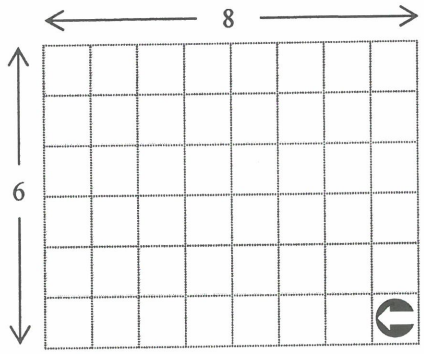
Answer THREE questions only.

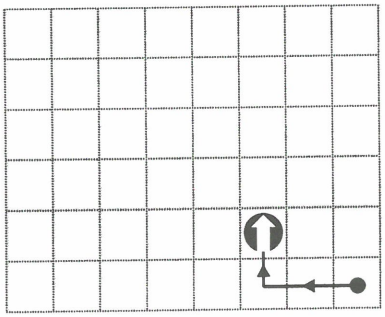
1. Peter buys a programmable window cleaner for cleaning a window with dimensions of 8 × 6 units. The initial state (position and heading direction) of the cleaner is shown in the diagram below.



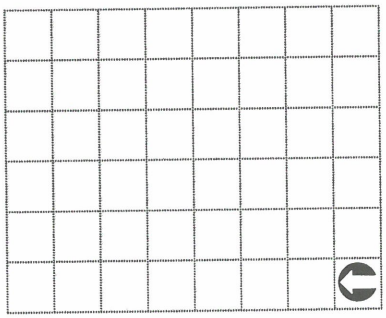
There are two subprograms provided by the manufacturer for commanding the cleaner:

Subprogram	Description
`MF`	Move forward 1 unit.
`TR`	Turn 90 degrees clockwise.

For example, the path and final state of the cleaner after executing `MF, MF, TR, MF` at its initial state are shown in the following diagram.



(a) Draw the path and final state of the cleaner after executing `TR, MF, MF, MF, TR, TR, TR, MF` at its initial state.



(2 marks)

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Peter writes two additional subprograms for commanding the cleaner:

Subprogram	Description
`FD(N)`	Move forward `N` units.
`TL`	Turn 90 degrees anti-clockwise.

(b) (i) Complete the pseudocode for `FD(N)` below.

```
for i from 1 to _____ do
   MF
```

(1 mark)

(ii) Complete the pseudocode for `TL` below.

```
for i from 1 to _____ do
   TR
```

(1 mark)

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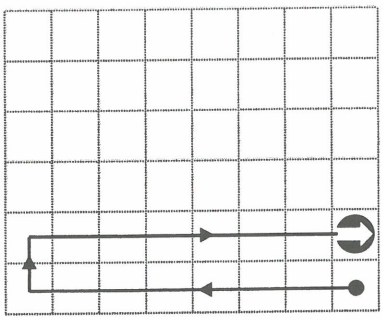
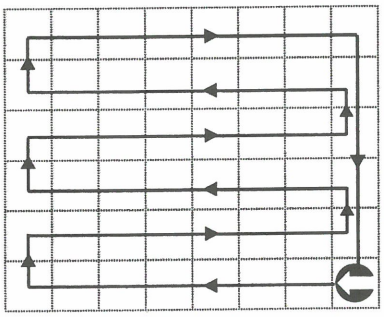
Peter writes two subprograms `ProA` and `ProB`.



(c) The diagram above shows the path and final state of the cleaner after executing `ProA` at its initial state. Write the pseudocode for `ProA`.

(2 marks)



(d) The diagram above shows the path and final state of the cleaner after executing `ProB` at its initial state. The cleaner finally returns to its initial state. Complete the pseudocode for `ProB` below.

```
for i from 1 to 2 do
    _____
    _____
    MF
    _____
    _____
    _____
    FD(5)
    _____
```

(3 marks)

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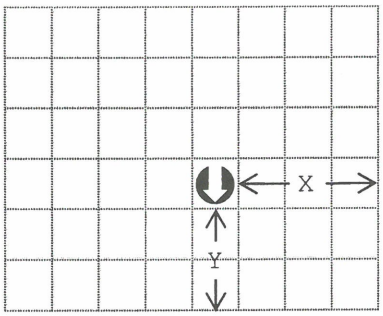
The following global variables are used to store the current state of the cleaner:

Variable	Description
X	The horizontal distance from the initial state
Y	The vertical distance from the initial state
D	An integer value indicates the current direction of the cleaner: 0 = ; 1 = ; 2 = ; 3 =

For example, when X = 3, Y = 2 and D = 3 , the current state of the cleaner is shown below.



