Answer:

```
cout << l[l.size() - 1];
```

Problem 373   Consider the following C++ program.

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

void mystery(char x[][4], int a, int b, char k) {
  for (int r = a; r <= b; r++) for (int c = a; c <= b; c++)
    x[r][c] = k;
}

void print(char x[][4], int s) {
  for (int r = 0; r < s; r++) {
    for (int c = 0; c < s; c++) cout << x[r][c];
    cout << endl;
  }
  cout << endl;
}

int main() {
  char x[4][4];
  mystery(x, 0, 3, 'X'); print(x, 4);
  mystery(x, 1, 2, 'Y'); print(x, 4);
  mystery(x, 2, 3, 'Z'); print(x, 4);
  mystery(x, 3, 2, '0'); print(x, 4);
  return 0;
}
```

(a) What is the output from the first call to the function print?

Answer:

```
XXXX
XXXX
XXXX
XXXX
```

(b) What is the output from the second call to the function print?

Answer:

```
XXXX
XYYX
XYYX
XXXX
```

(c) What is the output from the third call to the function print?

Answer:

```
XXXX
XYYX
XYZZ
XXZZ
```

(d) What is the output from the fourth call to the function print?

Answer:

```
XXXX
XYYX
XYZZ
XXZZ
```

Problem 374   Write header lines (prototypes) for the following functions. **Do not attempt to supply the blocks for the functions**.

(a) A function called **isPrime** that tests whether an integer is prime. (For example, 7 is prime, but 9 is not.)

Answer:

```
bool isPrime(int x)
```

(b) A function called **firstChar** which uses a string as input and returns the first character in the string.

Answer:

```
char firstChar(string x)
```

(c) A function called **printThree** which uses as input an array of integers. The task of the function is to print the first three elements of the array.

Answer:

```
void printThree(int x[])
```

(d) A function called **printChess** which uses as input an 8×8 array of characters that represents a chess board. The task of the fuction is to print the board to output.

Answer:

```
void printChess(char x[][8], int r, int c)
```

(e) A function called **reverseWord** which is to use a string parameter and change it to become the string obtained by reversing its letters. (For example, an input string *was* would be changed to *saw*.)

Answer:

```
void reverseWord(string &x)
```

Problem 375   Write a function called *biggestEntry* that uses a two dimensional array (with 3 columns) with integer entries as its first parameter. It also uses parameters representing the row and column capacities. The function should return the value of the biggest entry in the array.

For example, a program that uses the function follows.

```
int main() {
   int x[2][3] = {{1,2,3},{4,7,3}};
   cout << biggestEntry(x, 2, 3) << endl;
   return 0;
}
```

It should print 7 (since 7 is the biggest entry in the array).

Answer:

```
int biggestEntry(int a[][3], int r, int c) {
   int answer = a[0][0];
   for (int i = 0; i < r; i++) for (int j = 0; j < c; j++)
      if (a[i][j] > answer) answer = a[i][j];
   return answer;
}
```

Problem 376   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It asks the user to enter a positive integer value, n.

2. The program reads a value entered by the user. If n is not positive, the program should exit.

3. It prints out the number of digits in n.

4. It prints the number digits in the binary representation of n.

Here is an example of how the program should work:

```
Enter a positive integer n: 17
Digits in n: 2
Binary digits in n: 5
```

The number of binary digits is 5 because the binary representation of 17 is 10001. However, it is not necessary for your program to determine this binary representation.

Answer:

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

int length(int x, int base) {
   if (x < base) return 1;
   return 1 + length(x / base, base);
}

int main() {
   int n;
   cout << "Enter a positive integer n: ";
   cin >> n;
   if (n <= 0) exit(1);
   cout << "Digits in n: " << length(n, 10) << endl;
   cout << "Binary digits in n: " << length(n, 2) << endl;
   return 0;
}
```

Problem 377   Write a complete C++ program that does the following.

