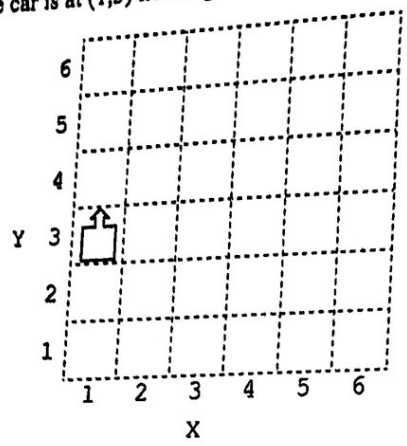
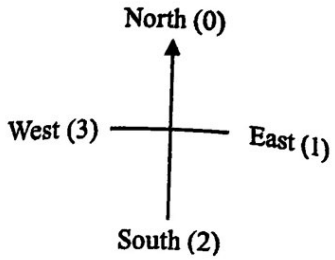
Answer all questions.

1. Tom develops a mobile application for controlling a toy car, shown at position (X,Y) on the map below. The car is at (1,3) heading north:

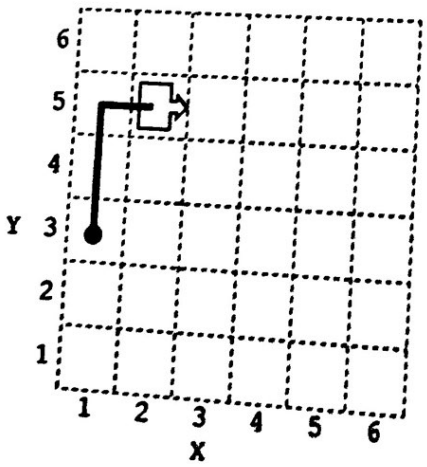




Tom creates the following:

Variable/Subprogram	Description
`dir`	An integer variable for storing the direction the car is heading in: 0 = North 1 = East 2 = South 3 = West
MF	A subprogram that moves the car forward 1 unit.
TR	A subprogram that turns the car clockwise by 90 degrees.

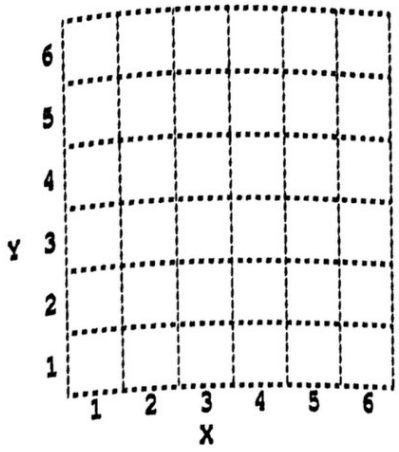
For example, the initial position of the car is (1,3) and `dir = 0`. After executing `MF, MF, TR, MF`, the final position of the car will be (2,5) and `dir = 1`.



Answers written in the margins will not be marked.

Please stick the barcode label here.

(a) Assume that the initial position of the car is (1,1) and `dir = 0`. Draw the path and final position of the car after executing `TR, MF, MF, TR, TR, TR, MF`. Show the direction it is heading in.

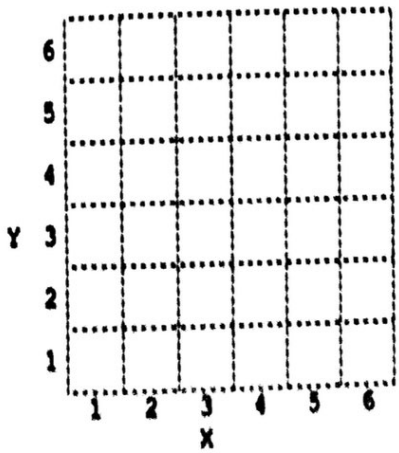


(2 marks)

(b) Read the following pseudocode for `P(N)`.

```
P(N)
    while N > 0 do
        for i from 1 to N do
            MF
        TR
        for i from 1 to N do
            MF
        TR
        N ← N - 1
```

Assume that the initial position of the car is (1,1) and `dir = 0`. Draw the path and final position of the car after executing `P(5)`. Show the direction it is heading in.



