2014-DSE
ICT
PAPER 2D

HONG KONG EXAMINATIONS AND ASSESSMENT AUTHORITY

HONG KONG DIPLOMA OF SECONDARY EDUCATION EXAMINATION 2014

INFORMATION AND COMMUNICATION TECHNOLOGY

PAPER 2D

Software Development

Question-Answer Book

11.15 am – 12.45 pm (1 hour 30 minutes)
This paper must be answered in English

Please stick the barcode label here.

Candidate Number									
Programming Language Used (Please tick one)	Pascal ☐ C ☐ Visual Basic ☐ Java ☐								

INSTRUCTIONS

(1) After the announcement of the start of the examination, you should first write your Candidate Number in the space provided on Page 1 and stick barcode labels in the spaces provided on Pages 1, 3, 5 and 7.

(2) Tick the appropriate box for the programming language used. **No marks will be awarded if you tick either more than one box or no boxes.**

(3) **ANSWER ALL QUESTIONS.** Write your answers in the spaces provided in this Question-Answer book. Do not write in the margins. Answers written in the margins will not be marked.

(4) Supplementary answer sheets will be supplied on request. Write your candidate number, mark the question number box and stick a barcode label on each sheet, and fasten them with string **INSIDE** this book.

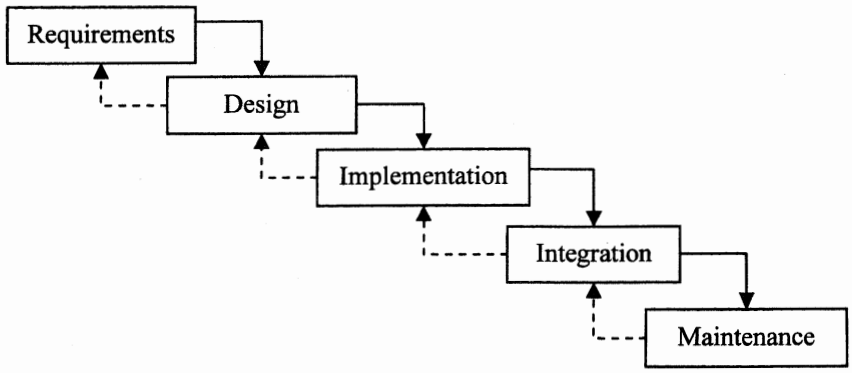
(5) No extra time will be given to candidates for sticking on the barcode labels or filling in the question number boxes after the 'Time is up' announcement.

* A 2 0 0 E 0 2 D *

Answer all questions.

1. Tom is going to develop an interactive voice response (IVR) system for customer service. Customers can interact with the system via a telephone keypad.

(a) Tom uses the following Waterfall Model to develop the IVR system.



(i) In which stage should the unit test be performed? _____

(ii) In which stage should the system test be performed? _____

(iii) What is the major difference between a system test and a user acceptance test?

_____

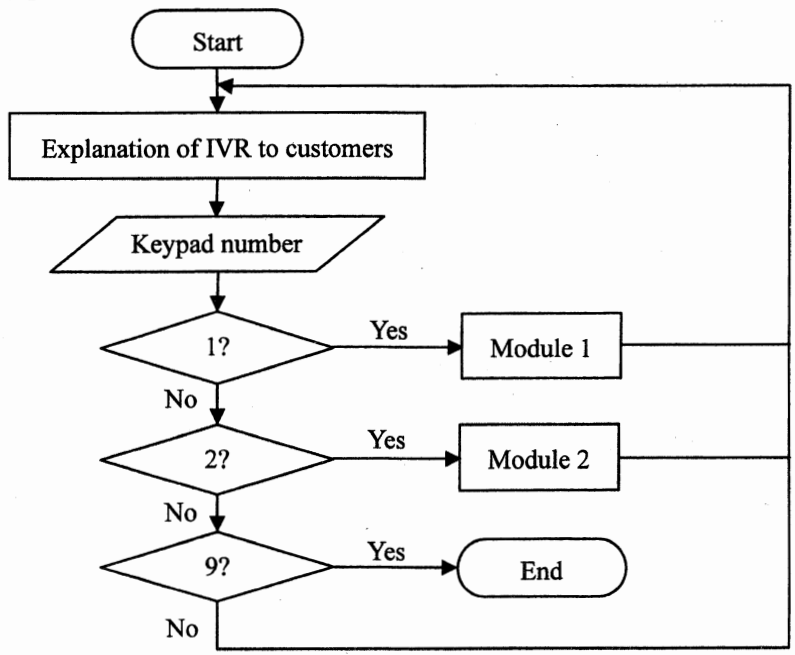
_____

(iv) What is the purpose of the arrows with dashed lines?