1. It asks the user to enter 5 single digit positive integers.

2. If any number is out of range, it says: "That is too hard."

3. Otherwise it adds the numbers and prints their sum.

Here is an example of how the program should work:

```
Give me 5 single digit positive integers:   9 9 9 6 9
42
```

Answer:

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

int main() {
    int answer = 0, x;
    cout << "Give me 5 single digit positive integers: ";
    for (int i = 1; i <= 5; i++) {
        cin >> x;
        if (x <= 0 || x >= 10) {
            cout << "That is too hard." << endl;
            exit(0);
        }
        answer += x;
    }
    cout << answer << endl;
    return 0;
}
```

Problem 378   Write C++ statements to carry out the following tasks. Do not write complete programs, just give a single line, or a few lines of C++ instructions. Assume that the following variables have been declared, and if necessary have values, for each part:

```
int x;
string f, l;
```

(i) Read a user's first name to f and their last name to l.

Answer:

```
cin >> f >> l;
```

(ii) Print out the string f followed by the string l with a space between them.

Answer:

```
cout << f << " " << l;
```

(iii) Set x to be $1 - 2 + 3 - 4 + 5 - \ldots + 999$. The formula involves all integers from 1 to 999. Odd numbers are added, even numbers subtracted.

Answer:

```
x = 0;
for (int i = 1; i < 1000; i++)
    if (i % 2 == 0) x -= i;
    else x += i;
```

(iv) Repeatedly double x, until the value of x exceeds 1024.

Answer:

```
while (x <= 1024) x *= 2;
```

(v) Read a word into f from a user. If the word is "Freddy", print output saying "Hello", otherwise do nothing.

Answer:

```
cin >> f;
if (f == "Freddy") cout << "Hello" << endl;
```

Problem 379   Consider the following C++ program.

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

void mystery(string array[], int p[], int q) {
   if (q < 0) cout << "Help!" << endl;
   else if (q <= 2) cout << p[q] << endl;
   if (q > 2) {
     for (int i = 0; i <= q; i++) cout << array[p[i]] << " ";
     cout << endl;
   }
}

int main() {
  string x[5] = {"This", "is", "a", "dumb", "question"};
  int a[10] = {0, 4, 1, 3, 3, 3, 2, 2, 2, 2};
  mystery(x, a, -10);
  mystery(x, a, 0);
  mystery(x, a, 1);
  mystery(x, a, 3);
  mystery(x, a, 5);
  return 0;
}
```

(a) What is the output from the first call to the function mystery?

Answer:

```
Help!
```

(b) What is the output from the second call to the function mystery?

Answer:

```
0
```

(c) What is the output from the third call to the function mystery?

Answer:

```
4
```

(d) What is the output from the fourth call to the function mystery?

Answer:

```
This question is dumb
```

(e) What is the output from the fifth call to the function mystery?

Answer:

```
This question is dumb dumb dumb
```

Problem 380   Write header lines (prototypes) for the following functions. **Do not attempt to supply the blocks for the functions**.

(a) A function called **isLeapYear** that tests whether an integer represents a leap year. (For example, 2008 is a leap year, but 2007 is not.)

Answer:

```
bool isLeapYear(int y)
```

(b) A function called **temperatureDifference** which uses as input two double precision values that represent the temperature in New York measured in degrees Fahrenheit and the temperature in Paris measured in degrees Celsius. The function is to calculate and return the difference between the temperatures in degrees Fahrenheit.

Answer:

```
double temperatureDifference(double n, double p)
```

(c) A function called **addCurve** which uses as input an array of integer test scores. The task of the function is to add 10 to every score in the array.

Answer:

```
void addCurve(int s[], int capacity)
```

(d) A function called **printTicTacToe** which uses as input a 3×3 array of characters that represents a Tic-Tac-Toe game. The task of the fuction is to print the board to output.

Answer:

```
void printTicTacToe(char [][3])
```

(e) A function called **reverseDigits** which is to use an integer parameter and return the integer obtained by reversing the digits in the parameter.

Answer:

```
int reverseDigits(int x)
```

Problem 381   Write a function called *biggestDigit* that uses an integer input parameter and returns the largest digit in the input. The input should be assumed to be positive.

For example, a program that uses the function follows.

```
int main() {
    cout << biggestDigit(1760) << endl;
    return 0;
}
```

It should print 7 (since 7 is the biggest digit in 1760).

A little extra credit will be given for good recursive solutions.

