Assume that all variables without declaration shown in the following program segments have already been declared properly. Integers in problem statements are 32-bit signed variables (**Pascal**: `longint`, **C**: `int`). Assume all the programs are compiled properly without using any compiler flag (except the `"-o"` option in **C**).

	Format	# Questions	Total Marks
Section A1	True or False	5	5
Section A2	Multiple Choice	20	20
Section B	Fill-in-the-blanks	7 (A-M)	20
Total			**45**

Section A1 (5 marks)

For each question, determine whether the statement is true or false, then mark the corresponding box (**T** or **F**) on the answer sheet. One mark for each correct answer. No marks will be deducted for wrong answers.

1. One of the ways for a vending machine to distinguish coins is by analyzing changes in magnetic flux when a coin passes through a sensor.

2. Evaluate the following expression. (For **C** version: `0` is equivalent to `false` and `1` is equivalent to `true`)

Pascal Version	C Version
`true or false and false`	`1 || 0 && 0`

3. The value stored in a variable of data type `char` has 128 possibilities.

4. Given the same input, if a program produces no error when running the first time, it must produce no error in the next time.

5. There exists a right-angled triangle, such that the side lengths of the triangle are all prime numbers.

Section A2 (20 marks)

For each question, choose the most appropriate answer and mark the corresponding box (**A**, **B**, **C** or **D**) on the answer sheet. One mark for each correct answer. No marks will be deducted for wrong answers.

6.   How many different possible outputs are there for the following program? Assume input will always be a 32-bit signed integer.

Pascal Version
```
var
  x: longint;
begin
  read(x);
  write((x mod 5) mod 3)
end.
```

C Version
```
#include <stdio.h>
int x;
int main() {
  scanf("%d", &x);
  printf("%d", (x % 5) % 3);
  return 0;
}
```

   A.   2
   B.   3
   C.   4
   D.   5

7.   a, b and c are integers. Consider the following program segment:

Pascal Version
```
a := b;
b := c;
c := a;
```

C Version
```
a = b;
b = c;
c = a;
```

At the end of the program segment, which of the following must be true?

Pascal Version
         i.   a = b
        ii.   b = c
       iii.   a = c

C Version
         i.   a == b
        ii.   b == c
       iii.   a == c

   A.   i only
   B.   ii only
   C.   iii only
   D.   i, ii and iii

8.   What is the output of the following program?

Pascal Version

```
var
  a, b, c: longint;
begin
  a := 1;
  b := 2016;
  c := 0;
  while (b > a) do
  begin
    b := b - 5;
    a := a + 6;
    c := c + 1
  end;
  write(c)
end.
```

C Version

```c
#include <stdio.h>
int a, b, c;
int main(){
  a = 1;
  b = 2016;
  c = 0;
  while (b > a){
    b = b - 5;
    a = a + 6;
    c = c + 1;
  }
  printf("%d", c);
  return 0;
}
```

   A.   182
   B.   183
   C.   184
   D.   185

9.   Consider the following program:

Pascal Version

```
var
  n, i: longint;
begin
  read(n);
  for i := 2 to n - 1 do
  begin
    if (n mod i = 0) then
    begin
      write('Composite');
      halt
    end
  end;
  write('Prime')
end.
```

C Version

```c
#include <stdio.h>
int n, i;
int main() {
  scanf("%d", &n);
  for (i = 2; i <= n - 1; i++) {
    if (n % i == 0) {
      printf("Composite");
      return 0;
    }
  }
  printf("Prime");
  return 0;
}
```

The input n is always an integer between 2 and 100000000 (inclusive). Which of the following statements is correct?

   A.   Although it is not the most efficient way to do so, the program correctly determines whether n is a prime or a composite
   B.   The program may output nothing
   C.   There exists a valid input n that will cause runtime error.
   D.   When n is a square number, such as 4, 9, 16, ..., the program always output "Prime"

10.   Consider a 4 × 5 grid:

```
S....
.....
.....
....E
```

A robot that can only walk right or down is put into the cell S. By simple counting, there are 35 different paths for it to reach E. Now, an obstacle is put to block an empty cell (which will not be S or E) in order to minimize the number of different paths for the robot to reach E. What will that minimum number be?

