

**COMPUTER SCIENCE  
HIGHER LEVEL  
PAPER 2**

Wednesday 20 November 2002 (morning)

2 hours 30 minutes

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**INSTRUCTIONS TO CANDIDATES**

- Do not open this examination paper until instructed to do so.
- Answer all the questions.

1. A small shop stocks drinks and other items for sale. Details of the items are held in a stock file with the following record structure:

```
newtype ITEM record
    CODE integer
    DESCRIPTION string
    PRICE real
    STOCK integer
    REORDER integer
endrecord
```

```
declare DATA is ITEM file
```

Records are held in the DATA file in sequential order of CODE which is a 5-digit integer. The following algorithm conducts an iterative binary search of the DATA file.

```
procedure BINARYSEARCH(val WANTED integer,
                       val SIZE integer,
                       ref FOUND boolean,
                       ref PLACE integer)

// FOUND returns true if the WANTED code is in the file
// PLACE returns its location in the file DATA
// SIZE is the number of components in the data file
// The first component of DATA is numbered 0

declare MIDPOINT, LOW, HIGH, CODE integer
declare CURRENT is ITEM

FOUND <-- false
LOW <-- 0
HIGH <-- SIZE - 1

while (HIGH >= LOW) and (not FOUND) do
    MIDPOINT <-- (LOW + HIGH) div 2
    moveto (DATA, MIDPOINT)
    input (DATA) CURRENT
    if CURRENT.CODE > WANTED then
        HIGH <-- MIDPOINT - 1
    elsif CURRENT.CODE < WANTED then
        LOW <-- MIDPOINT + 1
    else
        FOUND <-- true
    endif
endwhile

PLACE <-- MIDPOINT

endprocedure BINARYSEARCH
```

*(This question continues on the following page)*

(Question 1 continued)

- (a) Outline why the parameters `FOUND` and `PLACE` are *pass-by-reference*. [2 marks]
- (b) Outline **one** difference between a *procedure* and a *function*. [2 marks]
- (c) Outline **one** difference between *iterative* and *recursive* algorithms. [2 marks]
- (d) Construct the algorithm which implements the binary search as a *recursive function* which returns the place of the wanted item in the file or `-1` if the item is not found. [10 marks]
- (e) Outline a Boolean condition that could be used to ensure that the `CODE` numbers all have 5 digits. [2 marks]
- (f) Construct the algorithm which conducts a *linear (sequential)* search of the data file and outputs the following information for each product whose `STOCK` level is less than the `REORDER` level:

```
ITEM CODE  
DESCRIPTION  
SHORT (which equals REORDER minus STOCK)
```

The algorithm must also output the total value of the stock in the shop (that is the sum of `STOCK*PRICE` for every item). [7 marks]

(This question continues on the following page)

(Question 1 continued)

The sales figures for each month are held in a 2D integer array SALES[500,13] with the following structure:

	1	2	3	4	5	6	7	8	9	10	11	12	13
1	10232	112	209	187	93	103	163	231	206	194	300	314	256
2	10343	13	15	32	22	34	33	...	...	...	...	...	...
3	10344	324	504	342	564	...	...						
4	10356	53	43	34	...								
5	10412	2	3	...									
6	11342	12	...										
7	<i>etc.</i>												
500	...	...	...										

(all cells are filled with integer data)

The first column of the array contains the 5-digit ITEM number and the remaining columns contain the sales figures with column 2 being January sales, column 3 being February sales and so on.