Answer:

```
int biggestDigit(int x) {
    if (x < 10) return x;
    int b = biggestDigit(x/10);
    if (x % 10 > b) return x % 10;
    return b;
}
```

Problem 382   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It asks the user to enter a positive integer value, n that is at most 100.

2. The program reads a value entered by the user. If n is not positive, or n is greater than 100, the program should exit.

3. It prints out all numbers between 1 and 1000 for which the sum of the digits is exactly n.

For example, if the user chooses 13 for n, the program should print out 49 because $4 + 9 = 13$. It would also print 58, 67, and other numbers with the same digit sum. It would not print 48 or 50.

(Suggestion: It might be convenient to write a function called *digitSum*.)

Answer:

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

int digitSum(int x) {
```

```
    if (x < 10) return x;
    return x % 10 + digitSum(x/10);
}

int main() {
   int n;
   cout << "Enter a value of n that is at most 100:";
   cin >> n;
   if (n <= 0 || n > 100) exit(0);

   for (int x = 1; x <= 1000; x++)
     if (digitSum(x) == n) cout << x << " ";
   cout << endl;
   return 0;
}
```

Problem 383   Write a complete C++ program that does the following.

1. It asks the user to enter a (single) first name.

2. The program stores the name, but if it is "Freddy", the program changes it to "you".

3. The program says hello to the user, using their name (or changed version).

Here is an example of how the program should work:

```
Who are you?    Max
Hello Max.
```

Answer:

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

int main() {
   string name;
   cout << "Who are you?    ";
   cin >> name;
   if (name == "Freddy") name = "you";
   cout << "Hello " << name << "." << endl;
   return 0;
}
```

Problem 384   Write C++ statements to carry out the following tasks. Do not write complete programs, just give a single line, or a few lines of C++ instructions. Assume that the following variables have been declared, and if necessary have values, for each part:

```
  int x;
  string s;
```

(i) Read a user's first name to s and their age to x.
Answer:

```
cout << "Enter your name and age: ";
cin >> s >> x;
```

(ii) Print out the number of characters in the string s.
Answer:

```
cout << s.size();
```

(iii) Set x to be $1^3 + 2^3 + \ldots + 71^3$, the sum of the cubes of the numbers from 1 to 71.

Answer:

```
x = 0;
for (int i = 1; i <= 71; i++)
   x += i * i * i;
```

(iv) Repeatedly generate and add a random value between 1 and 6 to x, until the value of x exceeds 100.

Answer:

```
x = 0;
while (x <= 100)
   x += (rand() % 6 + 1);
```

(v) Read a complete line of text into s from a user. If their text includes a substring "Queens", print output saying "College", otherwise do nothing.

Answer:

```
getline(cin, s);
if (s.find("Queens", 0) >= 0) cout << "College";
```

Problem 385   Consider the following C++ program.

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

void mystery(int &p, int q) {
  int temp = p;
  p = q;
  q = temp;
}

int main() {
  int p, q;
  for (p = 0; p < 5; p++) cout << p; cout << endl;
  for (q = 0; q < 5; ++q) cout << q;
  cout << endl;
  for (p = 3; p < 6; p++)
    for (q = 1; q <= 3; q++)
       cout << p - q; cout << endl;
  p = 4; q = 14;
  mystery(q, p);
  cout << p << " " << q << endl;
  p = 4; q = 14;
  cout << ++p - q-- << endl;
  return 0;
}
```

What is the output from the program?

Answer:

```
01234
01234
210321432
4 4
-9
```

Problem 386   Write header lines (prototypes) for the following functions. Do not attempt to supply the blocks for the functions.

(a) A function called **numberDigits** that is to return the number of digits of an integer.

Answer:

```
int numberDigits(int x)
```

(b) A function called **differenceMax** which is to return the difference between the maximum entries in two arrays of integers. (Do not assume that the arrays have the same capacities.)

Answer:

```
int differenceMax(int a[], int capA, int b[], int capB)
```

(c) A function called **swap** which is used to swap two values of type double.

Answer:

```
void swap(double &x, double &y)
```

(d) A function called **firstCharacter** which is to return the first character in a string.

Answer:

```
char firstCharacter(string s)
```

(e) A function called **median** which is to return the median (middle valued) entry in an array that holds an odd number of integer entries.

Answer:

```
int median(int a[], int cap)
```

Problem 387   Write a function called *plusTax* that uses parameters that specify a price (in cents) and a tax rate (as a percentage). The function calculates the amount of tax, rounded to the nearest cent. (Half cents must round up.) It adds the tax to the price and returns the result.

For example, a program that uses the function follows.

