

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 A	Multiple Choice	25	25
Section B	Fill-in-the-blanks	6 (A-M)	26
Total			51

Section A (25 marks)

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

1. A ring-like bracelet has 5 beads and each bead is either black or white. How many different necklace can there be? Two bracelets are considered to be identical if one can be obtained by rotating or flipping the other.
 - A. 8
 - B. 10
 - C. 16
 - D. 20

2. What is/are the difference(s) between a sorted array and a sorted linked list?
 - i. Binary Search can be performed on a sorted array, but not a sorted linked list.
 - ii. Generally it takes more time to delete an element from the middle of a sorted array than a sorted linked list.
 - iii. Given that you know all elements before storing it, it needs more memory for an array than a linked list.
 - A. i only
 - B. i and ii
 - C. ii and iii
 - D. All of above

3. If only one of the options is correct, which one is it?

- A. Option C is correct.
- B. Option A is wrong.
- C. Option B is wrong.
- D. If option A is wrong, then option D is correct.

4. What is the output of the following program?

Pascal Version

```
type node = record
  x:array[1..20] of longint;
  y:array[1..40] of char;
end;
var
  a:array[1..1000] of longint;
  b:array[1..250,1..10] of char;
  c:array[1..100] of node;
begin
  write(sizeof(a)+sizeof(b)+sizeof(c));
end.
```

C Version

```
#include <stdio.h>
typedef struct {
  int x[20];
  char y[40];
} node;
int a[1000];
char b[250][10];
node c[100];
int main() {
  printf("%d", sizeof(a)+sizeof(b)+sizeof(c));
  return 0;
}
```

- A. 1110
- B. 3600
- C. 9500
- D. 18500

5. What is the output of the following program?

Pascal Version

```
var x, i: longint;
begin
  x := 727650;
  i := 1;
  while (i < x) do
  begin
    if (x mod i = 0) then
      x := x div i;
    i := i + 1;
  end;
  write(x);
end.
```

C Version

```
#include <stdio.h>
int x, i;
int main() {
  x = 727650;
  i = 1;
  while ( i < x ) {
    if (x % i == 0)
      x = x / i;
    i = i + 1;
  }
  printf("%d", x);
}
```

- A. 7
- B. 11
- C. 35
- D. 385

6. Tic-tac-toe is a 2-player game. Each player takes turn to draw 'O' or 'X' onto a 3x3 grid. The first player chooses an empty cell to draw a 'O', then the second player chooses another empty grid cell to draw a 'X', and so on, until all cells are filled. A player wins if he can draw 3 same symbols ('O' or 'X') along any horizontal, vertical or diagonal line. If both players fail to do so, the game ends in a draw.

Given that both players do not want to lose. Which of the following situation(s) will turn out to end in a draw?

i.

	X	O

ii.

X		
O		

- A. i only
 B. ii only
 C. i and ii
 D. None of the above
7. A stands in front of B, B stands in front of C, C stands in front of D.

The distance between A and C is less than or equal to 5 meters.

The distance between B and D is less than or equal to 9 meters.

The distance between B and C is greater than or equal to 3 meters.

What is the greatest possible distance between A and D?

- A. 7
 B. 8
 C. 11
 D. 17

8. How many possible distinct numbers may the following expression produce?

Pascal Version

```
random(1011)*2-random(2013)
```

C Version

```
(rand()%1011)*2-rand()%2013
```

- A. 3022
 B. 3023
 C. 3024

D. None of the above

9. Given two different dates within the same year: (m_1, d_1) and (m_2, d_2) . m_1 and m_2 represents the month (1-12) while d_1 and d_2 represents the day-of-month (1-31). You may assume that both dates are valid.

$k*m_1+d_1 < k*m_2+d_2$

If the above expression returns true when (m_1, d_1) is earlier than (m_2, d_2) and returns false otherwise, the minimum possible value of k lies in the range:

- A. [29.50, 30.00]
- B. (30.00, 30.50]
- C. (30.50, 31.00]
- D. (31.00, 32.00]

10. What is the return value of function $f()$?

Pascal Version

```
function f:longint;
var i,k:longint;
begin
  k := 2;
  for i:=1 to 2013 do
    if (i mod k = 0) then
      k := k*k;
  f := k;
end;
```

C Version

```
int f() {
  int i, k = 2;
  for (i=1; i<=2013; ++i)
    if (i % k == 0)
      k = k*k;
  return k;
}
```

- A. 1024
- B. 2048
- C. 32768
- D. 65536

11. What is the output of the following program?

Pascal Version

```

var
  a:array[0..7] of longint =
    (4,7,1,6,2,8,3,5);
  x,ans,i,j,t:longint;
begin
  x:=4;
  for i:=0 to x-1 do
    for j:=1 to 7-i do
      begin
        if (a[j-1] > a[j]) then
          begin
            t := a[j-1];
            a[j-1] := a[j];
            a[j] := t;
          end;
        ans:=a[j];
      end;
    write(ans);
  end.