   A.   12
   B.   15
   C.   17
   D.   20

For questions 11 to 12, consider the following program:

Pascal Version

```pascal
var
  i, j: longint;
  tri: array[0..14, 0..14] of longint;
begin
  for i := 0 to 14 do
    for j := 0 to 14 do
      tri[i][j] := 0;
  tri[0][0] := 1;
  for i := 1 to 14 do
  begin
    tri[i][0] := 1;
    tri[i][i] := 1;
    for j := 1 to i - 1 do
      tri[i][j] := tri[i - 1][j] +
          tri[i - 1][j + 1]
  end;
  write(tri[7][1], ' ', tri[13][7])
end.
```

C Version

```c
#include <stdio.h>
int tri[15][15], i, j;
int main(){
  for (i = 0; i <= 14; i++)
    for (j = 0; j <= 14; j++)
      tri[i][j] = 0;
  tri[0][0] = 1;
  for (i = 1; i <= 14; i++) {
    tri[i][0] = 1;
    tri[i][i] = 1;
    for (j = 1; j <= i - 1; j++)
      tri[i][j] = tri[i - 1][j] +
          tri[i - 1][j + 1];
  }
  printf("%d %d", tri[7][1],
    tri[13][7]);
  return 0;
}
```

11.   What is the first output number?
   A.   7
   B.   13
   C.   21
   D.   1716

12.   What is the second output number?
   A.   7
   B.   13
   C.   21
   D.   1716

13.   Which of the following is the possible number of distinct permutation of 42 numbers? (There could be repeated numbers)

    i.   1
    ii.   2
    iii.   42
    iv. $1 \times 2 \times 3 \times \cdots \times 40 \times 41 \times 42$

  A.   iii only
  B.   iv only
  C.   i, iii and iv only
  D.   i, ii, iii and iv

14.   What is the minimum number of comparisons to determine the index of the maximum element in an array with 42 distinct numbers?

  A.   41
  B.   42
  C. $\dfrac{41 \times 42}{2}$
  D. $1 \times 2 \times 3 \times \cdots \times 40 \times 41 \times 42$

15.   Which of the following can be implemented using one or more arrays? Assume that the arrays are large enough.

    i.   Stack
    ii.   Queue
    iii.   Linked List

  A.   i only
  B.   ii only
  C.   i and ii only
  D.   i, ii and iii

16.   Considering the following program: (Variable declarations and implementations of P_push, P_pop, Q_push, Q_pop are omitted)

Pascal Version

```
var
  i: longint;
  a: array[0..7] of longint;
begin
  for i := 0 to 7 do
    read(a[i]);
  for i := 0 to 7 do
    P_push(a[i]);
  for i := 0 to 7 do
    Q_push(P_pop());
  for i := 0 to 6 do
    write(Q_pop(), ' ');
  write(Q_pop())
end.
```

C Version

```
#include <stdio.h>
int i, a[8];
int main() {
  for (i = 0; i <= 7; i++)
    scanf("%d", &a[i]);
  for (i = 0; i <= 7; i++)
    P_push(a[i]);
  for (i = 0; i <= 7; i++)
    Q_push(P_pop());
  for (i = 0; i <= 6; i++)
    printf("%d ", Q_pop());
  printf("%d", Q_pop());
}
```

Suppose P, Q are data structures. Suppose functions/procedures `P_push()`, `Q_push()`, `P_pop()` and `Q_pop()` are correctly implemented for the corresponding data structures. The input is an array of 8 integers separated by spaces. Which of the following combinations of P and Q will output the reversed array?

    i.   P: Stack, Q: Stack
    ii.   P: Stack, Q: Queue
    iii.   P: Queue, Q: Stack
    iv.   P: Queue, Q: Queue

A.   i only
B.   ii only
C.   ii and iii only
D.   iv only

For questions 17 to 18, imagine that we have a infinitely large International Chess chessboard in which the cell on row x and column y can be denoted as (x, y).