```
int main() {
    int cost = 100;        // cost is 100 cents
    double taxRate = 4.8;  // tax is at 4.8 percent
    cout << "With tax that is " << plusTax(cost, taxRate) << " cents." << endl;
    return 0;
}
```

It should find a tax of 4.8 cents, round up to 5 cents and print:

```
With tax that is 105 cents.
```

Answer:

```
int plusTax(int price, double rate) {
    double tax = price * rate / 100;
    int rounded = (int) (tax + 0.5);
    return price + rounded;
}
```

Problem 388   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It asks the user to enter a positive integer value, n that is at most 100.

2. The program reads a value entered by the user. If n is not positive, or n is greater than 100, the program should exit.

3. The program reads n integers from the user and then prints their last digits in reverse order of input.

For example, a run of the program might be as follows:

```
What is n?    7
Enter 7 numbers:    143 259 63 17 12 8 9
9 8 2 7 3 9 3
```

Answer:

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

int main() {
    int i, n;
    int numbers[100];
    cout << "What is n?  ";
    cin >> n;
    if (n <= 0 || n > 100) exit(1);

    cout << "Enter " << n << " numbers: ";
    for (i = 0; i < n; i++) cin >> numbers[i];
    for (i = n - 1; i >= 0; i--) cout << numbers[i] % 10 << " ";
    cout << endl;
    return 0;
}
```

Problem 389   Write a complete C++ program that first asks a user to do a simple math problem of your choosing. The user enters an answer and the program grades it as right or wrong.

For example the program might ask about 6×9 and respond to an incorrect answer of 42 as follows:

```
What is 6 x 9?
    42
Wrong!
```

Your program can always ask the same question. **Answer:**

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

int main() {
    int x;
    cout << "What is 6 x 9? ";
    cin >>  x;
    if (x != 54) cout << "Wrong!" << endl;
    else cout << "Right!" << endl;
}
```

Problem 390   Write a complete C++ program that asks a user to enter the prices of 100 different grocery items (each price as a decimal showing dollars and cents). The program calulates and prints the total cost of the items.

Answer:

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

int main() {
    double prices[100];
    cout << "Enter 100 item costs: " << endl;
    for (int i= 0; i < 5; i++) {
        cin >> prices[i];
```

```
    }
    double total = 0.0;
    for (int i = 0; i < 5; i++)
        total += prices[i];
    cout << "The total cost is: $" << total << endl;
}
```

Problem 391

Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It asks the user to enter a positive integer value, x.

2. The program reads a value entered by the user. If the value is not positive, the program repeatedly makes the user type in another value until a positive value of x has been entered. (Note positive means greater than 0.)

3. The program prints out x squares on top of each other, the first with size 1, the second with size 2, and so on.

For example, if the user enters 3 for x the program should print:

```
*

**
**

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

Answer:

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

void square(int s) {
  for (int row = 1; row <= s; row++) {
    for (int col = 1; col <= s; col++)
        cout << "*";
    cout << endl;
  }
  cout << endl;
}

int main() {
    int x;
    cout << "What is x? ";
    cin >> x;

    while (x <= 0) {
        cout << "Please give a positive value for x: ";
        cin >> x;
    }

    for (int i = 1; i <= x; i++) square(i);
}
```

Problem 392   Write a function called *percent* that uses two parameters x and y and returns the ratio x/y as a percentage.

For example, a program that uses the function percent follows.

```
int main() {
    double z;
    z = percent(1.5, 3.0);
    cout << z << endl;
}
```

It should print:

```
50.0
```

because $1.5/3 = 1/2 = 50\%$.

Answer:

```
double percent(double a, double b) {
    return 100 * a / b;
}
```

Problem 393   Write a C++ function called *range* that returns the difference between the largest and smallest elements in an array.