_____

(4 marks)

In the IVR system, a customer can choose from one of two modules by pressing keypad number 1 or 2. He can exit the system by pressing keypad number 9. The flowchart of the system is shown below:



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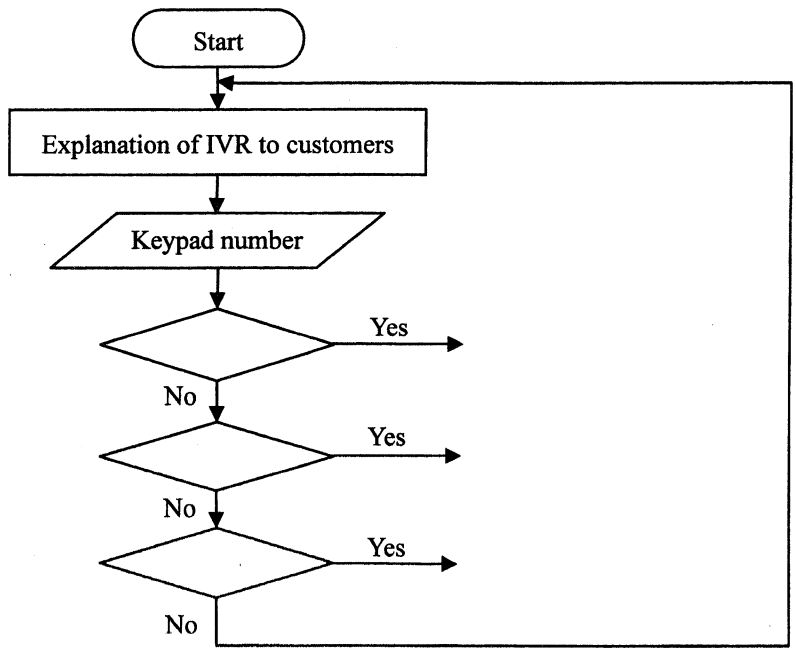
(b) (i) How many comparisons will be carried out if a customer presses keypad number 9? _____

(ii) Suppose that the percentages of pressing keypad numbers 1, 2, 9 and the other keypad numbers are 30%, 25%, 40% and 5% respectively. Complete the following flowchart to minimise the expected number of comparisons.



(4 marks)

In the IVR system, module 2 connects customers to account managers. The number of customers may be more than the number of account managers. Tom considers using a queue to store the information of customers in the waiting list.

The queue is implemented using an array `Q` with index from `0` to `n-1` and two integer variables `Qfirst` and `Qlast`. There are two subprograms, `PUSH` and `POP`. `PUSH(i)` adds the telephone line `i` to the end of the queue. `POP()` returns the first entry in the queue and removes it from the queue.

`Q`, `Qfirst`, `Qlast` and `n` are global variables.

(c) (i) Why does Tom use a queue instead of a stack to store the information of customers in the waiting list?

_____

_____

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(ii) The initial values of `Qfirst` and `Qlast` are `0`.

Complete `POP`.

[Pascal version]

```
procedure PUSH(i : Integer);
begin
  Q[Qlast] := i;
  Qlast := (Qlast + 1) mod n;
end;

function POP : Integer;
var Rvalue : integer;
begin
  if ( [          ] ) then
    POP := -1
  else begin
    Rvalue := [          ] ;
    Qfirst := [          ] ;
    POP := Rvalue;
  end;
end;
```

[C version]

```
void PUSH(int i) {
  Q[Qlast] = i;
  Qlast = (Qlast + 1) % n;
}

int POP() {
int Rvalue;
  if([          ]){
    Rvalue = -1;
  } else {
    Rvalue = [          ] ;
    Qfirst = [          ] ;
  }
  return Rvalue;
}
```


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[Visual Basic version]

```
Private Sub PUSH(ByVal i As Integer)
  Q(Qlast) = i
  Qlast = (Qlast + 1) Mod n
End Sub

Private Function POP() As Integer
Dim Rvalue As Integer

  If (                              ) Then
    Rvalue = -1
    Else

      Rvalue =

      Qfirst =
  End If
  POP = Rvalue
End Function
```

[Java version]

```
private static void PUSH(int i)
{
  Q[Qlast] = i;
  Qlast = (Qlast + 1) % n;
}

private static int POP() {
  int Rvalue;

  if(                              ) {
    Rvalue = -1;
  } else {

    Rvalue =                        ;

    Qfirst =                        ;
  }
  return Rvalue ;
}
```

(iii) When `POP()` returns `-1`, what does this mean? _____

(6 marks)

(d) Refer to the implementation of `PUSH` above.