(e) Peter writes subprograms to command the cleaner to go back to its initial state.

(i) He assumes D = 3 and writes a subprogram ProC with the use of X and Y that commands the cleaner to go back to its initial state. Write the pseudocode for ProC.

(2 marks)

(ii) He writes a subprogram ProD that commands the cleaner to go back to its initial state whatever the value of D (from 0 to 3) is. Complete the pseudocode for ProD below.

```
for i from [          ] to [          ] do
    [          ]
ProC
```

(2 marks)

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(f) The subprograms can be developed by using low-level languages or high-level languages. Give an advantage of using each type of languages.

_____

_____

_____

_____

(2 marks)

2. Eva creates a stack `S` where a variable `N` stores the number of elements in `S`. She uses the following subprograms:

Subprogram	Description
`clear(S)`	Removes all elements in `S`.
`isEmpty(S)`	Returns `TRUE` if `S` is empty, `FALSE` otherwise.
`push(S,K)`	Inserts an item `K` in `S` as its top element.
`pop(S)`	Removes and returns the top element of `S`.

(a) (i) Write down the value of `N` and `X` after executing the following pseudocode:

```
clear(S)
push(S,2)
push(S,5)
X ← pop(S)
```

N = _____ X = _____

(2 marks)

(ii) Write the pseudocode for `isEmpty(S)`.

```
isEmpty(S)
```

(2 marks)

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`A` is an array of 5 elements storing **non-negative integers** and at least one '+' character. Eva writes the pseudocode for a subprogram `Sub1`.

```
Sub1
   clear(S)
   for i from 1 to 5 do
      if A[i] <> '+' then
           push(S, A[i])
      else
           B ← pop(S)
           C ← pop(S)
           push(S, B+C)
   return pop(S)
```

For example, the return value of `Sub1` is `3` for the following initial content of `A`.

i	1	2	3	4	5
A[i]	0	0	1	2	+

(b) (i) Write down the return value of `Sub1` for the initial content of `A` below.

i	1	2	3	4	5
A[i]	1	2	3	+	+

(1 mark)

(ii) Write down the return value of `Sub1` for the initial content of `A` below.

i	1	2	3	4	5
A[i]	1	2	3	+	4

(2 marks)

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Eva modifies `Sub1` to `Sub2` by rewriting the last statement, as shown below:

```
Sub2
   clear(S)
   for i from 1 to 5 do
      if A[i] <> '+' then
           push(S, A[i])
      else
           B ← pop(S)
           C ← pop(S)
           push(S, B+C)
   if N = 1 then
      return pop(S)
   else
      return -1
```

(c) (i) Complete the following initial content of `A` that will make `Sub2` return `-1`.

i	1	2	3	4	5
A[i]	1			1	

(2 marks)

(ii) There is a problem in `Sub2` when `pop(S)` is executed with an empty `S`. Complete the following initial content of `A` that will cause such a problem.

i	1	2	3	4	5
A[i]	1			1	1

(1 mark)

(d) Eva modifies `Sub2` to `Sub3` with the use of a Boolean variable `flag` to solve the problem in(c)(ii). Complete `Sub3` below.

```
Sub3
   clear(S)
   flag ← TRUE
   for i from 1 to 5 do
        if [                    ] then
           if A[i] <> '+' then
               push(S, A[i])
           else if [                    ] then
                   B ← pop(S)
                   C ← pop(S)
                   push(S, B+C)
               else
                   flag ← FALSE
   if N = 1 then
        return pop(S)
   else
        return -1
```

(2 marks)