- (g) Construct the algorithm which outputs the following information for each product in the array:

ITEM CODE  
 LOWEST (that is the lowest value of sales in the 12 months) [5 marks]

*This question requires the use of the Case Study.*

2. (a) State **one** reason why the CT numbers are stored in 2 **bytes** even though only 12 **bits** are required for storage. [2 marks]
- (b) Outline **one** difference and **one** similarity between *parity checks* and *check sums* used to ensure *data integrity*. [4 marks]
- (c) Outline the meaning of the term *handshaking*. [2 marks]
- (d) Modern investigations use *digital modelling* and simulation in preference to physical models, made of plaster, for example. Explain **two** advantages and **two** disadvantages of *digital modelling* compared to *physical modelling*. [8 marks]
- (e) Outline any **two** ethical issues relating to the case study. [4 marks]
- (f) Outline any **two** precautions that a researcher should take to ensure that his or her username and password are not found out by *hackers*. [4 marks]
- (g) Explain **one** way in which the job of a researcher in this field might have changed since the introduction of CT. [2 marks]
- (h) Outline **one** advantage and **one** disadvantage of the *world-wide-web* as a medium for sharing scientific data such as the cranial reconstructions described in the case study. [4 marks]

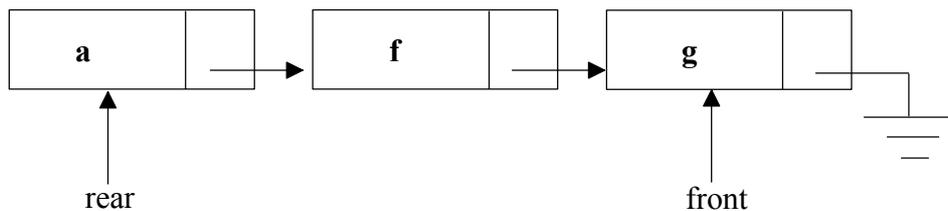
3. Consider the following two algorithms used to delete an integer value from an array:

```
function SHUFFLE(var PLACE integer,  
                ref INTARRAY integer array[1..SIZE]) result boolean  
  
  if PLACE <= SIZE then  
    for I <-- PLACE to (SIZE - 1) do  
      INTARRAY[I] <-- INTARRAY[I+1]  
    endfor  
    return true  
  else  
    return false  
  endif  
  
end SHUFFLE
```

```
function MARK (var PLACE integer,  
              ref INTARRAY integer array[1..SIZE]) result boolean  
  
  if PLACE <= SIZE then  
    INTARRAY[PLACE] <-- -999  
    return true  
  else  
    return false  
  endif  
  
end MARK
```

- (a) Compare the efficiency of these two algorithms in execution time and memory requirements. A determination of their big-O time complexity is expected as part of your answer. [6 marks]

A queue is implemented as a linked list, *g* is the element at the front of the queue:



- (b) Describe how a new element can be *enqueued* to this structure. [3 marks]
- (c) Explain how this structure can be modified to use a *circular linked list*. [2 marks]
- (d) Outline a method that could be used to count the number of items in the modified queue. [4 marks]

4. During the execution of a computer program, data held in *primary memory* is passed to the ALU and instructions are passed to the CU.

(a) Explain the functions of the *accumulator*, *instruction register* and *program counter* in this process. [6 marks]

(b) Outline **one** recent development in processor architecture that attempts to overcome the limitations of processing machine instructions one by one. [2 marks]

As part of the *fetch-decode-execute cycle*, the *interrupt register* is checked. An 8-bit register is shown below:

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

The most significant bit holds the highest priority *interrupt*.

(c) State the hexadecimal representation of this register. [1 mark]

(d) Explain how a byte such as hexadecimal 80 can be used to check the status of the *most significant bit*. [2 marks]

(e) *Buffers* are used with *peripheral devices*. In some situations they may become full. [2 marks]

(i) Outline why *buffers* are used.

(ii) Outline **one** way that the system would deal with a full *buffer*. [2 marks]

5. A data processing company uses a mainframe computer to prepare mobile phone bills. When a new customer is added the data is put onto a tape file. This tape is then sorted by customer ID order and used to update the customer *master file* which is held on disk, also in customer ID order.

(a) State **one** error that can occur when the *master file* is updated (not including file corruption or programming errors). [1 mark]

(b) Outline **one** reason why the *master file* is held on disk. [2 marks]

The company takes over another large company.

(c) Outline **two** problems that may occur when combining the two companies' customer files. [4 marks]

(d) Explain the process of merging together two sorted customer files. [8 marks]

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