Answer all questions.

1. Tom writes a subprogram F1 to process a global integer array, A, of size n. The pseudocode for F1 is:

```
Subprogram F1
  isStop ← FALSE
  pos ← n - 1
  while isStop <> TRUE do
     if A[pos] = 1 then
           A[pos] ← 0
           pos ← pos - 1
     else
           A[pos] ← 1
           isStop ← TRUE
```

Suppose that n = 8.

(a) (i) Suppose that the initial content of A is the binary representation of the decimal value 1:

	0	1	2	3	4	5	6	7
A:	0	0	0	0	0	0	0	1

What is the content of A after executing F1?

	0	1	2	3	4	5	6	7
A:								

(1 mark)

(ii) Suppose that the initial content of A is the binary representation of the decimal value 7:

	0	1	2	3	4	5	6	7
A:	0	0	0	0	0	1	1	1

What is the content of A after executing F1?

	0	1	2	3	4	5	6	7
A:								

(1 mark)

(iii) What is the purpose of F1?

____

____

(2 marks)

(b) Tom creates some test data to test boundary cases for F1.

(i) Why does Tom need to test the boundary cases?

(1 mark)

(ii) Which of the following cases is/are boundary case(s) for F1? Justify your answer.

Case 1

	0	1	2	3	4	5	6	7
A:	0	0	0	0	0	0	0	0

Case 2

	0	1	2	3	4	5	6	7
A:	1	1	1	1	1	1	1	0

Case 3

	0	1	2	3	4	5	6	7
A:	1	1	1	1	1	1	1	1

(2 marks)

Answers written in the margins will not be marked.

Answers written in the ...

(c) Tom plans to write a subprogram `F2(m)` where `m` is an integer input parameter. The pseudocode for `F2` is:

```
Subprogram F2(m)
    for i from 1 to m
        execute F1
```

(i) Assume that the initial content of `A` is:

	0	1	2	3	4	5	6	7
A:	0	0	0	0	0	0	1	0

What is the content of `A` after executing `F2(4)`?

	0	1	2	3	4	5	6	7
A:								

(1 mark)

(ii) What is the purpose of `F2`?

____

(2 marks)

(iii) After executing `F2(1000)`, Tom finds that the result is not what he expected. Why not?

____

____

(1 mark)

(iv) In order to generate the proper result for `F2(1000)`, what change in `A` should be made? Explain your answer briefly.

____

____

____

____

(2 marks)

2. Mary develops a voice messaging system. The soundtrack of a voice message is recorded by storing its reading at each sampling time point. For example, a soundtrack with eight sampling time points is:

Sampling time point	1	2	3	4	5	6	7	8
Reading	392	392	330	330	330	294	294	294

Method A is used in the system to store soundtracks.

Method A: Store the average reading at every two sampling time points. For example, the soundtrack above will be stored in the following table:

Sampling time point	1 – 2	3 – 4	5 – 6	7 – 8
Reading	392	330		

(a) (i) Complete the table for the soundtrack above. (1 mark)

(ii) Give one benefit and one drawback of using Method A to store soundtracks.

Benefit: ______________________________

____

Drawback: ______________________________

______________________________ (2 marks)

Mary considers upgrading the voice messaging system by using Method B to store soundtracks, as shown below:

Method B: Use a structured data type to represent a pair of values <X, Y>, where

X = reading
Y = the number of sampling time points that X lasts for

In the soundtrack in the example above, as the readings 392, 330 and 294 last for 2, 3 and 3 sampling time points respectively, <392,2>,<330,3>,<294,3> is used to represent the soundtrack.

(b) Suppose that <420,3>,<430,5> is used to represent a soundtrack using Method B. Use Method A to represent this soundtrack.

Sampling time point	1 – 2	3 – 4	5 – 6	7 – 8
Reading				

(2 marks)

Answers written in the margins will not be marked.

Mary plans to upgrade the voice messaging system.

(c) Suggest **two** ways to gather users' requirements.