(3 marks)

Answers written in the margins will not be marked.

To make control easier, Tom creates the following:

Subprogram	Description
TN	Turns the car so that it heads north.
TE	Turns the car so that it heads east.
TS	Turns the car so that it heads south.
TW	Turns the car so that it heads west.

The pseudocode for `TE` is given below:

```
TE
  for i from 1 to (5 - dir) do
    TR
```

(c) (i) Which subprogram is the following pseudocode for? _____

```
for i from 1 to (3 - dir) do
  TR
```

(ii) Tom finds that `TE` may execute more `TR` than necessary. Complete the following pseudocode for solving this problem. (1 mark)

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

(d) Finally, Tom creates a subprogram `MOVE(X, Y, NX, NY)` that moves the car from position `(X, Y)` to position `(NX, NY)`. (2 marks)

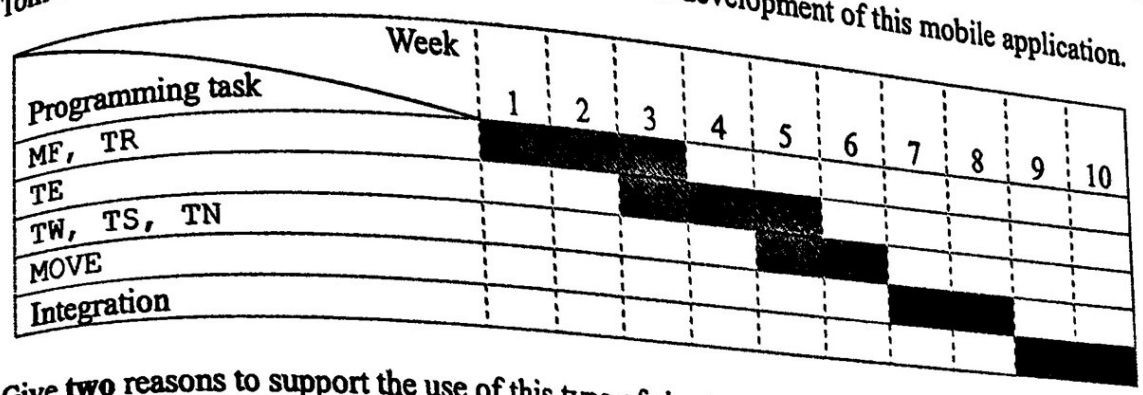
Complete the pseudocode for `MOVE(X, Y, NX, NY)` below.

```
MOVE(X, Y, NX, NY)
  if [          ] then
      TE
  else
      TW
  for i from 1 to [          ] do
      MF
  if [          ] then
      TN
  else
      TS
  for i from 1 to [          ] do
      MF
```

(5 marks)

Answers written in the margins will not be marked.

(c) Tom draws the following chart at the beginning of the development of this mobile application.



Give **two** reasons to support the use of this type of chart.

(2 marks)

Answers in the margins will not be marked.

2. There are N consecutive numbers starting from S:

S, S+1, S+2, ..., S+N-1

A is an integer array with indexes from 0 to (N-2). It stores the numbers above in random order. As a result, one of the N consecutive numbers cannot be stored in A. In the following example, N = 10 and S = 5. The missing number is 9.

i	0	1	2	3	4	5	6	7	8
the i-th entry of A	6	5	14	12	7	13	11	10	8

The algorithms FC1, FC2 and FC3 can all be used to find this missing number.