```

C Version

```

#include <stdio.h>

int a[8] = {4,7,1,6,2,8,3,5};
int x=4, ans=-1, i, j, t;

int main() {
  for (i=0; i<x; ++i)
    for (j=1; j<8-i; ++j) {
      if (a[j-1] > a[j]) {
        t = a[j-1];
        a[j-1] = a[j];
        a[j] = t;
      }
      ans = a[j];
    }
  printf("%d", ans);
  return 0;
}

```

- A. 3
- B. 4
- C. 5
- D. 6

12. X, Y and Z are specialized at making wineX, wineY and wineZ respectively. The three persons are smart and they have a way to fairly trade their wine among each other. The total value of wine received by one is equal to the value he gave away.

Suppose X kept half of wineX and gave one-fourth of wineX to Y and one-fourth to Z.

Y divided wineY evenly among the three persons, one-third going to each other.

Z gave half of wineZ to X and divided the other half wineZ evenly between Y and himself.

The result is summarized in the following table:

	wineX	wineY	wineZ
X	1/2	1/3	1/2
Y	1/4	1/3	1/4
Z	1/4	1/3	1/4

If wineZ is worth 3 thousand dollars. What are the values (in thousand dollars) of wineX and wineY respectively?

- A. wineX: 3 wineY: 4
- B. wineX: 4 wineY: 3
- C. wineX: 5 wineY: 3
- D. wineX: 6 wineY: 3

For questions 13-14, consider the following program:

Pascal Version

```
var
  i,sum : longint;
  a,b:array[1..8] of longint;

function sum5(start:longint):longint;
begin
  sum := 0;
  for i := start to start+4 do
    sum := sum+a[i];
  sum5 := sum;
end;
begin
  a[1]:=4; a[2]:=2; a[3]:=9; a[4]:=10;
  a[5]:=1; a[6]:=3; a[7]:=7; a[8]:=5;
  fillchar(b,36,0);
  for i := 1 to 4 do begin
    sum:=sum5(i);
    b[i]:=sum;
  end;
end.
```

C Version

```
#include <stdio.h>
#include <string.h>
int i,sum;
int a[9], b[9];
int sum5(int start) {
  sum = 0;
  for (i=start; i<start+5; i++)
    sum+=a[i];
  return sum;
}
int main() {
  a[1]=4; a[2]=2; a[3]=9; a[4]=10;
  a[5]=1; a[6]=3; a[7]=7; a[8]=5;
  memset(b,0,36);
  for (i=1; i<=4; i++) {
    sum=sum5(i);
    b[i]=sum;
  }
  return 0;
}
```

13. Before program exits, what is the value of $b[1]$?

- A. 25
- B. 26
- C. 30
- D. None of the above

14. Before program exits, what is the maximum value of b ?

- A. 25
- B. 26
- C. 30
- D. None of the above

15. Assume you know the following relationships:

- i. If it is cloudy today, Ken feels sad.
- ii. If Ken feels sad, he will play computer games for a whole day.
- iii. If Ken plays computer games for a whole day, he will eat a lot at dinner.

You know that Ken plays computer games for a whole day today, which of the following statements can be **TRUE**?

- A. Today is cloudy.
- B. Ken feels sad today.
- C. Ken eats a lot at dinner.
- D. All of above

16. Which of the following code segments will **NOT** exit?

Pascal Version	C Version
i. <code>a:=2013;</code> <code>while (a>0) inc(a);</code>	i. <code>a=2013;</code> <code>while (a>0) ++a;</code>
ii. <code>b:=2013.0;</code> <code>while (b<>0.0) b:=b-0.5;</code>	ii. <code>b=2013.0;</code> <code>while (b!=0.0) b=b-0.5;</code>
iii. <code>c:=2013.0;</code> <code>while (c<>0.0) c:=c-0.1;</code>	iii. <code>c=2013.0;</code> <code>while (c!=0.0) c=c-0.1;</code>

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

For questions 17-19, consider the following program segment:

Pascal Version

```

procedure P1(n:longint);
var i,j,k:longint;
begin
  for i:=0 to n-1 do
    for j:=i+1 to n-1 do
      for k:=j+1 to n-1 do
        write('*');
end;
procedure P2(n:longint);
var i,j:longint;
begin
  for i:=0 to n-1 do
    for j:=0 to n-1 do
      write('*');
end;
procedure P3(n:longint);
var i:longint;
begin
  if (n >= 1) then
  begin
    for i:=0 to n-1 do
      write('*');
    P3(n div 2);
    P3(n div 2);
  end;
end;
procedure P4(n:longint);
begin
  if (n >= 5) then
  begin
    write('*');
    P4(n-1);
    P4(n-1);
  end;
end;
end;

```

C Version

```

void P1(int n){
  int i,j,k;
  for (i=0; i<n; i++)
    for (j=i+1; j<n; j++)
      for (k=j+1; k<n; k++)
        printf("*");
}

void P2(int n){
  int i,j;
  for (i=0; i<n; i++)
    for (j=0; j<n; j++)
      printf("*");
}

void P3(int n){
  int i;
  if (n >= 1){
    for (i=0; i<n; i++)
      printf("*");
    P3(n/2);
    P3(n/2);
  }
}

void P4(int n){
  if (n >= 5){
    printf("*");
    P4(n-1);
    P4(n-1);
  }
}

```

17. Among $P1(4)$, $P2(4)$, $P3(4)$ and $P4(4)$, which of them will print the most number of '*'?

- A. P1
- B. P2
- C. P3
- D. P4

18. Among P1 (9), P2 (9), P3 (9) and P4 (9), which of them prints the most number of '*'?
- A. P1
 B. P2
 C. P3
 D. P4
19. What is the minimum value of n such that P4 (n) prints more '*' than all P1 (n), P2 (n) and P3 (n)?
- A. 10
 B. 11
 C. 12
 D. Such n does not exist
20. Consider the following program. If 5 * are printed, which of the following **CANNOT** be the initial content of array a?

Pascal Version

```
var x,k,i:longint;
    a:array[0..7] of longint;
begin
    // initialization of array a goes here
    x:=0; k:=1;
    for i:=0 to 7 do
    begin
        if (a[i] * k > x * k) then
        begin
            write('*');
            x:=a[i];
            k:=-k;
        end;
    end;
end.
```

C Version

```
#include <stdio.h>
int x, k, i;
int a[8];
int main() {
    // initialization of array a goes here
    x = 0, k = 1;
    for (i=0; i<8; ++i) {
        if (a[i] * k > x * k) {
            printf("*");
            x = a[i];
            k = -k;
        }
    }
    return 0;
}
```

- A. -1, 2, 3, -5, -1, 3, -3, -1
 B. -1, 2, -1, -5, -1, 3, -3, 0
 C. 1, -2, -7, -5, -1, -3, -3, -1
 D. 1, -2, 7, -5, 1, -3, -3, -1

21. Let $\text{swap}(x, y)$ be a function which can swap the values of variables x and y . What is the output of the following program segment?

Pascal Version

```

var k,i:longint;
a: array[0..4] of longint;
procedure f(m:longint);
var i:longint;
begin
  if (m=0) then
  begin
    k:=k+a[0];
    exit;
  end
else
  begin
    for i:=0 to m-1 do
    begin
      swap(a[i],a[m-1]);
      f(m-1);
      swap(a[i],a[m-1]);
    end;
  end;
end;
begin
  for i:=0 to 4 do
    a[i]:=i;
  k:=0;
  f(5);
  writeln(k);
end.

```

C Version

```

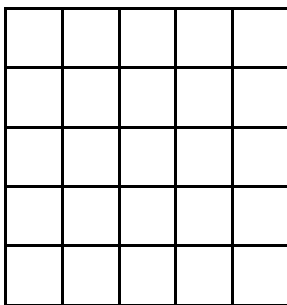
int k,i;
int a[5];
void f(int m){
  int i;
  if (m==0) {
    k=k+a[0];
    return;
  } else {
    for (i=0; i<m; i++) {
      swap(a[i],a[m-1]);
      f(m-1);
      swap(a[i],a[m-1]);
    }
  }
}

int main(){
  for (i=0; i<5; i++)
    a[i]=i;
  k=0;
  f(5);
  printf("%d\n",k);
  return 0;
}

```

- A. 0
- B. 120
- C. 240
- D. 360

22. How many ways are there to fill 3 cells with black such that no two black cells are in the same row?



- A. 1250
- B. 1600
- C. 2500
- D. 7500

23. What is the output of the following program?

Pascal Version

```

var ans,i:longint;
function f(n:longint):longint;
var cnt,k:longint;
begin
  cnt:=0;
  k:=1;
  while (k<=n) do
  begin
    if (k and n > 0) then
      cnt:=cnt+1;
      k:=k*2;
    end;
    f:=cnt;
  end;

begin
  ans:=0;
  for i:=0 to 31 do
    ans:=ans+f(i);
  writeln(ans);
end.