(2 marks)

(d) She considers using parallel conversion or direct cutover conversion for the upgrade. Describe the conversions and give a benefit of each conversion.

(i) Parallel conversion

(2 marks)

(ii) Direct cutover conversion

(2 marks)

(e) Mary uses the programming language Python to write the system. She reads an extract from an article about Python below:

Python supports multiple programming paradigms including object-oriented and procedural styles. It has large and comprehensive libraries, regarded as one of Python's greatest strengths. Python programs are usually executed by an interpreter.

(i) Describe the characteristics of the object-oriented and procedural styles in a programming language.

(2 marks)

(ii) How do these large and comprehensive libraries help Mary and other programmers?

(2 marks)

(iii) Briefly describe how an interpreter operates.

(2 marks)

Answers written in the margins will not be marked.

Please tick the appropriate box to indicate the programming language used in Question 3.

Pascal ☐ C ☐ Visual Basic ☐ Java ☐

3. Susan plans to write a password checking program to validate passwords. A password is valid only if it contains at least one capital letter and no space characters. She designs subprograms using some variables, as shown below:

Variable	Description
P	A global character array for storing an input password
N	A global integer variable for storing the length of the input password

Subprogram	Return value
`hasCap`	A Boolean value to indicate whether `P` has at least one capital letter
`noSpace`	A Boolean value to indicate whether `P` has no space characters

(a) Write the following subprograms. You may define other variables if necessary.

(i) `hasCap`

(3 marks)

Answers written in the margins will not be marked

(ii) `noSpace`

(3 marks)

(b) Write a subprogram `checkPassWd` to return a Boolean value to indicate whether the password stored in `P` is valid or not, with the use of `hasCap` and `noSpace`.

(2 marks)

Answers written in the margins will not be marked.

There is a list of 100 forbidden passwords:

Index	Forbidden password
1	123456aA
2	Abcd1234
3	Qwer1234
4	1234Qwer
5	Default1
6	3Jul2018
7	1234Abcd
⋮	⋮
100	Qwertyu1

Susan uses the following algorithm to search for a password from the list by using a linear search.

Line number	Content
1	FP ← a list of forbidden passwords
2	Input a password to be searched for and store it in PASSWORD
3	FOUND ← FALSE
4	n ← 100
5	i ← 1
6	while (i <= n) AND (FP[i] <> PASSWORD) do
7	i ← i + 1
8	FOUND ← (i <= n) AND (FP[i] = PASSWORD)

(c) Find the number of string comparisons done on Line 6 for each of the following cases:

(i) Search for 'Qwer1234'. ______________ (1 mark)

(ii) No password can be matched. ______________ (1 mark)

(d) Suppose that the list is sorted in ascending order.

(i) The time efficiency of the linear search cannot be improved when the password can be found in the list. Why not?

____

____

(1 mark)

(ii) How can the time efficiency of the linear search be improved for the case in (c)(ii)? Indicate the change in the algorithm for this improvement.

____

____

____

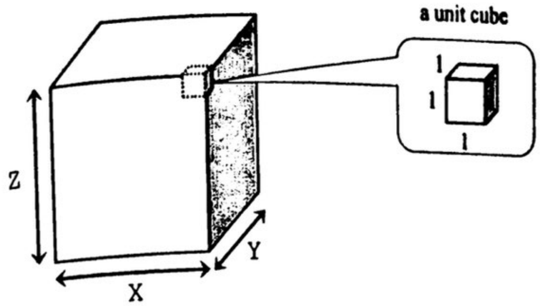
____

(2 marks)

(e) Susan uses binary search to replace linear search in the algorithm. Assume that there are 100 forbidden passwords. Find the number of string comparisons to be done in the worst case. Explain your answer briefly.

(2 marks)

Paul uses a three-dimensional (3D) printer to construct 3D objects by printing materials layer by layer, from the bottom layer to the top layer. In the following example, the 3D printer prints a rectangular block of size X×Y×Z, constructed by several unit cubes of size 1×1×1.



