Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

COMPUTER SCIENCE **9608/43**

Paper 4 Written Paper **May/June 2017**

MARK SCHEME

Maximum Mark: 75

Published

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<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>1(a)</td><td>
<table>
<tr><th>Label</th><th>Op code</th><th>Operand</th><th>Comment</th><th></th></tr>
<tr><td>START:</td><td>IN</td><td></td><td>// INPUT character</td><td rowspan="2">1</td></tr>
<tr><td></td><td>STO</td><td>CHAR</td><td>// store in CHAR</td></tr>
<tr><td></td><td>LDM</td><td>#65</td><td>// Initialise ACC (ASCII value for 'A' is 65)</td><td>1</td></tr>
<tr><td>LOOP:</td><td>OUT</td><td></td><td>// OUTPUT ACC</td><td>1 + 1</td></tr>
<tr><td></td><td>CMP</td><td>CHAR</td><td>// compare ACC with CHAR</td><td>1</td></tr>
<tr><td></td><td>JPE</td><td>ENDFOR</td><td>// if equal jump to end of FOR loop</td><td>1</td></tr>
<tr><td></td><td>INC</td><td>ACC</td><td>// increment ACC</td><td>1</td></tr>
<tr><td></td><td>JMP</td><td>LOOP</td><td>// jump to LOOP</td><td>1</td></tr>
<tr><td>ENDFOR:</td><td>END</td><td></td><td></td><td></td></tr>
<tr><td>CHAR:</td><td colspan="2"></td><td></td><td></td></tr>
</table>
</td><td>8</td></tr>
<tr><td>1(b)</td><td>
<table>
<tr><td>START:</td><td>LDD</td><td>NUMBER</td><td></td><td>1</td></tr>
<tr><td></td><td>AND</td><td>MASK</td><td>// set to zero all bits except sign bit</td><td>1</td></tr>
<tr><td></td><td>CMP</td><td>#0</td><td>// compare with 0</td><td>1</td></tr>
<tr><td></td><td>JPN</td><td>ELSE</td><td>// if not equal jump to ELSE</td><td>1</td></tr>
<tr><td>THEN:</td><td>LDM</td><td>#80</td><td>// load ACC with 'P' (ASCII value 80)</td><td>1</td></tr>
<tr><td></td><td>JMP</td><td>ENDIF</td><td></td><td></td></tr>
<tr><td>ELSE:</td><td>LDM</td><td>#78</td><td>// load ACC with 'N' (ASCII value 78)</td><td rowspan="2">1</td></tr>
<tr><td>ENDIF:</td><td>OUT</td><td></td><td>//output character</td></tr>
<tr><td></td><td>END</td><td></td><td></td><td></td></tr>
<tr><td>NUMBER:</td><td colspan="2">B00000101</td><td>// integer to be tested</td><td></td></tr>
<tr><td>MASK:</td><td colspan="2">B10000000</td><td>// show value of mask in binary here</td><td>1</td></tr>
</table>
</td><td>7</td></tr>
</table>

Question	Answer	Marks
2(a)	1 mark for the declaration of the array. 1 mark for assigning a 0 to Customer ID (CustomerID ← 0) 1 mark for getting the correct record (Customer[x].) 1 mark for setting up a loop to go <u>from 0 to 199</u> `DECLARE Customer : ARRAY[0 : 199] OF CustomerRecord` 1 `FOR x ← 0 TO 199` 1 `Customer[x].CustomerID ← 0` 1+1 `ENDFOR`	**4**

2(b)(i)	`PROCEDURE InsertRecord(BYVAL NewCustomer : CustomerRecord)`
	`  TableFull ← FALSE`
	`  // generate hash value`
	`  Index ←` **`Hash(NewCustomer.CustomerID)`** 1
	`  Pointer ← Index  // take a copy of index`
	
	`  // find a free table element`
	`  WHILE` **`Customer[Pointer].CustomerID > 0`** 1
	`  Pointer ←` **`Pointer + 1`** 1
	`  // wrap back to beginning of table if necessary`
	`  IF` **`Pointer > 199`** 1
	`  THEN`
	`Pointer ← 0` 1
	`  ENDIF`
	`  // check if back to original index`
	`  IF` **`Pointer = Index`** 1
	`  THEN`
	`  TableFull ← TRUE`
	`  ENDIF`
	`  ENDWHILE`
	`  IF` **`NOT TableFull`** 1
	`  THEN`
	`Customer[Pointer] ← NewCustomer` 1
	`  ELSE`
	`OUTPUT "Error"` 1
	`  ENDIF`
	`ENDPROCEDURE`
		9