17.   A "Bishop" can move to any cell in 4 diagonal directions in one step as shown in the following diagram:
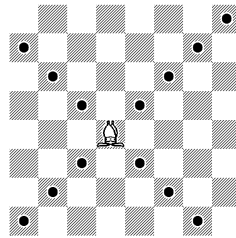
Given that there is only one bishop on the chessboard and it is positioned at $(24, 12)$, which of the following cell(s) could it visit in **arbitrary number of steps**?

    i. $(77, 53)$
    ii. $(24, 1)$
    iii. $(58, 12)$

A.   ii only
B.   i and ii only
C.   i and iii
D.   i, ii and iii

18.   On the other hand, a "King" can move to one of 8 neighboring cells in one step as shown in the following diagram:
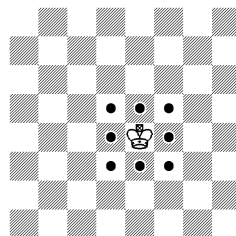
Given that there is only one king on the chessboard and it is positioned at $(2552, 121)$, what is the minimum number of steps required to move it to $(37, 3736)$?

A.   3615
B.   6129
C.   6130
D.   6131

19.　　What is the output of the following program?

Pascal Version

```
var
  i, j: longint;
  x: array[0..999] of longint;
begin
  for i := 1 to 999 do
    x[i] := 0;
  for i := 2 to 999 do
    if x[i] = 0 then
    begin
      j := i;
      while (j <= 999) do
      begin
        x[j] := x[j] + 1;
        j := j + i
      end
    end;
  write(x[30] + x[37] +
      x[60] + x[999])
end.
```

C Version

```
#include <stdio.h>

int i, j, x[1000];

int main() {
  for (i = 1; i <= 999; i++)
    x[i] = 0;
  for (i = 2; i <= 999; i++)
    if (x[i] == 0) {
      j = i;
      while (j <= 999) {
        x[j] = x[j] + 1;
        j = j + i;
      }
    }
  printf("%d", x[30] + x[37] +
      x[60] + x[999]);
  return 0;
}
```

　　A.　　8
　　B.　　9
　　C.　　10
　　D.　　11

20.　　Consider the following program:

Pascal Version

```
var
  n: longint;
begin
  read(n);
  if (n < 0) then n := 0;
  if (n < 5) then n := n * 5;
  if (n >= 10) then n := n - 8;
  write(n)
end.
```

C Version

```
#include <stdio.h>
int n;
int main() {
  scanf("%d", &n);
  if (n < 0) n = 0;
  if (n < 5) n = n * 5;
  if (n >= 10) n = n - 8;
  printf("%d", n);
  return 0;
}
```

The input n is an integer. Which of the following is true?
　　A.　　The maximum possible output is 12
　　B.　　The output is always larger than or equal to the input
　　C.　　There are totally 5 different positive integer inputs that will cause the program creating the output that is equal to the input.
　　D.　　None of the above

21. Consider the following program:

Pascal Version

```
var
  n, i, x, y: longint;
  a: array[0..9] of longint;
begin
  for i := 0 to 9 do
    read(a[i]);
  x := 0;
  y := 9;
  while (x <> y) do
  begin
    if (a[x] < a[y]) then
      inc(x)
    else
      dec(y)
  end;
  write(x)
end.
```
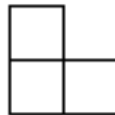
C Version

```c
#include <stdio.h>
int n, i, x, y;
int a[10];
int main() {
  for (i = 0; i <= 9; i++)
    scanf("%d", &a[i]);
  x = 0;
  y = 9;
  while (x != y) {
    if (a[x] < a[y])
      x++;
    else
      y--;
  }
  printf("%d", x);
  return 0;
}
```

Which of the following input leads to the maximum output?
  A.   1 0 5 7 8 0 3 4 6 2
  B.   7 1 3 9 4 8 2 5 6 0
  C.   5 4 9 0 3 2 7 8 9 1
  D.   1 2 7 4 3 0 8 6 5 6

22. L-piece is a shape that can cover exactly three grid cells with four different rotations, here is an L-piece:

The grid is tiled completely if and only if each grid cell is covered by a L-piece.
Assume that we are tiling 16 L-pieces on 7×7 grid with a single cell removed initially, which of the following grid(s) are possible to be tiled completely? (You may treat $(1,1)$ and $(7,7)$ as the top-leftmost and bottom-rightmost cell respectively. (x, y) denotes the grid in row x and column y)
  i.   The grid with cell $(7, 7)$ removed
  ii.   The grid with cell $(3, 6)$ removed
  iii. The grid with cell $(2, 5)$ removed
  A.   ii only
  B.   i and ii only
  C.   i and iii only
  D.   i, ii and iii

