Diploma Programme
Programme du diplôme
Programa del Diploma

Computer science
Higher level
Paper 1

Friday 30 October 2020 (afternoon)

2 hours 10 minutes

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]**.

8820 – 7011

8 pages

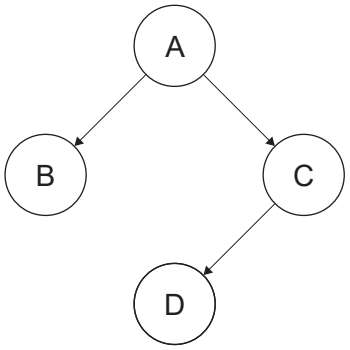
Section A

Answer **all** questions.

1. (a) Outline **one** feature of a word processor that could reduce the amount of typing required when writing letters. [2]

(b) State the purpose of technical documentation provided with software. [1]

2. Consider the following binary tree.



(a) State the result of inorder traversal of this binary tree. [1]

(b) State the result of preorder traversal of this binary tree. [1]

3. Describe how an operating system uses paging when running a program. [3]

4. Compare direct changeover with parallel running as a method of implementation. [4]

5. Outline **one** feature of autonomous agents. [2]

6. The machine instruction cycle is a sequence of actions that a central processing unit (CPU) performs to execute each machine code instruction in a program.

(a) State the part of the central processing unit (CPU) that performs the decoding. [1]

(b) Outline the function of the memory address register (MAR). [2]

7. Describe the steps involved in using the bubble sort algorithm to sort an array. [4]

8. Construct a truth table for the following logical expression. [4]

(A XOR B) AND NOT C

Section B

Answer **all** questions.

9. A school has a local area network (LAN) connecting its computers and peripheral devices. The LAN also provides access to the internet.

(a) Describe the role of a router in this network. [3]

Users have been troubled by slow speeds when accessing the internet.

(b) Outline **two** reasons why there might be a reduction in data transmission speed at certain times. [4]

(c) Outline **two** measures that the school could take to safeguard its data from unlawful access via the internet. [4]

The inventory of office supplies used in the school is stored on the computer as a single file.

Each of the office supplies in the inventory (such as paper, ink, toner, printers, pens, staplers, pencils and scissors) has a unique ID number, name, maximum quantity, minimum quantity and remaining quantity.

(d) Outline the steps in an algorithm that would output a list of supplies with the quantity to be ordered. [4]

10. Website developers need to consider a range of usability factors when designing a website.

(a) Identify **two** usability factors that need to be considered in the design of a website. [2]

(b) Outline **one** reason why visual displays on a computer screen can create difficulties for some people. [2]

A company promotes its products online. To make a purchase, customers are required to register with the company and provide data like their name, date of birth, age, gender and email address. Once registered, more than one customer is able to access the server to retrieve and modify their data at the same time.

(c) (i) State where the customer data is held during the process of modifying their data. [1]

(ii) Explain how the operating system ensures that each customer's data is secure when multiple users are accessing the data at the same time. [4]

The company is considering sharing its customers' data with marketing organizations.

(d) Explain why there could be ethical issues for the company when sharing its customers' data. [6]

11. A company produces and sells domestic floor-cleaning robots.

The floor-cleaning robots can clean different surfaces like wood and carpet. The floor-cleaning robots can also avoid obstacles or stairs.

Sensors are used by the processor that controls the floor-cleaning robot so that it can move safely.

(a) Describe **two** types of sensors used in the floor-cleaning robots. [4]

(b) Explain the function of an output transducer in this situation. [3]

A computerized security system for the company's headquarters protects against unauthorized access using a swipe-card system. Each door has a swipe-card reader that is connected to the central computer. A database stores the IDs of all employees and the rooms they are allowed to access.

(c) (i) Identify **one** alternative computerized method that could be used in place of the swipe-card readers. [1]

(ii) Describe how the method identified in (c)(i) functions. [3]

(d) Compare polling **and** interrupts as mechanisms for the swipe-card readers to interact with the central computer. [4]

12. (a) Describe **one** difference between stack and queue data structures. [2]

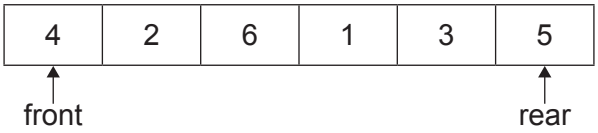
(b) State the purpose of the following queue methods:

(i) `enqueue()` [1]

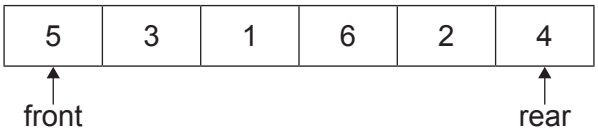
(ii) `dequeue()` [1]

(iii) `isEmpty()` [1]

Assume that the queue Q holds the following data:



The reversed queue Q would be:



(c) Construct an algorithm in pseudocode for reversing the queue using a stack data structure. You may assume that the data in the queue is input and a new empty stack is created. Only the standard queue and stack operations are allowed. [5]

Consider the following recursive method:

```
mystery(N)
    if N>0 then
        return 3 + mystery(N-3)
    else
        return 3
    end if
end mystery
```

where `N` is an integer.