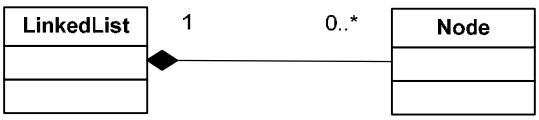
Question	Answer	Marks

2(b)(ii)	FUNCTION SearchHashTable(BYVAL SearchID : INTEGER) RETURNS INTEGER
	  // generate hash value
	  Index ← **Hash(SearchID)** 1
	  // check each record from index until found or not there
	  WHILE (**Customer[Index].CustomerID <> SearchID)** 1
	  AND (**Customer[Index].CustomerID > 0**) 1
	  Index ← Index + 1 1
	  // wrap if necessary
	  IF **Index > 199** 1
	  THEN
	  Index ← 0 1
	  ENDIF
	  ENDWHILE
	  // has customer ID been found?
	
	  IF **Customer[Index].CustomerID = SearchID** 1
	  THEN
	  RETURN Index 1
	  ELSE
	  RETURN -1 1
	  ENDIF
	ENDFUNCTION
		9

2(b)(iii)	A record out of place may not be found	**1**

Question	Answer	Marks

3	`FUNCTION Find(BYVAL Name : STRING,`
	`  BYVAL Start : INTEGER,`
	`  BYVAL Finish : INTEGER) RETURNS INTEGER`
	`  // base case`
	`  IF` **`Finish < Start`** 1
	`  THEN`
	`  RETURN -1`
	`  ELSE`
	`  Middle ←` **`(Start + Finish) DIV 2`** 1
	`  IF` **`NameList[Middle] = Name`** 1
	`  THEN`
	`  RETURN` **`Middle`** 1
	`  ELSE  // general case`
	`  IF SearchItem >` **`NameList[Middle]`** 1
	`  THEN`
	`Find(Name, Middle + 1, Finish)` 1
	`  ELSE`
	`Find(Name, Start, Middle - 1)` 1
	`  ENDIF`
	`  ENDIF`
	`  ENDIF`
	`ENDFUNCTION`
		7

Question	Answer	Marks
4(a)(i)	containment/aggregation	**1**
4(a)(ii)	 1 mark for the two classes (in boxes) and connection with correct end point 1 mark for 0 ..* 0	**Max 2**

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>4(b)</td><td>

mark as follows:

- Class heading and ending
- Constructor heading and ending
- Parameters in constructor heading
- Declaration of (private) attributes : Pointer, Data
- Assignment of parameters to Pointer and Data

Python Example

<pre>
class Node: 1
   def __init__(self, D, P):   1 + 1
      self.__Data = D   1
      self.__Pointer = P   1
      return
</pre>

Example Pascal

<pre>
type
   Node = class   1
      private   1
         Data : String;
         Pointer : Integer;
      public
         constructor Create(D : string; P : integer);
         procedure SetPointer(P : Integer);
         procedure SetData(D : String);
         function GetData() : String;   ignore
         function GetPointer() : Integer;
   end;
  constructor Node.Create(D : string; P : integer);   1+1
   begin
      Data := D;
      Pointer := P;   1
   end;
</pre>

Example VB.NET

<pre>
Class Node   1
   Private Data As String
   Private Pointer As Integer   1
   Public Sub New(ByVal D As String, ByVal P As Integer)   1+1
      Data = D
      Pointer = P   1
   End Sub
End Class
</pre>

</td><td>5</td></tr>
<tr><td>4(c)(i)</td><td>A pointer that doesn't point to any data/node/address</td><td>1</td></tr>
</table>

Question	Answer	Marks
4(c)(ii)	–1 (accept NULL) The array only goes from 0 to 7 // the value is not an array index	**2**

4(c)(iii)	**mark as follows:**
	• Class and constructor heading and ending
	• Declare private attributes (HeadPointer, FreeListPointer, NodeArray)
	• Initialise HeadPointer to null
	• Initialise FreeListPointer to 0
	• Looping 8 times …
	• Creating empty node in NodeArray
	• Use .SetPointer method to point each new node to next node
	• Set last node pointer to null pointer
	