An example of a single layer printed by the 3D printer is shown in Figure 1.

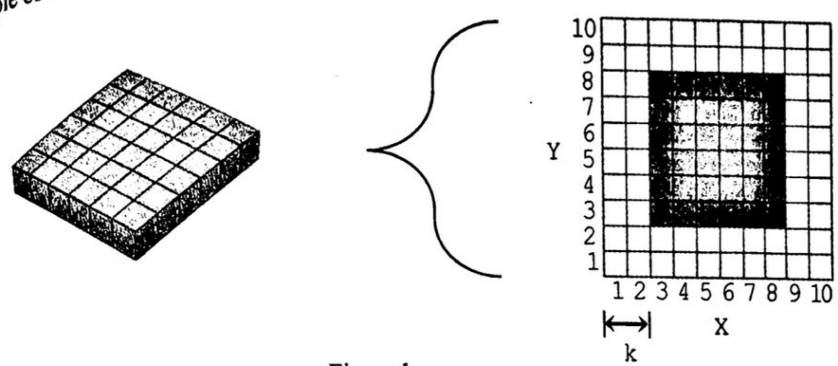


Figure 1

(a) The 3D printer can apply a subprogram SQ(k) to print a square layer of size $(10 - k \times 2) \times (10 - k \times 2) \times 1$, with the bottom left corner at position (X,Y) = (k+1, k+1). k is an integer input parameter. The pseudocode of SQ is:

```
SQ(k)
    for X from k+1 to 10-k do
        for Y from k+1 to 10-k do
            print a unit cube at the position (X, Y)
```

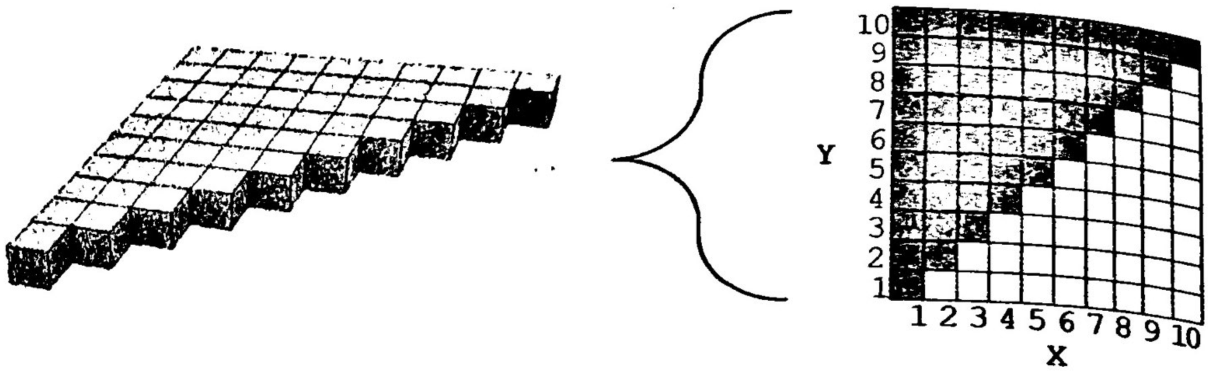
The square layer in Figure 1 is printed by SQ(2). Other than 6×6×1, list all the sizes of the square layers that can be printed by SQ.

____

____

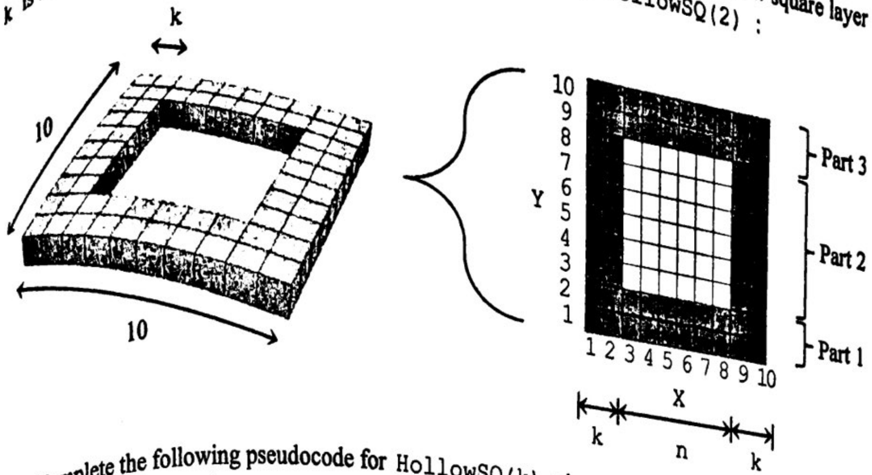
(2 marks)