```

C Version

```

#include <stdio.h>
int ans, i;
int f(int n){
  int cnt,k;
  cnt=0;
  k=1;
  while (k<=n){
    if (k&n > 0)
      ++cnt;
      k*=2;
    }
  return cnt;
}

int main(){
  ans=0;
  for (i=0; i<32; i++)
    ans+=f(i);
  printf("%d\n",ans);
  return 0;
}

```

- A. 32
- B. 80
- C. 96
- D. 160

24. There are some cities with some roads connecting them. Each road connects two cities, and has different length (i.e. no two roads have the same length). One can travel from a city to another only through roads. For any two cities, there is one or no road connecting them.

Now you have to travel from city A to city B. To minimize the length of the path, you plan to travel through the road connecting A and C, then the road connecting C to B (no other paths have shorter length).

Which of the following statements is always **TRUE**?

- A. You will have to travel a longer distance if you are forbidden to visit city C.
- B. If the length of the road connecting A and C is reduced, then the path you have chosen will be the only shortest path (i.e. every other path has longer length).
- C. If the length of the road connecting A and C is increased such that it becomes the longest road, then the path you have chosen will no longer be the shortest.
- D. If there is a road connecting A and B, then it is at least twice as long as the shortest road.

25. Consider the following function:

Pascal Version

```
function f(n:longint):longint;
var ans,i:longint;
begin
  ans:=n;
  for i:=2 to n do
  begin
    if (n mod i = 0) then
      ans:=ans div i*(i-1);
    while (n mod i = 0) do
      n:=n div i;
  end;
  f:=ans;
end;
```

C Version

```
int f(int n){
  int ans,i;
  ans=n;
  for (i=2; i<=n; i++){
    if (n%i==0)
      ans=ans/i*(i-1);
    while (n%i==0)
      n/=i;
  }
  return ans;
}
```

Which of the following input n produces the greatest value of $f(n)$?

- A. 997
- B. 1001
- C. 1024
- D. 1089

END OF SECTION A

Section B (26 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.

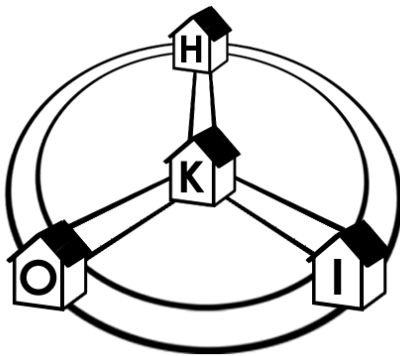
Note:

- (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. Let x be the minimum positive multiple of 17 that contains only digit '1'. How many digits does x have?

_____ **A** _____

2.



The above figure shows a map of a village with 4 houses.

Houses and roads may be visited/used zero or more times.

Examples of paths of length 3 are $H \rightarrow K \rightarrow O \rightarrow I$ and $K \rightarrow I \rightarrow O \rightarrow I$.

Please note that $H \rightarrow K \rightarrow O \rightarrow I$, $H \rightarrow O \rightarrow K \rightarrow I$ and $I \rightarrow O \rightarrow K \rightarrow H$ are considered different.

The total number of different paths of length 3 is _____ **B** _____.

The total number of different paths of length 6 is _____ **C** _____.

3. Assume stack s contains some integers and r be an empty stack.

You can perform the following operations on the stack:

<code>push(a, x)</code>	push the interger x into stack a
<code>pop(a)</code>	pop an interger from the top of stack a and return that value
<code>peek(a)</code>	return the top value of stack a
<code>empty(a)</code>	return TRUE if stack a is empty, return FALSE otherwise

Complete the program such that stack r store the content of s in ascending order from bottom to top.