	Python Example
	`class LinkedList:` 1
	`  def __init__(self):` 1
	`  self.__HeadPointer = - 1` 1
	`  self.__FreeListPointer = 0` 1
	`  self.__NodeArray = []`
	`  for i in range(8):` 1
	`  ThisNode = Node("", (i + 1))` 1
	`  self.__NodeArray.append(ThisNode)`
	`  self.__NodeArray[7].SetPointer(- 1)` 1
	
	Example Pascal
	`type`
	`LinkedList = class` 1
	`  private`
	`  HeadPointer : Integer;`
	`  FreeList : Integer;`
	`  NodeArray : Array[0..7] of Node;`
	`  public`
	`  constructor Create();`
	`  procedure FindInsertionPoint(NewData : string; var PreviousPointer, NextPointer : integer);`
	`  procedure AddToList(NewData : string);`
	`  procedure OutputListToConsole();`
	`end;`
	`constructor LinkedList.Create();` 1
	`var i : integer;`
	`begin`
	`  HeadPointer := -1;` 1
	`  FreeList := 0;` 1
	`  for i := 0 To 7 do` 1
	`  NodeArray[i] := Node.Create('', (i + 1));` 1
	`  NodeArray[7].SetPointer(-1);` 1
	`end;`
		Max 7

Question	Answer	Marks

	Example VB.NET
	`Class LinkedList` 1
	`  Private HeadPointer As Integer`
	`  Private FreeList As Integer`
	`  Private NodeArray(7) As Node`
	
	`  Public Sub New()` 1
	`  HeadPointer = -1` 1
	`  FreeList = 0` 1
	`  For i = 0 To 7` 1
	`  NodeArray(i) = New Node("", (i + 1))` 1
	`  Next`
	`  NodeArray(7).SetPointer(-1)` 1
	`  End Sub`
	`End Class`	

4(c)(iv)	• Creating instance of LinkedList assigned to contacts
	
	Python Example
	`contacts = LinkedList()`
	
	Pascal Example
	`var contacts : LinkedList;`
	`  contacts := LinkedList.Create;`
	
	VB.NET Example
	`Dim contacts As New LinkedList`
		1

Question	Answer	Marks

4(c)(v)	**mark as follows:**
	• Start with HeadPointer
	• Output node data
	• Loop until null pointer
	• Following pointer to next node
	• Use of getter (ie GetData/GetPointer)
	
	Python Example
	`def OutputListToConsole(self) :`
	`  Pointer = self.__HeadPointer` 1
	`  while Pointer != -1 :` 1
	`  print(self.__NodeArray[Pointer].GetData())` 1+1
	`  Pointer = self.__NodeArray[Pointer].GetPointer()` 1
	`  print()`
	`  return`
	
	Pascal Example
	`procedure LinkedList.OutputListToConsole();`
	`  var Pointer : integer;`
	`  begin`
	`  Pointer := HeadPointer;` 1
	`  while Pointer <> -1 do` 1
	`  begin`
	`  WriteLn(NodeArray[Pointer].GetData);` 1+1
	`  Pointer := NodeArray[Pointer].GetPointer;` 1
	`  end;`
	`  end;`
	
	VB.NET Example
	
	`Public Sub OutputListToConsole()`
	`  Dim Pointer As Integer`
	`  Pointer = HeadPointer` 1
	`  Do While Pointer <> -1` 1
	`  Console.WriteLine(NodeArray(Pointer).GetData)` 1+1
	`  Pointer = NodeArray(Pointer).GetPointer` 1
	`  Loop`
	`End Sub`
		5

Question	Answer	Marks

4(c)(vi)	**mark as follows:**
	• Store free list pointer as NewNodePointer
	• Store new data item in free node
	• Adjust free pointer
	• F list is currently empty
	• Make the node the first node
	• Set pointer of this node to Null Pointer
	• Find insertion point
	• If previous pointer is Null pointer
	• Link this node to front of list
	• Link new node between Previous node and next node
	
	Python Example
	`def AddToList(self, NewData):`
	
	`  NewNodePointer = self.__FreeListPointer`
	
	`  self.__NodeArray[NewNodePointer].SetData(NewData)`
	
	`  self.__FreeListPointer = self.__NodeArray[self.__FreeListPointer].GetPointer()`
	
	`  if self.__HeadPointer == -1:`
	
	`  self.__HeadPointer = NewNodePointer`
	`  self.__NodeArray[NewNodePointer ].SetPointer(-1)`
	`  else:`
	`  PreviousPointer, NextPointer = self.FindInsertionPoint(NewData)`
	`  if PreviousPointer == -1 :`
	
