

**Computer science**  
**Higher level**  
**Paper 1**

Friday 3 November 2017 (afternoon)

2 hour 10 minutes

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**Instructions to candidates**

- Do not open this examination paper until instructed to do so.
- Section A: answer all questions.
- Section B: answer all questions.
- The maximum mark for this examination paper is **[100 marks]**.

### Section A

Answer **all** questions.

1. Identify **two** essential features of a computer language. [2]

2. In the context of a networked world, state the role of

(a) a client. [1]

(b) a server. [1]

3. Identify **one** method of inputting data that can improve the accessibility of a computer system for some users. [1]

4. **Copy** and complete the following truth table. [3]

A	B	A NOR B	(A NOR B) OR A
FALSE	FALSE	...	...
...	...	...	...

5. Construct a logic diagram for the Boolean expression

NOT A OR B AND C. [3]

6. Consider the following recursive method, where N is a positive integer

```

mystery(N)
  if (N > 0) AND (N mod 2 = 0) then
    mystery(N-2)
  end if
  output N
end mystery

```

(a) Determine the output produced by the method call `mystery(5)`. [1]

(b) Determine the output produced by the method call `mystery(4)`. [3]

(c) Construct an iterative algorithm for the method `mystery()`, which uses a single `while` loop instead of recursion. [4]

7. The machine instruction cycle is the process by which a program instruction is fetched, decoded, executed and the results are stored.
- (a) State where all instructions and data are stored. [1]
- (b) Outline the role of the data bus and address bus in this process. [2]
8. Define the term *bit*. [1]
9. Outline what is meant by beta testing. [2]

### Section B

Answer **all** questions.

**10.** An application package used in an office includes a word processor.

- (a) Describe how a spellchecker checks whether a word in a text file is correctly spelt or not. [2]

The office manager decides to buy and install new software and hardware.

- (b) Outline **one** problem that may arise from the installation of new hardware and software in the office. [2]

The changeover to the new system can be achieved by either direct changeover or phased conversion.

- (c) Compare direct changeover and phased conversion. [4]

The new software allows basic text summaries and analysis to help check text files, including functions such as calculating word frequency.

- (d) Identify **one** way of testing this software. [1]

One of the methods in this software is `findFirst(CH, CHARARRAY)` which accepts a character, `CH`, and a one-dimensional array of characters, `CHARARRAY`, and returns the position of the first occurrence of character `CH` in `CHARARRAY`. It returns `-1` if `CH` does not appear in the array `CHARARRAY`.

For example, consider the character array `MESSAGE`, which is of length 19.

[0]	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]
A	U	R	O	R	A		M	U	S	I	S		A	M	I	C	A	.

For this array:

- The character at position 8 in the sentence is "U" and hence `MESSAGE[8] = "U"`.
- The character at position 18 in the sentence is "." and hence `MESSAGE[18] = "."`.
- The method `findFirst('A', MESSAGE)` returns 0.
- The method `findFirst('S', MESSAGE)` returns 9.
- The method `findFirst('Z', MESSAGE)` returns -1.

- (e) Construct an efficient algorithm for the method `findFirst()`. You should use the function `len()`, which returns the number of characters in an array (for example, `len(MESSAGE)` returns 19). [6]

11. A wireless local area network (WLAN) is used to extend access to a school's wired local area network.

- (a) Identify **one** hardware component of the WLAN, other than computers. [1]

The advantages of this WLAN are user-mobility and economical access points.

- (b) Outline **two** disadvantages of this WLAN. [4]

- (c) Identify **three** ways in which the network administrator can reduce the risk of unauthorized access to confidential data. [3]

The concept of packet data transmission is used within this network.

**Figure 1** shows the simplified structure of a data packet.

**Figure 1: The structure of a data packet**

Header (12 bytes)	Data (112 bytes)	Trailer / Footer (4 bytes)
<ul style="list-style-type: none"><li>• address of sender</li><li>• address of receiver</li><li>• protocol</li><li>• sequence number</li><li>• ...</li></ul>	Actual data to be transmitted (payload)	<ul style="list-style-type: none"><li>• transmission codes</li><li>• error checking codes</li><li>• control bits</li><li>• ...</li></ul>

- (d) Define the term *protocol*. [1]

- (e) With reference to **Figure 1**, explain how data is transferred by packet switching. [6]

12. A biotechnology company owns a resource centre which collects and classifies organisms for use in research.

Only authorized employees are allowed access to some laboratories in the resource centre.

These laboratories are protected by locked doors. Each door is controlled by a separate microprocessor. A digital camera is used to scan the iris of an employee who wishes to enter the lab. If the employee is authorized the doors are unlocked.

- (a) Identify **two** benefits of using a digital camera as an input device in this control system. [2]
- (b) Outline the use of a microprocessor in this control system. [2]
- (c) Outline the function of an output transducer. [2]

The company is planning to use a centralized computer system to secure the resource centre's building.

