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 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 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() {
   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 3   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 4   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] = {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 5   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 6   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 7   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 8   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 9   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 10   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 11   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 12   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 13   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 14   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] = {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 15   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 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)

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

(b)

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

(c)

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

(d)

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

(e)

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

Problem 16   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 17   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 18   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 19   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 20   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 21   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 22   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 23   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 24   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 25   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 26   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 27   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 28   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 29   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 30   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 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 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 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() {
    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 33   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 34   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 35   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 36   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 37   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 38   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 39   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 40   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 41   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 42   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 43   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 44   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 45   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 46   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 47   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 48   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 49   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 50   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 51   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 52   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 53 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 54 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 55   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 56   Consider the following C++ program. It is compiled to **a.out** and executed with the command
./a.out CS111.

```
#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 57   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 58   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] = {"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 59   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 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 60   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 61   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 62   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 63   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 64   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 65   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 66   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 67   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 68   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 69   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 70   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 71   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 72   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 73   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 74   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 75   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 76   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 77   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 78   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 79   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 80   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 81   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 82   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 83   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 84   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 85   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 86   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:

```
#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 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 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:

```
#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 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 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 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:

```
#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 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 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:

```
#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 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 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 91   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 92   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 93   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 94   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 95   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 96   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 97   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 98   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 99   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 100   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 101   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 102   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 103   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 104   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:

```cpp
#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 105   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}};

   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 106   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 107   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 arrray 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 108   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 109   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
ABCCCC
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 110   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 111   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 112   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 113   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 114   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 115   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 116   Consider the following C++ program.

```cpp
#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:

13
12

Problem 117   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 118   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 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 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:

```cpp
#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 120   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}};

   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:

```cpp
double twoD(double a, int b)
```

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

Answer:

```cpp
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 121   Consider the following C++ program.

```cpp
#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:

3

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

Answer:

4
2

Problem 122   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 123   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 124   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 125   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 126   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 127   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.

```
#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:

```
int main(int x, char  *y[]) {         // line a
```

(b) Correct line (b):

Answer:

```
    if (f == 0) return 0;             // line b
```

(c) Correct line (c):

Answer:

```
    while (1 == 1) {                  // line c
```

(d) Correct line (d):

Answer:

```
        x -= 1;                       // line d
```

(e) Correct line (e):

Answer:

```
    cout <<  y[x] << endl;          // line e
```

Problem 128   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 129   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 130   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:

```cpp
#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 131   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[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:

```cpp
int subtract(int z, int y)
```

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

Answer:

```cpp
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 132   Consider the following C++ program.

```
#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:

5

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

Answer:

6
6

Problem 133   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 134   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 135   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 136   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:

```cpp
#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 137   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() {
   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:

```cpp
double decimalPart(double x)
```

(b) Title line for **medianPosition** as called at the line marked (b).

Answer:

```cpp
void medianPosition(double x[], int cap)
```

(c) Title line for **swap1** as called at the line marked (c).

Answer:

```cpp
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 138   Consider the following C++ program.

```
#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 139   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 140   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 141   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 142 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:

```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 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 143   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() {
   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:

```cpp
bool isTrue(bool x)
```

(b) Title line for **allTrue** as called at the line marked (b).
Answer:

```cpp
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 144   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 145   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 146   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 147   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 148   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 perimimeter 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 = '0';
      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 149   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 150   Consider the following C++ program.

```
#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 151   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 152   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 153   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 154   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:

```
#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 155   Write **title lines** for the functions that are called by the following main program. **Do not supply the blocks for the functions.**

```
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:

```
bool isT(char x)
```

(b) Title line for **allTrue** as called at the line marked (b).

Answer:

```
void allTrue(char b[], int cap)
```

(c) Title line for **swap1** as called at the line marked (c).

Answer:

```
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 156   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 157 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 158 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 159 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 160   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:

```
#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 161   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 << 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:

```
double decimalPart(double x)
```

(b) Title line for **median** as called at the line marked (b).
Answer:

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

(c) Title line for **swap1** as called at the line marked (c).
Answer:

```
void swap1(int &x, int &y)
```

(d) Title line for **swap2** as called at the line marked (d).
Answer:

```
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 162   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 163   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 164   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 165   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 166   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 167   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 168   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 169   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 170   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 171   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 172 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 173   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 174   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 175   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 176   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 177   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 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 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 179   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 180   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(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 181   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 182   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 183   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 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 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 185 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 186   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 187   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 188   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 189   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 190   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 191   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 192   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 193   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 194   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 195   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 196   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 197   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 198   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 199   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 200   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 201   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 202   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 203   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 204   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 205   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 206   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 207   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 208   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 209   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 210   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 211   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 212   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 213   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 214   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 215   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 216   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 217   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 218   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 219   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 220   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 221   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 222 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:

```cpp
#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 223 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 224   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 225   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 226   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 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() {
   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 228   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 229   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 230   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 231   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 232   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 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() {
   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 234   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 235 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 236   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 237   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:

```
exSla1lm1
```

Problem 238   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 239   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 240   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 241   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 242   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 243   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:

```
eSx11al1m
```

Problem 244   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 245 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 246   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 247   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 248   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 249   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 250   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 251   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 252   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 253   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 254   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 255   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 256 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 257   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 258   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 259   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 260   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 261   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 262   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 263   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 264   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 265   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 266   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 267   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 268   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 269   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 270   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 271   Consider the following C++ program.

```
#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 272   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.

```
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 273   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 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 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 275   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 276   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 277   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 278   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 279   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 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 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 281   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 282   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 283   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 284   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 285   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 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 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 287   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 288   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 289   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 290   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 291   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 292   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 293   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 294   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 295   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 296   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 297   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 298   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 299   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 300   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 301

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 302   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 303   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 304   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 305   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 306   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 307   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 308   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 309   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 310   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 311   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 312   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;
}
```