	`  self.__NodeArray[NewNodePointer ].SetPointer (self.__HeadPointer)`
	`  self.__HeadPointer = NewNodePointer`
	`  else:`
	
	`  self.__NodeArray[NewNodePointer ].SetPointer(NextPointer)`
	`  self.__NodeArray[PreviousPointer].SetPointer(NewNodePointer)`
		Max 6

Question	Answer	Marks
	Pascal Example	

```
    procedure LinkedList.AddToList(NewData : string);
    var NewNodePointer , PreviousPointer,
                                        NextPointer : integer;
    begin
      // make a copy of free list pointer
      NewNodePointer := FreeListPointer;
      // store new data item in free node
      NodeArray[NewNodePointer].SetData(NewData);
      // adjust free pointer
      FreeListPointer :=
NodeArray[FreeListPointer].GetPointer;
      // if list is currently empty
      if HeadPointer = -1
         then
            // make the node the first node
            begin
               HeadPointer := NewNodePointer;
               // set pointer to Null pointer
               NodeArray[NewNodePointer].SetPointer(-1);
            end
         else
            // find insertion point
            begin
               FindInsertionPoint(NewData, PreviousPointer,
                                                 NextPointer);
               // if previous pointer is Null pointer
               if PreviousPointer = -1
                  then
                     // link node to front of list
                     begin
                        NodeArray[NewNodePointer]
                                    .SetPointer(HeadPointer);
                        HeadPointer := NewNodePointer ;
                     end
                  else
                     // link new node between
                                  Previous node and next node
                     begin
                        NodeArray[NewNodePointer ]
                                      .SetPointer(NextPointer);
                        NodeArray[PreviousPointer]
                                 .SetPointer(NewNodePointer);
                     end;
             end;
     end;
```

Question	Answer	Marks

	VB.NET Example
	`Public Sub AddToList(ByVal NewData As String)`
	`  Dim NewNodePointer, PreviousPointer, NextPointer As Integer`
	`  ' make copy of free list pointer`
	`  NewNodePointer= FreeListPointer`
	`  ' store new data item in free node`
	`  NodeArray(NewNodePointer).SetData(NewData)`
	`  ' adjust free pointer`
	`  FreeListPointer = NodeArray(FreeListPointer).GetPointer`
	`  ' if list iscurrently empty`
	`  If HeadPointer = -1 Then`
	`  ' make the node the first node`
	`  HeadPointer = NewNodePointer`
	`  ' set pointer to Null pointer`
	`  NodeArray(NewNodePointer).SetPointer(-1)`
	`  Else`
	`  ' find insertion point`
	`  FindInsertionPoint(NewData, PreviousPointer, NextPointer)`
	`  ' if previous pointer is Null pointer`
	`  If PreviousPointer = -1 Then`
	`  ' link to front of list`
	`  NodeArray(NewNodePointer).SetPointer(HeadPointer)`
	`  HeadPointer = NewNodePointer`
	`  Else`
	`  ' link new node between Previous node and next node`
	`  NodeArray(NewNodePointer).SetPointer(NextPointer)`
	`  NodeArray(PreviousPointer).SetPointer(NewNodePointer)`
	`  End If`
	`  End If`
	`End Sub`	

Question	Answer	Marks

Pseudocode for reference:

```
PROCEDURE AddToList(NewData)
   // remember value of free list pointer
   NewNodePointer ← FreeListPointer
   // add new data item to free node pointed to by free list
   NodeArray[NewNodePointer].Data ← NewData
   // adjust free pointer to point to next free node
   FreeListPointer  ← NodeArray[FreeList].Pointer
   // is list currently empty?
   IF HeadPointer = NullPointer
      THEN
         // make the node the first node
         HeadPointer ← NewnodePointer
         // set pointer of new node to Null pointer
         NodeArray[NewNodePointer].Pointer ← NullPointer
      ELSE
         // find insertion point
         CALL FindInsertionPoint(NewData, PreviousPPointer, NextPointer)
         // if previous pointer is Null pointer
         IF PreviousPointer = NullPointer
            THEN
               // link new node to front of list
               NodeArray[NewNodePointer].Pointer ← HeadPointer
               HeadPointer ← NewNodePointer
         ELSE
            // link new node between previous node and next node
            NodeArray[NewNodePointer].Pointer ← NextPOinter
            NodeArray[PreviousPointer].Pointer ← NewNodePointer
         END IF
   ENDIF
END PROCEDURE
```