23.   Which of the following best estimates the weight of a 32GB microSD memory card?
    A.   0.05 g
    B.   0.25 g
    C.   1 g
    D.   5 g

24.   Skylake is the ...
    A.   codename for a version of CPU
    B.   codename for a version of operating system
    C.   name of a programming language
    D.   name of a server software

25.   You have 200 units of food in the storage and 3 villagers initially. Your base can create a villager instantaneously by consuming 50 units of food from the storage. A villager produces 1 unit of food each second and put it into the storage in the end of the second.

What is the fastest time of having 500 units of food in the storage?
    A.   69
    B.   70
    C.   72
    D.   100

END OF SECTION A

Section B (20 marks)

The blanks are labeled from A to M. Please fill in the blanks on the answer sheet.

Except otherwise specified, two marks for each correct blank. No marks will be deducted for wrong answers.

Note:

    (1) You must not use the `?:` operator in C.

    (2) You must not use any library function unless the appropriate library(s) is/are included.

    (3) You can write only one character in each box on the answer sheet.

    (4) No answer with length greater than the designated number of boxes will be accepted.

1.   Complete the following program such that it reads an integer input between 0 and 1000000 (inclusive) and outputs the number's square root, corrected to 3 decimal places. For example, the program should output `1.414` when the input is `2`, and output `3.000` when the input is `9`.

Pascal Version

```
var
  x: longint;
begin
  read(x);
  _____A_____;
end.
```

C Version

```
#include <stdio.h>
#include <math.h>
int main() {
  int x;
  scanf("%d", &x);
  _____A_____;
  return 0;
}
```

Answer: _____A_____ (2 marks)

2.   The $3n + 1$ conjecture (Collatz conjecture) is a famous open problem. It is related to an infinite sequence of integers $\{S_i\}$, where S_0 is a given positive integer and

    (1) If S_i is even, $S_{i+1} = \frac{1}{2} \times S_i$

    (2) If S_i is odd, $S_{i+1} = 3 \times S_i + 1$

For example, if $S_0 = 6$, we get the sequence $6, 3, 10, 5, 16, 8, 4, 2, 1, 4, 2, 1, \ldots$

The $3n + 1$ conjecture asks that whether, for all S_0, the sequence ends with the '$4, 2, 1$' cycle.

Complete the following program segment such that it reads `x` as the value of S_0, and prints the sequence until the appearance of the first `"1"`.

Pascal Version

```
read(x);
while (_____B_____) do
begin
  write(x, ', ');
  if (_____C_____) then
    x := x * 3 + 1
  else
    _____D_____;
end;
write(1);
```

C Version

```
scanf("%d", &x);
while (_____B_____) {
  printf("%d, ", x);
  if (_____C_____)
    x = x * 3 + 1;
  else
    _____D_____;
}
printf("1");
```

For example, if `x = 6`, output should be: `6, 3, 10, 5, 16, 8, 4, 2, 1`

Answer: _____B_____ (1 mark)

Answer: _____C_____ (1 mark)

Answer: _____D_____ (1 mark)

3.   There are ten people standing in a line, labeled in order with distinct integers from 1 to 10. Some of them are programmers. Given that:

   (1) Among people labeled 3 to 7, exactly two are programmers.

   (2) Among people labeled 4 to 9, exactly three are programmers.

   (3) Among people labeled 1 to 5, exactly three are programmers.

Among the ten people, there are at most _____E_____ programmers and at least _____F_____ programmers.

Answer: _____E_____ (1 mark)

Answer: _____F_____ (1 mark)

4.   Suppose array a (**Pascal**: `a[1..n] of longint`, **C**: `int a[n]`) contains distinct integers sorted in ascending order, integer n stores the size of array a and integer x stores the integer to find. The program below tries to implement binary search to check whether integer x exists in array a. However, the program contains an error that can be fixed by changing exactly one line. Find the line and correct it. You may assume variables `l`, `r`, `mid` are declared as `int` (**Pascal**: `longint`).