(i) In terms of `n`, what is the maximum number of entries stored in the queue? _____

(ii) What will happen if the number of customers in the waiting list exceeds the value in (d)(i)?

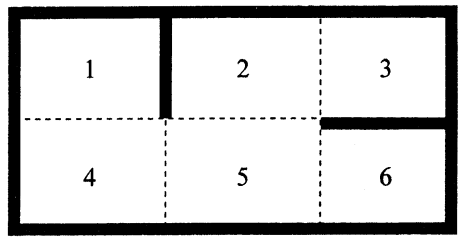
_____

(2 marks)

Answers written in the margins will not be marked.

2. John uses a two-dimensional array `A` with indexes `i` and `j` to represent a maze with `n` squares. Only `true` and `false` are the values in `A`. The `(i,j)`-th element in `A` is `true` only if square `i` can access square `j` directly. The `(i,i)`-th element in `A` is always `false` for all `i`.

(a) For example, the maze below has 6 squares. Square 1 can access Square 4 directly but it cannot access the other squares directly.



(i) Fill in the following entries in `A` for `i = 2`.

A		j					
		1	2	3	4	5	6
i	1	false	false	false	true	false	false
	2						
	⋮	⋮	⋮	⋮	⋮	⋮	⋮

(ii) What is the number of elements in `A`? _____

(3 marks)

John observes that

- square `i` cannot access square `i` itself directly;
- if square `i` can access square `j` directly, square `j` can access square `i` directly too.

(b) (i) What is the relationship between the `(i,j)`-th element and `(j,i)`-th element in `A`?

_____

(ii) Suppose `n = 6`. John thinks that he can use 15 elements in `A` to store all the information about the maze. Justify his idea.

_____

_____

_____

_____

_____

_____

(4 marks)

Answers written in the margins will not be marked.

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A function `isNeighbor(i,j)` returns `true` if square `i` can access square `j` directly. Otherwise it returns `false`.

John defines another function `twoNeighbors(i,j)`. This function returns `true` if there exists square `p` such that square `i` can access square `p` directly and square `p` can access square `j` directly where `i ≠ j`. Otherwise it returns `false`.

(c) Use the maze with 6 squares in (a).

(i) Give two parameters such that `twoNeighbors` returns `true`.

`twoNeighbors(_____, _____)`

(ii) Complete the algorithm of `twoNeighbors` below.

```
twoNeighbors(i,j)
RESULT ← [          ]
if i ≠ j
    for p from 1 to 6 do
        RESULT ← RESULT OR
                 (isNeighbor([          ]) AND isNeighbor([          ]))
return RESULT
```

(5 marks)

(d) John chooses to use an object-oriented programming language to implement a mobile application of the maze. Justify his choice with a characteristic of mobile applications.

_____

_____

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_____

(2 marks)

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3. Tom creates the following linked list to store student names. He uses arrays to represent the linked list in which a pointer `Next` is used to store the address of the next node. The first node stores 'START'.

Address	Content	Next
0	START	3
1	Ben	4
2	Kate	-1
3	Amy	4
4	Jade	5
5	Elle	-1
⋮	⋮	⋮

(a) (i) Write down the content of the next two nodes after 'START' in order.

_____

(ii) Tom uses '−1' to represent a null pointer. Other than '−1', give the possible range of values that he can use.

_____

(iii) How many nodes are there in this link list including the first node 'START'? _____

(4 marks)

Answers written in the margins will not be marked.

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Tom designs LL1 by adding another pointer, `Previous`. In each node, `Previous` points to the previous node, as shown in the following example.

LL1

Address	Content	Previous	Next
0	START	-1	3
1	John	3	4
2			
3	Susan	0	1
4	Fiona	1	-1

Tom designs two operations, `DELETE` and `INSERT`. `DELETE(n)` will delete the `n`-th node while `INSERT(n, sname)` will insert a node with the content of `sname` after the `n`-th node. The first node stores 'START'.