- (d) Compare a centrally controlled system with the system described above. [4]

The operating system has an important role in this system.

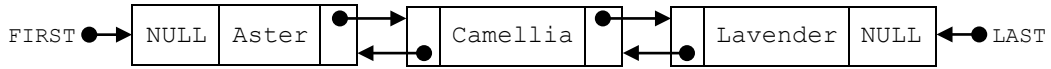
- (e) Identify **two** functions of the operating system. [2]

Polling and interrupt are two operating system management techniques.

- (f) Suggest with reasons which of these two techniques is the most appropriate for this centrally controlled system. [3]

13. (a) Describe the features of a dynamic data structure. [2]

Consider the following doubly linked list which holds the names of flowers in alphabetical order.



- (b) Explain how “Primrose” could be inserted into this doubly linked list. You should draw a labelled diagram in your answer. [6]

Consider the two stacks: FLOWERS and FRUITS.

**FLOWERS**

Aster
Broom
Camellia
Day Lily
Lavender
Primrose
Yarrow

**FRUITS**

Apple
Cherry
Orange
Pear

- (c) Show the output produced by the following algorithm. [4]

```

loop while (NOT FRUITS.isEmpty()) AND (NOT FLOWERS.isEmpty())
  X = FRUITS.pop()
  Y = FLOWERS.pop()
  if X < Y then
    output X
  else
    output Y
  end if
end loop
    
```

A third stack, FLOFRU, is needed. It should contain all the data from FLOWERS and FRUITS and will store it as shown below

**FLOFRU**

Yarrow
Primrose
Lavender
Day Lily
Camellia
Broom
Aster
Pear
Orange
Cherry
Apple

- (d) Describe how the FLOFRU stack could be created. [3]

14. Consider the following two-dimensional array, MAT, with dimensions 6 × 6.

	[0]	[1]	[2]	[3]	[4]	[5]
[0]	7	0	0	0	0	0
[1]	0	0	0	0	0	0
[2]	0	0	-3	0	9	0
[3]	0	0	0	0	0	0
[4]	0	0	-1	0	0	0
[5]	0	-6	0	0	-5	1

The value -1 is stored in MAT at position [4][2]. The position [4][2] means row 4 and column 2.

(a) State the total number of elements stored in MAT. [1]

(b) State the number of non-zero elements in MAT. [1]

A two-dimensional array in which most of the elements are zero is called a **sparse matrix**. A sparse matrix can be compressed by storing only non-zero elements using three one-dimensional arrays.

The **first array**, VALUES, stores all non-zero elements taken from the sparse matrix in row-major order (left-to-right then top-to-bottom order).

The length of the array VALUES is equal to the number of non-zero elements in the sparse matrix. For the sparse matrix above, MAT, the array VALUES is:

[0]	[1]	[2]	[3]	[4]	[5]	[6]
7	-3	9	-1	-6	-5	1

The **second array** is ROWC. ROWC[i] stores the number of non-zero elements, from row 0 to row i of the sparse matrix, **inclusive**.

The length of ROWC is equal to the number of rows in the sparse matrix. For MAT the array ROWC is:

[0]	[1]	[2]	[3]	[4]	[5]
1	1	3	3	4	7

For example, ROWC[2] stores 3 because in MAT there are three non-zero elements from row 0 to row 2, inclusive.

The **third array**, COL, stores the column index for each non-zero element in the sparse matrix. COL[i] stores the sparse matrix column index for the non-zero element stored in VALUES[i]. For MAT the array COL is:

[0]	[1]	[2]	[3]	[4]	[5]	[6]
0	2	4	2	1	4	5

(This question continues on the following page)



**(Question 14 continued)**

- (c) Construct an algorithm that compresses a  $6 \times 6$  two-dimensional array, such as `MAT`, into the three one-dimensional arrays described on page 8. You may assume that the  $6 \times 6$  array is inputted and all three one-dimensional arrays are initialized. [6]

Consider the following three arrays. They hold the compressed contents of a  $7 \times 7$  sparse matrix, `BIGMAT`.

VALUES

[0]	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
15	20	37	43	57	60	70	89	90	92

ROWC

[0]	[1]	[2]	[3]	[4]	[5]	[6]
1	3	4	5	5	7	10

COL

[0]	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
0	1	2	1	3	0	1	0	5	6

- (d) For a given column, `C`, in `BIGMAT`, outline how it could be determined that this column contains no non-zero elements. [2]
  - (e) State how many rows in `BIGMAT` contain only zeros. [1]
  - (f) (i) State the index in `VALUES` of the first non-zero element in row 5 of `BIGMAT`. [1]  
(ii) For a given row, `R`, in `BIGMAT`, determine the range of indexes in `VALUES` where non-zero elements in row `R` of `BIGMAT` are placed. You may assume that there is at least one non-zero element in row `R`. [3]
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