Pascal Version

```
11  l := 1;
12  r := n;
13  while (l <= r) do
14  begin
15    mid := (l + r) div 2;
16    if (a[mid] < x) then
17      l := mid + 1
18    else
19      r := mid - 1
20  end;
21  if (a[mid] = x) then
22    write('Found')
23  else
24    write('Not found');
```

C Version

```
51  l = 0;
52  r = n - 1;
53  while (l <= r)
54  {
55    mid = (l + r) / 2;
56    if (a[mid] < x)
57      l = mid + 1;
58    else
59      r = mid - 1;
60  }
61  if (a[mid] == x)
62    printf("Found");
63  else
64    printf("Not found");
```

Line number: _____G_____ (1 mark)

Correction: _____H_____ (2 marks)

5.   The following program attempts to output all factors of positive integer input x.

Pascal Version

```
var
  i, k, t, x: longint;
begin
  read(x);
  k := x;
  writeln(1);
  if (x > 1) then
  begin
    for i := 2 to x do
    begin
      t := 1;
      while (k mod i = 0) do
      begin
        k := k div i;
        t := t * i;
        writeln(t)
      end
    end
  end
end.
```

C Version

```c
#include <stdio.h>
int i, k, t, x;
int main() {
  scanf("%d", &x);
  k = x;
  printf("1\n");
  if (x > 1) {
    for (i = 2; i <= x; i++) {
      t = 1;
      while (k % i == 0) {
        k = k / i;
        t = t * i;
        printf("%d\n", t);
      }
    }
  }
  return 0;
}
```

I1.   Write down a positive integer input x that is greater than 30, so that the program outputs all the factors of
       x correctly.

 Answer: _____I1_____

I2.   Write down a positive integer input x that is greater than 30, so that the program outputs all the factors of
       x incorrectly.

 Answer: _____I2_____

2 marks are given only if both correct.

6.   A "cross shape" is shown below.

```
  *
 ***
  *
```

Consider the following grid. There are 2 cross shapes center at $(2, 2)$ and $(4, 4)$ respectively.
(**"."** denotes an empty grid cell, (x, y) denotes the grid in row x and column y)

```
 .*...
 ***..
 .*.*.
 ..***
 ...*.
```

We call 2 cross shapes touch each other if they share the same corner but no edge.
We call 2 cross shapes connected if they share the same edge.

Therefore, the above cross shapes touch each other.

Consider the following program segment, (a, b) stored the coordinate of the center of a cross shape, (x, y) stored the coordinate of center of another cross shape.

Pascal Version

```
read(a, b, x, y);
if (_____J_____) then
  write('They are connected');
if (_____K_____) then
  write('They touch each other');
```

C Version

```
scanf("%d%d%d%d", &a, &b, &x, &y);
if (_____J_____)
  printf("They are connected");
if (_____K_____)
  printf("They touch each other");
```

Complete the following blanks so that the program can correctly determine whether the cross shapes touch, connect or not.

The program should output **"They touch each other"** if and only if they touch each other.

The program should output **"They are connected"** if and only if they are connected.

It is guaranteed that two crosses do not overlap.

Note: You are allowed to use the **abs** function.

Answer: _____J_____ (2 marks)
Answer: _____K_____ (2 marks)

7.   **s** is a string containing some English words separated by spaces. Complete the following program segment so that it prints out the acronym of **s**. The acronym of a string includes the first letter and all capital letters that immediately follow a space.

For example, the acronym of "Hong Kong Olympiad in Informatics" is HKOI. You may assume that the string **s** contains only English letters and spaces, and begins with a letter.

Pascal Version

```
len := _____L_____;
write(s[1]);
for i := 2 to len do
  if (_____M_____) then
    write(s[i]);
```

C Version

```
len = _____L_____;
printf("%c", s[0]);
for (i = 1; i <= len - 1; i++)
  if (_____M_____)
    printf("%c", s[i]);
```

Answer for L was given to the contestants: **length(s) / strlen(s)**

Answer: _____M_____ (2 marks)

END OF PAPER