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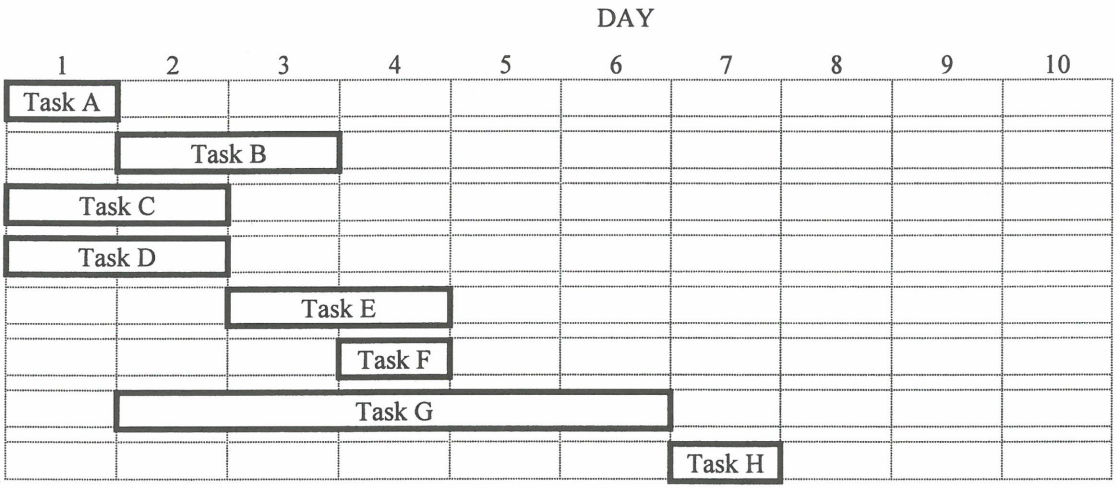
Answers written in the margins will not be marked.

(e) Eva performs the following tasks in developing an information system:

Task	Duration (day)	Depending on
A	1	–
B	2	–
C	2	–
D	2	–
E	2	A, B, C, D
F	1	E
G	5	A
H	1	E, F, G

She drafts the following Gantt chart for the development.



(i) State **two** major mistakes in the chart and their respective corrections.

(2 marks)

(ii) Eva decides to use a compiler instead of an interpreter for developing the system. Give a reason to support her decision.

(1 mark)

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3. Ms Li develops an application to manage a seating plan consisting of 5 rows, with 8 seats in each row.

Seat	Row 1	Row 2	Row 3	Row 4	Row 5
8	8	16	24	32	40
7	7	15	23	31	39
6	6	14	22	30	38
5	5	13	21	29	37
4	4	12	20	28	36
3	3	11	19	27	35
2	2	10	18	26	34
1	1	9	17	25	33

In the above seating plan, the numbers in the cells are the class numbers of 40 students. For example, the student with class number 12 sits in row `2`, seat `4`. Ms Li uses an array `SP[i,j]` to store the class number in row `i`, seat `j`, and thus `SP[2,4] = 12`.

(a) Write down the indexes of the element in `SP` that stores class number 23.

`SP[_____,_____]`

(1 mark)

(b) `AssignCN` is a subprogram that assigns class numbers to `SP` according to the above seating plan. Complete the pseudocode for `AssignCN` below.

```
AssignCN
   for i from 1 to 5 do
        for j from 1 to 8 do
             SP[i,j] ← 
```

(2 marks)

Ms Li writes the pseudocode for a subprogram `ArrangeSeat` that rearranges the seats for students randomly.

Line number	Content
1	`ArrangeSeat`
2	`   for i from 1 to 5 do`
3	`      for j from 1 to 8 do`
4	`         r ← a random integer between 1 and 5 inclusive`
5	`         s ← a random integer between 1 and 8 inclusive`
6	`         swap SP[i,j] and SP[r,s]`

(c) Suppose that a function `rand` returns a random number between 0 to 0.99 inclusive. Rewrite Line 5 using `rand`.

