



**COMPUTER SCIENCE
HIGHER LEVEL
PAPER 2**

Tuesday 16 November 2004 (morning)

2 hours 30 minutes

INSTRUCTIONS TO CANDIDATES

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

1. The mathematical function `FACTORIAL` can be defined as follows:

`FACTORIAL (0) = 1`
`FACTORIAL (N) = N * FACTORIAL (N-1);`

The following algorithm fragment could be used to calculate `FACTORIAL (5)`.

```
X <-- 5
F <-- 1
for C <-- 2 upto X do
    F <-- F * C
endfor
```

- (a) Copy and complete the following trace table for the algorithm given above.

F	C	F*C
1	2	2
2	3	6
6		
...

[2 marks]

- (b) Construct a *recursive* algorithm that will calculate the value of the `FACTORIAL` function.
- (c) Construct an algorithm `FACTDIFF` for a function which takes two parameters, X and Y and returns the difference between their `FACTORIALS` as a **positive** number.

[8 marks]

For example:

`FACTORIAL (3) = 6`
`FACTORIAL (2) = 2`

Then:

`FACTDIFF (2, 3) = 4`

If either parameter is negative, a suitable value should be returned to indicate an error. You should make use of function `FACTORIAL`, above.

[5 marks]

(This question continues on the following page)

(Question 1 continued)

A programmer requires a function to calculate the positive (absolute) difference between two factorials. The programmer decides that the running time of the `FACTORIAL` algorithm is too slow and decides to implement a lookup table (some sample values are shown below):

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
[1]	0	-1	-1	-1	-1	-1	...	...	...
[2]	1	0	-1	-1	-1	-1	...	...	...
[3]	5	4	0	-1	-1	-1	...	...	...
[4]	23	22	18	0	-1	-1	...	...	...
[5]	119	118	114	96	0	-1	...	...	...
[6]	719	718	714	696	600	0	...	...	...
[7]	...	...	...	...	...	...	...	...	...
[8]	...	...	...	...	...	...	...	...	...
[9]	...	...	...	...	...	...	...	...	...

The lookup table is stored in a global, two-dimensional array `LOOKUP` declared as follows:

```
declare LOOKUP integer array [1..9, 1..9]
```

- (d) Suggest why a row and a column for 0 have not been included and explain how the value of `FACDIFF (0, 5)` could be found from the table. [3 marks]
- (e) Construct the algorithm which will carry out the task described in (c) using the `LOOKUP` array, without using the `FACTORIAL` function. Assume the array `LOOKUP` already contains all the correct values. [5 marks]
- (f) Compare the efficiency of solution (e) with that of solution (c). [4 marks]

The following procedure can be used to fill part of the `LOOKUP` array with values:

```
procedure FILL( ref LOOKUP integer array[1..9, 1..9] )

declare ROW integer
declare COL integer

for ROW <-- 1 upto 9 do
  for COL <-- 1 upto 9 do
    if (COL <= ROW) then
      LOOKUP[ROW,COL] <-- -1
    else
      LOOKUP[ROW,COL] <-- FACTDIFF(ROW, COL)
    endif
  endfor
endfor
endprocedure FILL
```

- (g) State the *BigO* efficiency of this solution. [1 mark]
- (h) State **one** error the programmer has made and the correction required. [2 marks]

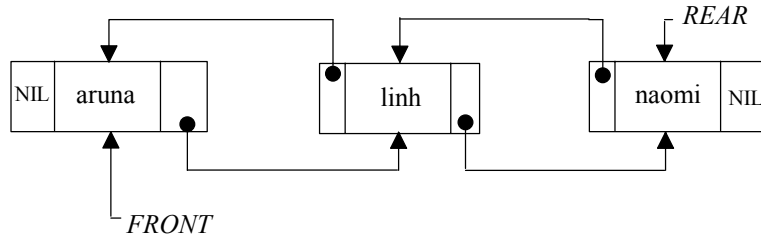
This question requires the use of the Case Study.

2. (a) Outline **one** characteristic of FMS (flexible manufacturing systems) that allows them to be *multipurpose machines*. [2 marks]
- (b) Compare the *human* operation of a machine tool with that of a *numerical control* system. [4 marks]
- (c) Explain, using specific examples from the case study, why there are many different *high level languages*. [4 marks]
- (d) (i) Draw a *binary tree* representing the following expression:

$$(A \cap (B \cup C)) \cup (E - F)$$

where symbols \cap , \cup and $-$ represent *boolean* operators of union, intersection and difference. [2 marks]
- (ii) Convert the expression given in part (i) into a *postfix* (RPN) expression. [2 marks]
- (e) The design department of a manufacturing company consists of five designers who have access to previous designs and to an expert system of real world objects. A previous design is to be modified in such a way that some parameters are changed and some real objects are reused. The design is then sent to the manufacturing department in another building and the product is manufactured using numerical control machines.
 - (i) Suggest a suitable *network topology* within the design department and describe how it would be used in this case. [3 marks]
 - (ii) Identify a suitable *network topology* for the manufacturing department. [1 mark]
 - (iii) With reference to *data integrity*, identify a suitable way of linking the two departments and state why it is suitable. [2 marks]
- (f) With reference to specific examples from the case study discuss **one** advantage and **one** disadvantage of FMS for:
 - (i) consumers [3 marks]
 - (ii) manufacturers. [3 marks]
- (g) Explain whether the following processes described on page 6 and page 7 of the case study are *batch*, *online* or *real-time processes*.
 - (i) Point to point movement of a machine tool [2 marks]
 - (ii) Adaptive control of a machine tool [2 marks]

3. A set of names is held in alphabetical order in a *doubly-linked* list with pointers to the front and rear:



- (a) Describe the structure of each node of the list. [3 marks]
- (b) Outline **one** advantage of storing the list as a *doubly-linked* list compared with a *single-linked* list. [4 marks]
- (c) Assume a new node containing ‘dorian’ is to be inserted in the correct position in the list. Explain the steps involved in the insertion. You may use a diagram, if you wish. [6 marks]
- (d) Draw a *balanced binary tree* which contains the same 3 nodes as the list drawn above. [2 marks]

4. A large bank runs a mainframe computer with a *multi-user, multi-tasking* operating system.

- (a) State **three** functions of an operating system. [3 marks]
- (b) Outline how the system keeps track of different users running different programs, apparently at the same time. [3 marks]
- (c) Outline the meaning of the term *virtual memory*. [2 marks]
- (d) Discuss **three** precautions that a network computer user should take to prevent a *hacker* breaking into the system. [4 marks]

A programmer writes a *high level language* program on the system which makes use of several library modules.

- (e) Explain the steps that are needed before the program can be run on the system. [3 marks]

5. A very large file of library books is held on disk and stored in order of a unique id. Some sample book records with a few fields is shown below:

id	title	author	year published	number of pages	more fields...
AF2234	A House on the plain	Tram, B	1998	239	...
BF4055	A Castle in the air	Vishwani, J	1955	451	...
KN4021	A Captain on the ship	Rimmer, A J	2002	108	...

- (a) Explain how a record is retrieved using a *binary search* on the id field. [4 marks]
- (b) Outline how a record can be retrieved using a partially indexed sequential file organization. [3 marks]
- (c) Explain how the file could be sorted on the author field even though it is too large to fit into computer memory. [3 marks]
- (d) Outline a method of *file organization* that permits efficient searching by author, book or year. [2 marks]
- (e) Explain how a *partially-indexed file organization* could be used to access the records by id number field. [3 marks]
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