The 3D printer prints a triangle-shaped layer, as shown below:



(b) Write the pseudocode for printing this layer.

The 3D printer can apply a subprogram `HollowSQ(k)` for printing a 10×10×1 hollow square layer where k is the thickness. The following hollow square layer is printed by `HollowSQ(2)` :



(c) Complete the following pseudocode for `HollowSQ(k)` where n×n×1 is the size of the empty space in the middle of the layer.

```
HollowSQ(k)
    n ← ______

    for Y from 1 to k do
        for X from 1 to 10 do                          } Part 1
            print a unit cube at the position (X, Y)
    for Y from (k+1) to (k+n) do
        for X from 1 to ______ do
            print a unit cube at the position (X, Y)   } Part 2
        for X from (k+n+1) to ______ do
            print a unit cube at the position (X, Y)
    for Y from ______ to 10 do
        for X from 1 to 10 do                          } Part 3
            print a unit cube at the position (X, Y)
```

(4 marks)

The 3D printer can apply a subprogram `MUP` to move up a layer for printing.

(d) Draw the 3D object constructed by the following pseudocode.

```
SQ(4)
MUP
SQ(4)
```

(2 marks)

The 3D printer prints materials layer by layer, from the bottom layer to the top layer. Figure 2 and Figure below are two examples created by the 3D printer.

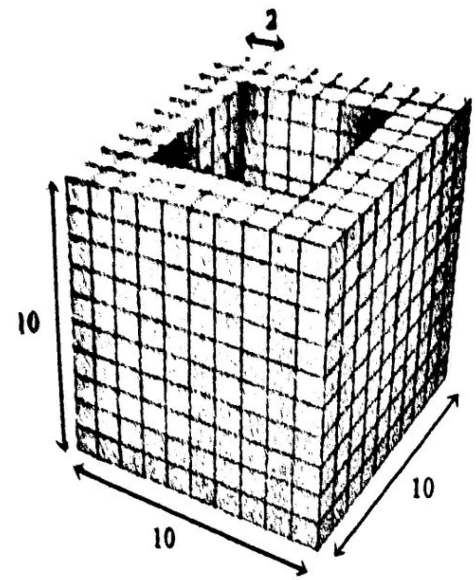


Figure 2

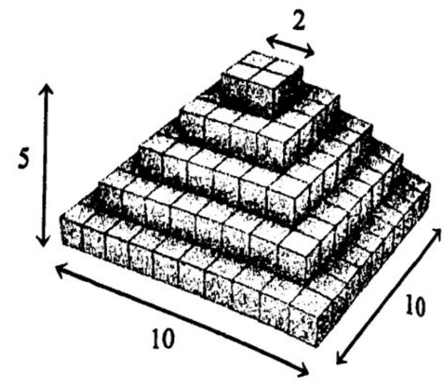


Figure 3

(e) (i) Figure 2 is a $10 \times 10 \times 10$ hollow cube where the thickness is 2. There is an $6 \times 6 \times 10$ empty space in the middle. Write the pseudocode for printing this hollow cube with the use of `HollowSQ` in (c).

(2 marks)

(ii) Figure 3 is a pyramid-shaped object created by several square layers. Write the pseudocode for printing this pyramid-shaped object with the use of `SQ` in (a).

(2 marks)

END OF PAPER