`s ←` _____

(2 marks)

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(d) (i) Ms Li writes a subprogram `FindStudent(k)` using linear search to find the row number and seat number of the student with class number `k`. Complete the pseudocode for `FindStudent(k)` below.

```
FindStudent(k)
   for i from 1 to 5 do
       for j from 1 to 8 do
            if [                              ] then
                output i, j
```

(1 mark)

(ii) The `if` statement in `FindStudent(k)` will be executed a definite number of times. Suggest an improvement in the algorithm to enhance its efficiency.

_____

_____

_____

_____

(2 marks)

(iii) Ms Li chooses not to use binary search in (d)(i). Why not? Explain briefly.

_____

_____

(1 mark)

(e) Ms Li writes a subprogram `CheckNeighbour` for checking whether any two students with consecutive class numbers sit in:

1. the same row number and consecutive seat numbers, or
2. consecutive row numbers and the same seat number

Complete the pseudocode for `CheckNeighbour` below.

```
CheckNeighbour
 for i from 1 to 5 do
   for j from 1 to 8 do
     if j <= [      ] then
       if (SP[i,j+1] - SP[i,j] = 1) or (SP[i,j+1] - SP[i,j] = -1) then
             output 'same row number'
     if i <= [      ] then
       if [                                ] then
             output 'same seat number'
```

(4 marks)

Answers written in the margins will not be marked.

(f) Ms Li plans to implement this application in 100 schools. However, she decides to first implement it in several schools for one school year. Give **two** reasons to support her decision.

_____

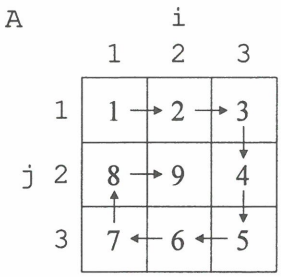
_____

_____

_____

(2 marks)

4. The subprogram `FillNo` assigns numbers from `1` to `9` spirally in a clockwise direction to a two-dimensional array `A[i,j]`, as shown below:



John writes the pseudocode for `FillNo`:

Line number	Content
1	`Initialise all elements in A as 0`
2	`X ← 1`
3	`Y ← 1`
4	`D ← 0`
5	`DX ← 1`
6	`DY ← 0`
7	`for k from 1 to 9 do`
8	`  A[X,Y] ← k`
9	`  if (X+DX = 0) or (X+DX > 3) or (Y+DY = 0) or`
10	`    (Y+DY > 3) or (A[X+DX,Y+DY] > 0) then`
11	`    D ← D + 1`
12	`    D ← remainder of (D/4)`
13	`    if D = 0 then DX ← 1`
14	`  DY ← 0`
15	`    else if D = 1 then DX ← 0`
16	`  DY ← 1`
17	`    else if D = 2 then DX ← -1`
18	`  DY ← 0`
19	`    else DX ← 0`
20	`  DY ← -1`
21	`  X ← X + DX`
22	`  Y ← Y + DY`

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(a) If the following modifications on `FillNo` are made, write down the numbers stored in `A` after executing `FillNo`.

Line 8 is modified to: `A[4-X, 4-Y]` ← `k`
Line 10 is modified to: `(Y+DY > 3) or (A[4-X-DX, 4-Y-DY] > 0) then`

A		i		
		1	2	3
	1			
j	2			
	3			

(2 marks)

(b) For each of the following cases, modify `FillNo` so as to assign the numbers below to `A`.

(i) Modify Line 8 and 10.

A		i		
		1	2	3
	1	1	8	7
j	2	2	9	6
	3	3	4	5

Line 8: _____

_____

Line 10: _____

_____

(3 marks)

(ii) Modify only one line.

A		i		
		1	2	3
	1	9	8	7
j	2	2	1	6
	3	3	4	5

Line _____ : _____

_____

(2 marks)

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(c) John plans to implement `FillNo` with either a procedural language or an object-oriented language.

(i) Suggest **two** criteria for selecting a programming language.

(2 marks)

(ii) Give **two** characteristics of an object-oriented language, other than the concept of an object.

(2 marks)

(d) John integrates subprograms into an information system.

(i) John has completed the system test. Why does he still need to conduct a user acceptance test? Give **two** reasons for this.

(2 marks)

(ii) Why is system documentation so important in the system development? Give **two** reasons for this.

(2 marks)

END OF PAPER

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