It should be possible to use your function in the following program. (The output from this program is 10 because the difference between the largest element 13 and the smallest element 3 is $13 - 3 = 10$).

```
main() {
    int data[6] = {11, 12, 11, 3, 12, 13};
    int x;
    x = range (data, 6);
       //   data is the array to search, 6 is the number of elements of the array
    cout << "The range is: " << x  << endl;
}
```

Answer:

```
int range(int d[], int c) {
  int min = d[0];
  int max = d[0];
  for (int i = 1; i < c; i++) {
     if (d[i] < min) min = d[i];
     if (d[i] > max) max = d[i];
  }
  return max - min;
}
```

Problem 394   Consider the following C++ program.

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

void mystery(int data[], int p, int q) {
  data[p] = data[q];
  data[q] = 0;
}

void print(int data[], int p) {
  for (int i = 0; i < p; i++)
     cout << data[i] << " ";
  cout << endl;
}

main() {
  int scores[8] = {3, 1, 4, 1, 5, 9, 2, 6};
  int quiz[7] = {0, 1, 2, 3, 4, 5, 6};
  print(quiz, 4);
  print(scores, 4);
  mystery(scores, 3, 4);
  print(scores, 8);
  for (int i = 0; i < 3; i++)
     mystery(quiz, i, i+ 1);
  print(quiz, 7);
}
```

What is the output from the program?

Answer:

```
0 1 2 3
3 1 4 1
3 1 4 5 0 9 2 6
1 2 3 0 4 5 6
```

Problem 395   Write C++ functions called *elementSwap* and *swap* that swap either the values of two elements of an array or the values of two variables.

It should be possible to use your function in the following program. (The output from this program is: 4 3 because the values of x and y are exchanged.)

```
main() {
    int a[6] = {11, 12, 11, 3, 12, 13};
    int x = 3, y = 4;
    elementSwap(a, 0, 5);
    swap(x, y);
    cout << x  << " " << y << endl;
}
```

Answer:

```
void elementSwap(int a[], int x, int y) {
  int temp = a[x];
  a[x] = a[y];
  a[y] = temp;
}

void swap(int &x, int &y) {
    int temp = x;
    x = y;
    y = temp;
}
```


Problem 396   Write a complete C++ program that asks a user to enter the 10 quiz scores for each student in a class of 30 students. For each of the 10 quizzes, the program decides which student(s) have got the highest scores and prints their numbers. (Hint: Store quiz data in a table.)

Sample output might look like:

```
Top Scores:

Quiz 0:   Students: 5 17 23
Quiz 1:   Students: 2 11 17 26
Quiz 2:   Students: 2 17 23 26 27

and so on....
```

Answer:

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

void topScores(int quiz[][10], int n, int q) {
    int max = quiz[0][q];
    int s;
    for (s = 1; s < n; s++)
      if (quiz[s][q] > max) max = quiz[s][q];
    cout << "Quiz " << q << ":   Students: ";
    for (s = 0; s < n; s++)
      if (quiz[s][q] == max) cout << s << " ";
    cout << endl;
}

int main() {
```

```
    int quiz[30][10];
    int s, q;

    for (s = 0; s < 30; s++) {
        cout << "Enter 10 quiz scores for student " << s << " : ";
        for (q = 0; q < 10; q++)
            cin >> quiz[s][q];
    }

    for (q = 0; q < 10; q++) topScores(quiz, 30, q);
    return 0;
}
```

Problem 397   Consider the following C++ program. What is the output?

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

main() {
    int i = 1, j = 1, k = 1;
    while (i < 10)
        cout << i++;
    cout << endl;
    while (j < 10)
        cout << ++j;
    cout << endl;
    while (++k < 10)
        cout << k++;
    cout << endl;

    return 0;
}
```

Answer:

```
123456789
2345678910
2468
```

Problem 398   Write a complete C++ program that does the following:

1. It generates two random numbers x and y each between 1 and 100. (You should use the functions *rand* and *srand*.)

2. It adds x and y to make a secret code.

3. It prints the secret code.

For example, if the program generated the numbers $x = 11$ and $y = 13$ which add to 24, the output would be:

```
The secret code is 24.
```

Answer:

```
#include <iostream>
#include <stdlib.h>
#include <time.h>
using namespace std;
```