(d) Determine the value of `mystery(7)`. Show all your working. [3]

(e) Outline **one** disadvantage of solving problems recursively. [2]

13. Images in computers are stored as two-dimensional arrays.

A black-and-white image (**Figure 1**) is stored as a 10 × 10 two-dimensional array named MAT (**Figure 2**).

Each element of MAT holds a number for a colour; 1 represents the colour black and 0 represents the colour white.

Figure 1: The simple black-and-white image

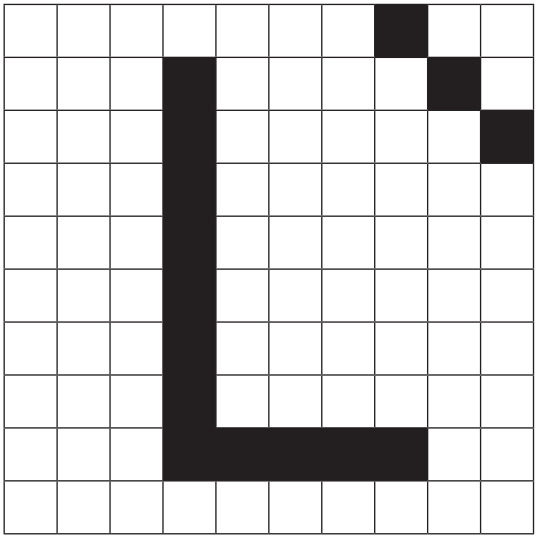


Figure 2: The corresponding two-dimensional array MAT

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

In an application, the black-and-white image can be inverted (all white pixels are changed to black, and all black pixels are changed to white).

Method `invert(N,A)` accepts a positive integer `N` and an `N` × `N` two-dimensional array `A` that holds the data for a simple black-and-white image; it returns the inverted `N` × `N` two-dimensional array `A`.

(a) Construct an algorithm in pseudocode for the method `invert(N,A)`. [3]

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(Question 13 continued)

In the application, it is also possible to rotate an image clockwise by 90 degrees (90°). For example, when the simple black-and-white image is rotated, the corresponding 10 × 10 two-dimensional array MAT is updated.

This would mean the first row of the original MAT is the last column in the rotated MAT, the second row is the second-to-last last column, … and the last row is the first column.

Figure 3: The simple black-and-white image rotated by 90° (clockwise)

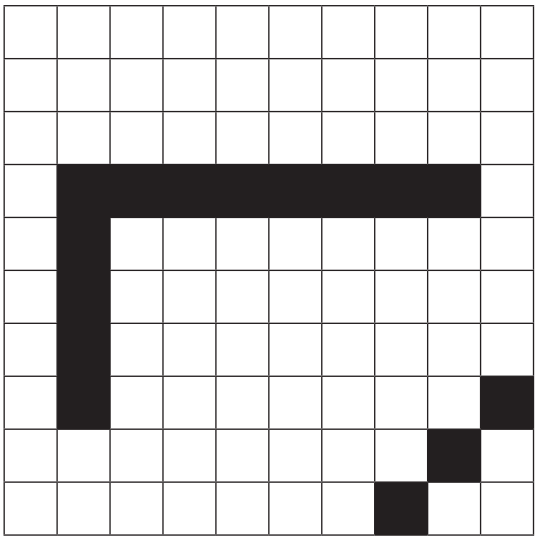

Figure 4: The corresponding two-dimensional array MAT

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

Consider the following algorithm fragment:

```
K=input()
loop for M=0 to K mod 4 - 1
    A=rotate(N,A)
end loop
```

where:

- `N` is an integer and `A` is the `N` × `N` two-dimensional array that holds data about an image
- `K(K>=0)` is an integer showing how many times the image should be rotated
- method `rotate(N,A)` accepts an integer `N` and an `N` × `N` two-dimensional array `A` representing an image. It returns an `N` × `N` two-dimensional array representing the image rotated clockwise by 90°.

(b) (i) State the number of degrees by which the image will be rotated if the input value of `K` is 3. [1]

(ii) Outline why it is more efficient that the loop in the given algorithm fragment executes `(K mod 4)` times instead of `K` times. You may give an appropriate example in your answer. [2]

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(Question 13 continued)

The algorithm for method `rotate(N,A)` uses an additional `N` × `N` two-dimensional array, named `B`. The `N` × `N` dimensional array `B` is initialized and updated using the values from `A` to represent the image rotated clockwise by 90°.

(c) Construct the algorithm in pseudocode for the method `rotate(N,A)` described above. [3]

To avoid inefficient use of memory, a new algorithm for the method `rotate(N,A)` is constructed.

The `N` × `N` two-dimensional array `A` should be rotated clockwise by 90°, **without** the use of any additional arrays.

One way of rotating the two-dimensional array `A` clockwise by 90° is to transpose `A`, and then reverse each row of `A`.

The transpose of `A` is formed by turning all the rows of `A` into columns. For example, the value in the first row and third column (`A[1][3]`) is swapped with the value in the third row and first column (`A[3][1]`).

(d) Construct the new algorithm in pseudocode for the method `rotate(N,A)` described above. [6]