(b) Tom updates the example of LL1 above by executing the following operations in order.

```
INSERT(4, 'Mary')
DELETE(3)
```

Update LL1 below.

LL1

Address	Content	Previous	Next
0	START	-1	
1			
2			
3			
4			

(4 marks)

(c) Give one advantage and one disadvantage of adding `Previous` to the design.

_____

_____

_____

_____

(2 marks)

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(d) Tom modifies LL1 and designs LL2. He uses `PTR` to replace `Previous` and `Next`. `PTR` of each node stores the sum of the addresses in `Previous` and `Next` (i.e. `PTR = Previous + Next`).

For example, given the following LL1,

LL1

Address	Content	Previous	Next
0	START	-1	3
1	John	3	4
2			
3	Susan	0	1
4	Fiona	1	-1
5			

the corresponding LL2 will be

LL2

Address	Content	PTR
0	START	2
1	John	7
2		
3	Susan	1
4	Fiona	0
5		

(i) In the following LL2, write down the content of the next three nodes after 'START' in order.

LL2

Address	Content	PTR
0	START	0
1	Candy	3
2	Ben	3
3	Amy	6
4	Lee	7
5	Daisy	7

(ii) What is the benefit of using LL2?

(4 marks)

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4. Mr Chan works on string pattern analysis.

(a) Consider the following algorithm for a given string `ST`.

```
check ← TRUE
n ← length of ST
for i from 1 to n do
    if i-th character of ST ≠ (n-i+1)-th character of ST
        check ← FALSE
return check
```

(i) Dry run the algorithm with the following different string values of `ST` and write down the corresponding return values.

ST	check
ACGT	
GACTTCAG	
ACGCA	

(ii) What is the purpose of this algorithm?

_____

_____

(iii) Rewrite the first statement of the loop to improve the efficiency of the algorithm.

for `i` from _____ to _____ do

(5 marks)

Answers written in the margins will not be marked.

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Given a subprogram `MyLen` that returns the length of its input string, Mr Chan wants to write a subprogram `IsSub(T1, T2)` that checks whether `T2` is a substring of `T1`.

(b) Complete the algorithm of `IsSub`.

```
IsSub(T1, T2)
i ← 1
r ← FALSE
while (r is [          ] ) and (MyLen(T1) - MyLen(T2) + 1 ≥ i) do
    j ← [          ]
    r ← TRUE
    while ( [          ] > j) do
            j ← j + 1
            if [          ] -th character of T1 ≠ j-th character of T2
                    r ← FALSE
    i ← i + 1
return r
```

(5 marks)

(c) Mr Chan finishes the coding of `IsSub(T1, T2)`. He also writes another subprogram `MyCopy`.

[Pascal version]

`Function MyCopy(T:string; pos, n:integer):string` returns a substring of `T` where `pos` is the starting position of the substring and `n` is the length of the substring. The index of a string starts from 1. For example,

T	pos	n	MyCopy(T, pos, n)
AACTTGGTAC	3	4	CTTG

[C version]

`void MyCopy(char T[], char substr[], int pos, int n)` copies a substring of `T` into `substr` where `pos` is the starting position of the substring and `n` is the length of the substring. The index of a character array starts from 0. For example,

T	pos	n	substr
AACTTGGTAC	2	4	CTTG

[Visual Basic version]

`Function MyCopy(T As String, pos As Integer, n As Integer) As String` returns a substring of `T` where `pos` is the starting position of the substring and `n` is the length of the substring. The index of a string starts from 1. For example,

T	pos	n	MyCopy(T, pos, n)
AACTTGGTAC	3	4	CTTG

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[Java version]

`String MyCopy(String T, int pos1, int pos2)` returns a substring of `T` where `pos1` and `pos2` are the starting position and the ending position of the substring respectively. The character at `pos2` is excluded. The index of a string starts from 0. For example,

T	pos1	pos2	MyCopy(T, pos1, pos2)
AACTTGGTAC	2	6	CTTG

Mr Chan wants to find the length of the longest common substring of two given strings. For example,

T1	T2	longest common substring of T1 and T2	length of the substring
AACTTGGTAC	AAGACTG	ACT	3

Assume that two global variables `n1` and `n2` have stored `MyLen(T1)` and `MyLen(T2)` respectively and `n1 >= n2`. Write a subprogram `LongSub(T1, T2)` in Pascal, C, Visual Basic or Java that displays the length of the longest common substring of `T1` and `T2`.

(6 marks)

END OF PAPER

Answers written in the margins will not be marked.