```
int main() {
  srand(time(NULL));
  int x, y;
  x = rand() % 100 + 1;
  y = rand() % 100 + 1;
  int code = x + y;
  cout << " The secret code is " << code << endl;
  return 0;
}
```

Problem 399   Write a complete C++ program that does the following. (Programs that correctly carry out some of the tasks will receive partial credit.)

1. It asks the user to enter a positive integer value, x.

2. The program reads the value entered by the user.

3. If the value is not positive, the program terminates. Otherwise, the program prints a checkerboard pattern that forms a square of side x.

For example, if the user enters 5 for x the program should print the following diagram with 5 lines.

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

(Hint: How is an even numbered row printed? How about an odd numbered row?)

Answer:

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

int main() {
   int x;
   cout << "Enter a positive integer value, x:";
   cin >> x;
   if (x <= 0) exit(1);

   for (int r = 1; r <= x; r++) {
     for (int c = 1; c <= x; c++) {
        if ((r + c) % 2 == 0) cout << "*";
        else cout << " ";
     }
     cout << endl;
   }

   return 0;
}
```

Problem 400   Write a C++ function called *negSum* that returns the sum of all negative elements in an array of integers.

It should be possible to use your function in the following program. (The output from this program is -12 because the negative elements -5, -4, and -3 have a sum of $-12 = -5 + (-4) + (-3)$.)

```
main() {
   int data[6] = {-5, -4, 1, 3, 2, -3};
   int x;
```

```
      x = negSum (data, 6);
        //   data is the array to search, 6 is the number of elements of the array
      cout << "The negative sum is: " << x  << endl;
}
```

Answer:

```
int negSum(int array[], int cap) {
    int answer = 0;
    for (int i = 0; i < cap; i++)
        if (array[i] < 0) answer += array[i];
    return answer;
}
```

Problem 401   Write header lines (prototypes) for the following functions. Do not supply the blocks for the functions.

(a) A function called **isOdd** that is used to decide whether an integer is odd.

Answer:

```
bool isOdd(int x)
```

(b) A function called **max** which determines the largest of 3 double precision values.

Answer:

```
double max(double x, double y, double z)
```

(c) A function called **swap** which is used to swap two integer values.

Answer:

```
void swap(int &x, int &y)
```

(d) A function called **total** which is to find the sum of all entries in an array of integers.

Answer:

```
int total(int array[], int cap)
```

(e) A function called **maxIndex** which is to find the index of the largest element in an array of double precision values.

Answer:

```
int maxIndex(double array[], int cap)
```

(f) A function called **sort** which is to sort an array of integers into order.

Answer:

```
void sort(int array[], int cap)
```

Problem 402   Write a complete C++ program that:

1. Asks a user to enter the number of students in a class and the number of quizzes taken by the class.

2. If either of these numbers is less than 1 or more than 99 the program should exit.

3. The program should then prompt the user to enter all of the scores for each of the quizzes, starting with all scores for Quiz 1, followed by all scores for Quiz 2 and so on.

4. The program should print the number of the student with the highest total.

Number students and quizzes starting at 1.

A sample run of the program might look like:

```
How many students:   3
How many quizzes:    4

Enter scores for Quiz 1:   10   7 0
Enter scores for Quiz 2:   10 10 0
Enter scores for Quiz 3:   10   6 0
Enter scores for Quiz 4:   10   9 0

Student 1 got the highest total.
```

Answer:

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

int main() {
   int score[100][100];
   int r, c;
   int totals[100];
   int numStudents, numScores;

   cout << "Enter the number of students and the number of quizzes: ";
   cin >> numStudents >> numScores;
   if (numStudents <= 0 || numStudents >= 100
         || numScores <= 0 || numScores >= 100) exit(1);

   for (r = 1; r <= numScores; r++) {
      cout << "Enter the scores for Quiz " << r << ": ";
      for (c = 1; c <= numStudents; c++) cin >> score[r][c];
   }

   for (c = 1; c <= numStudents; c++) totals[c] = 0;
   for (r = 1; r <= numScores; r++) {
      for (c = 1; c <= numStudents; c++)
         totals[c] += score[r][c];
   }

   int topStudent = 1;
   for (c = 1; c <= numStudents; c++)
      if (totals[c] > totals[topStudent])
         topStudent = c;
   cout << "Student " << topStudent << " got the highest total." << endl;
   return 0;
}
```