(a) found is a Boolean variable. The pseudocode for FC1 is:

```
Line 1: FC1
Line 2:   for i from S to (S+N-1) do
Line 3:       found ← FALSE
Line 4:       for j from 0 to (N-2) do
Line 5:           if A[j] = i then
Line 6:               found ← TRUE
Line 7:       if found = FALSE then
Line 8:           output i
```

Suppose that N = 10, S = 5 and the content of A is:

i	0	1	2	3	4	5	6	7	8
the i-th entry of A	9	8	14	10	5	7	6	12	13

(i) What is the output on Line 8? _____ (1 mark)

(ii) How many times will Line 5 be executed? _____ (2 marks)

(b) B is a Boolean array. The pseudocode for FC2 is:

```
Line 1: FC2
Line 2:   for i from S to (S+N-1) do
Line 3:       B[i] ← FALSE
Line 4:   for j from 0 to (N-2) do
Line 5:       B[A[j]] ← TRUE
Line 6:   for i from S to (S+N-1) do
Line 7:       if B[i] = FALSE then
Line 8:           output i
```

Suppose that `N = 10`, `S = 5` and the content of `A` is:

i	0	1	2	3	4	5	6	7	8
the i-th entry of A	9	8	14	10	5	7	6	12	13

(i) Write the content of `B` after executing `FC2` in the following table. Use 'T' and 'F' to denote 'TRUE' and 'FALSE' respectively.

i	5	6	7	8	9	10	11	12	13	14
the i-th entry of B	T	T								

(1 mark)

(ii) Suppose that `N` is very large. Which algorithm, `FC1` or `FC2`, is more efficient in terms of execution time? Explain briefly.

(2 marks)

(iii) `FC2` is updated and `B[0], B[1], ..., B[N-1]` is used instead of `B[S], B[S+1], ..., B[S+N-1]`. Complete `FC2` below.

```
Line 1: FC2
Line 2:    for i from 0 to [          ] do
Line 3:        B[i] ← FALSE
Line 4:    for j from 0 to (N-2) do
Line 5:        B[ [          ] ] ← TRUE
Line 6:    for i from 0 to [          ] do
Line 7:        if B[i] = FALSE then
Line 8:            output [          ]
```

(3 marks)

(c) The pseudocode for FC3 is:

```
Line 1: FC3
Line 2:    temp ← 0
Line 3:    for i from S to (S+N-1) do
Line 4:       temp ← temp + i
Line 5:    sum ← 0
Line 6:    for i from 0 to (N-2) do
Line 7:       sum ← sum + A[i]
Line 8:    output (temp - sum)
```

(i) What does the value of temp on Line 8 represent?

(1 mark)

(ii) What does the value of sum on Line 8 represent?

(1 mark)

(iii) Give an advantage of FC3 over FC1.

(1 mark)

(iv) Give an advantage of FC3 over FC2.

(1 mark)

(d) Suppose that `N = 10, S = 5` and there are two missing numbers. One of the three algorithms **cannot** find the two missing numbers. Which one? Give an example of two missing numbers to illustrate your answer.

(2 marks)

3. Mary creates a queue `Q` with

`A` – an integer array with indexes from 0 to 99,
`H` – an integer variable for storing the index of the head element of `Q`, and
`N` – an integer variable for storing the number of elements in `Q`.

Consider the following subprograms:

Subprogram	Description
`isFull(Q)`	Returns `TRUE` if `Q` is full, `FALSE` otherwise.
`isEmpty(Q)`	Returns `TRUE` if `Q` is empty, `FALSE` otherwise.
`enq(Q,K)`	Inserts an integer `K` in `Q` as its tail element.
`deq(Q)`	Removes and returns the head element of `Q` if `Q` is not empty.
`tail(Q)`	Returns the index of the tail element of `Q`.

Mary assumes that `H` is always zero. She writes some pseudocodes, as below:

```
isFull(Q)
    if N = 100 then
        return TRUE
    else
        return FALSE

enq(Q, K)
    if isFull(Q) then
        output 'Not successful'
    else
        A[tail(Q)+1] ← K
        N ← N + 1

deq(Q)
    if isEmpty(Q) then
        output 'Not successful'
    else
        temp ← A[H]
        N ← N - 1
        for i from H to (N - 1) do
            A[i] ← A[i+1]
    return temp

tail(Q)
    return (H+N-1)
```

(a) (i) Assume that `H = 0 , N = 5` and the content of `A` is:

i	0	1	2	3	4	5	...	97	98	99
A[i]	40	35	18	66	18		...			