Pascal Version

```
while not empty(s) do
begin
  tmp := pop(s);
  while (not empty(r)) and (_____ D >tmp) do
  begin
    push(_____ E);
  end;
  push(r, tmp);
end;
```

C Version

```
while (!empty(s)){
  tmp = pop(s);
  while (!empty(r) && _____ D >tmp) {
    push(_____ E);
  }
  push(r, tmp);
}
```

4. Consider the following program:

Pascal Version

```

10 var
11   x1,y1,x2,y2:longint;
12 function dist(x1,y1,x2,y2:longint):longint;
13 begin
14   dist:=trunc(sqrt((x1-x2)*(x1-x2)+(y1-y2)*(y1-y2)));
15 end;
16 begin
17   readln(x1,y1,x2,y2);
18   if (dist(x1,y1,x2,y2)<1) then
19     writeln('The distance is less than 1')
20   else if (dist(x1,y1,x2,y2)=1) then
21     writeln('The distance is 1')
22   else
23     writeln('The distance is greater than 1');
24 end.
```

C Version

```

50 #include <stdio.h>
51 #include <math.h>
52 int x1,y1,x2,y2;
53 int dist(int x1, int y1, int x2, int y2) {
54   return floor(sqrt((x1-x2)*(x1-x2)+(y1-y2)*(y1-y2)));
55 }
56 int main() {
57   scanf("%d %d %d %d",&x1,&y1,&x2,&y2);
58   if (dist(x1,y1,x2,y2)<1)
59     printf("The distance is less than 1\n");
60   else if (dist(x1,y1,x2,y2)==1)
61     printf("The distance is 1\n");
62   else
63     printf("The distance is greater than 1\n");
64   return 0;
65 }
```

The program checks if the distance between two coordinates (x_1, y_1) , (x_2, y_2) is less than, equal to, or greater than 1. You may assume that x_1, y_1, x_2 and y_2 are integers in $[-10000, 10000]$. Unfortunately, this program contains a logic error but it can be fixed by changing a single line. Identify the line and rewrite it.

Line Number: **F**

Rewrite the line: **G**

Note for C Version: `y1` is defined as `double y1(double)` in `<math.h>`.

In this question please assume that there is no such definition.

Disregard if you do not understand this note.

5. Assume array a (**Pascal**: $a[0..n-1]$, **C**: $a[n]$) consists of distinct positive integers and $\max(i, j)$ returns the maximum value between $a[i]$ to $a[j]$ inclusive.

Complete the program such that it finds the second maximum value of array a .

Pascal Version

```

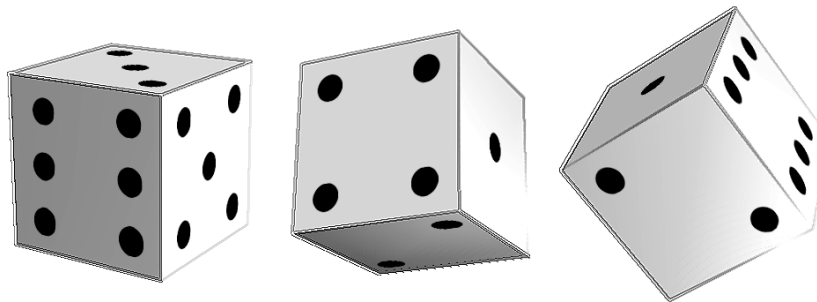
maximum := max(0, n-1);
i := 0; j := n-1;
while (j>i) do
begin
  k :=           H          ;
  if (          I           = maximum) then
    j := k
  else
    i := k+1;
end;
a[i] := -a[i];
secondmaximum :=           J          ;
a[i] := -a[i];
    
```

C Version

```

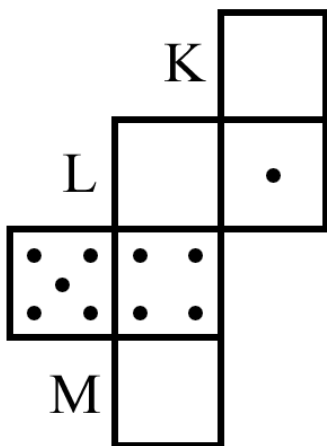
maximum = max(0, n-1);
i = 0; j = n-1;
while (j>i) {
  k =           H          ;
  if (          I           == maximum)
    j = k;
  else
    i = k+1;
}
a[i] = -a[i];
secondmaximum =           J          ;
a[i] = -a[i];
    
```

6. Observe the following non-standard die.



Now, complete its net on the answer sheet.

1 mark for each correct value. 2 marks for each correct value and orientation.



END OF PAPER