Write the content of `A` after executing `enq(Q,20)`, `deq(Q)` and `deq(Q)`.

i	0	1	2	3	4	5	...	97	98	99
A[i]							...			

Answers written in the margins will not be marked.

Answers written in the margins will not be marked.

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

(2 marks)

Mary changes the implementation of `Q` by allowing `H` to be any value from 0 to 99. Thus, the next element of `A[99]`, if any, is stored in `A[0]`.

For the new implementation of `Q`, Mary adjusts the pseudocode for `tail(Q)` and `deq(Q)` accordingly while the other subprograms remain unchanged.

(b) Suppose that `H = 98` , `N = 2` and the content of `A` is:

i	0	1	2	3	4	5	...	97	98	99
A[i]							...		76	22

Then, `enq(Q,12)` is executed. `H = 98` , `N = 3` and the content of `A` becomes:

i	0	1	2	3	4	5	...	97	98	99
A[i]	12						...		76	22

Then, `deq(Q)` is executed. `H = 99` , `N = 2` and the content of `A` becomes:

i	0	1	2	3	4	5	...	97	98	99
A[i]	12						...			22

Finally, `deq(Q)` , `enq(Q,8)` and `deq(Q)` are executed.

(i) What is the content of `A`?

i	0	1	2	3	4	5	...	97	98	99
A[i]							...			

(1 mark)

(ii) What is the value of `H`? _____

(1 mark)

(iii) What is the value of `N`? _____

(1 mark)

Answers written in the margins will not be marked.

(c) Write the pseudocode for `tail(Q)` for the new implementation of `Q`.

(4 marks)

(d) Complete the pseudocode for `deq(Q)` for the new implementation of `Q` below.

```
deq(Q)
  if isEmpty(Q) then
      output 'Not successful'
  else
      temp ← A[H]
      N ← N - 1
```

```
  return temp
```

(2 marks)

(e) Briefly explain why the new implementation of `Q` is more efficient.

(2 marks)

Answers written in the margins will not be marked.

Amy, Ben and Clara work on a project on upgrading a document management system (DMS) in an international company. They have some discussions during the system development.

Discussion 1

Amy: Which kind of programming language should we use for this project?
Ben: I suggest using a procedural language such as Pascal.
Clara: I prefer using an object-oriented language such as Python.

(a) (i) Briefly describe how object-oriented languages are different from procedural languages in terms of programming paradigms.

(2 marks)

(ii) Give **three** criteria Amy can use to select a programming language for the project, other than programming paradigms.

(3 marks)

Discussion 2

Amy: What is the progress of your programming work?
Ben: I have completed the security module of the DMS. I need to know whether it is compatible with the current system.
Clara: I have completed a new user interface. I need to know whether it meets users' expectations.

(b) What type of testing should Ben and Clara each carry out? What is the importance of each type of testing?

Ben:

Clara:

(4 marks)

Discussion 3

Amy: What do you think about the system conversion?

Ben: We should schedule a day for implementing the upgraded DMS and removing the old system in all the offices in different countries.

Clara: I disagree. I think we should first implement the upgraded DMS in the Hong Kong office. After that, we can do it for the other offices.

(c) Which strategy of system conversion (pilot conversion, phased conversion, parallel conversion or direct cutover conversion) did Ben and Clara each suggest? Give one advantage of each suggestion.

Ben: _____

_____

_____

_____

Clara: _____

_____

_____

_____

(4 marks)

(d) Give **two** reasons why regular updates of the DMS are necessary for the company.

_____

_____

_____

_____

(2 marks)

END OF PAPER

Answers written in the margins will not be marked.