L-Università ta' Malta

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE
EXAMINATIONS BOARD

ADVANCED MATRICULATION LEVEL
2019 FIRST SESSION

SUBJECT:	**Computing**
PAPER NUMBER:	I
DATE:	13th May 2019
TIME:	9:00 a.m. to 12:05 p.m.

Directions to Candidates

· Answer **ALL** questions.
· Good English and orderly presentation are important.
· All answers are to be written on the booklet provided.
· The use of flowchart templates is permitted but calculators may **not** be used.

SECTION A

1. Consider the following code which sorts the integer array called `myArray`:

```
int[] myArray = {6,8,7,5,9};
for (int i=1; i < myArray.length; i++) {
   int currentValue = myArray[i];
   int index = i;
   while (index > 0 && myArray[index-1] > currentValue) {
      myArray[index] = myArray[index-1];
      index--;
   }
   myArray[index] = currentValue;
}
```

   a. Show the contents of `myArray` after each iteration of the loop. (4)
   b. What type of sorting algorithm is being used? (1)
   (Total: 5 marks)

2. Consider the following two classes:

```
public class Employee {

  public void printSalary() {

    System.out.println("20,000");

  }

}


public class ComputerEngineer extends Employee {

  public void printSalary() {

    System.out.println("40,000");

  }

}
```

a. What is the `printSalary()` method in the `ComputerEngineer` class doing with respect to the `printSalary()` method in the `Employee` class?   (1)
b. What will the output be if the following code is executed?

```
Employee employee = new Employee();
employee.printSalary();
```
                                                                                    (1)
c. What will the output be if the following code is executed?

```
Employee employee = new ComputerEngineer();
employee.printSalary();
```
                                                                                    (1)
d. Would the code still compile if the access modifier of the `printSalary()` method in the `ComputerEngineer` class was changed to private? Give a reason for your answer.   (2)

(Total: 5 marks)

SECTION B

3. Name **THREE** switching techniques and briefly describe **TWO** of them. (5)
   (Total: 5 marks)

4. Suppose that you are to use even parity to transmit a byte of data: 11011011.
   a. Which bit value would you select as a parity bit to accompany the data being sent? Give **ONE** reason for your answer. (2)
   b. How would the receiver check whether there was an error in transmission? (1)
   c. Give **TWO** examples of retransmission schemes. (2)
   (Total: 5 marks)

5. a. What is device handshaking? Briefly describe the process of handshaking. (3)
   b. Name **TWO** scheduling algorithms used in process control. (2)
   (Total: 5 marks)

6. a. Memory store protection is an important memory management task. Why is this task necessary? (1)
   b. Mention **TWO** issues which result due to memory fragmentation. (2)
   c. A solution to memory fragmentation is compaction. Briefly describe how compaction can be performed by the operating system. (2)
   (Total: 5 marks)

7. Consider the following decision table:

Conditions	Decision Rules			
Salary payment due	Yes		No	
Overtime worked	**Yes**	**No**	**Yes**	**No**
Actions				
Pay salary	X	X		
Pay overtime	X			

   a. Which action(s) is/are taken if an employee has worked overtime but the salary payment is not due? (1)
   b. Rewrite the decision table in the form of a flowchart. (4)
   (Total: 5 marks)

8. a. Mention and briefly describe **TWO** system maintenance techniques. (4)
   b. Name **ONE** circumstance in which it would be best to use Joint Application Development (JAD) when developing a new system. (1)
   (Total: 5 marks)

9. a. Mention **TWO** feasibility aspects to consider when conducting a feasibility study. (2)
   b. Name **THREE** stages in the system design life cycle apart from the feasibility study. (3)
   (Total: 5 marks)

10. a. A company assigns product codes to its products consisting of a letter followed by two digits and three further letters (e.g. F16QRB). Define this product code format using Backus-Naur Form (BNF). (4)

   b. State how EBNF is different to BNF. (1)

   (Total: 5 marks)

11. a. Mention the **TWO** conditions necessary for a table to be in the Third Normal Form. (2)

   b. Briefly describe each of the following: primary key, foreign key, attribute. (3)

   (Total: 5 marks)

12. Consider the following Employee table:

surname	name	employee_id	function	town
Borg	John	171	clerk	Sliema
Attard	Anthony	43	cashier	Sliema
Briffa	Louise	571	manager	Sliema
Camilleri	Corinne	89	cashier	Sliema
Zerafa	Mark	232	programmer	Balzan
Psaila	Paul	55	engineer	Balzan

   a. What is the result of the SQL query:

   SELECT name, surname
   FROM Employee
   WHERE function = 'cashier'

   (2)

   b. Mention **TWO** advantages and **ONE** disadvantage of storing the employee data as in the Employee table above when compared to a traditional file system. (3)

   (Total: 5 marks)

13. Consider the following list of stack operations:

```
push 10
push 15
pop
push 20
```

   a. At the end of each operation, show the stack contents and the returned value (if any). (4)

   b. What is the difference between a static and a dynamic stack structure? (1)

   (Total: 5 marks)

14. a. Sketch diagrams to show the structures of a double linked list and a binary tree. (4)

   b. What is a hash function? (1)

   (Total: 5 marks)

15. Using any method of your choice, show that

$$\overline{A}\,\overline{B}\,\overline{C} + B\,C = (\overline{A} + B)(B + \overline{C})(\overline{B} + C)$$

(5)
(Total: 5 marks)

16. A two's-complement eight-bit fixed-point format has four integer bits and four fractional bits. For this format:
    a. determine the binary representation of the hexadecimal number 5A; (1)
    b. determine the decimal representation of the hexadecimal number 5A; (1)
    c. determine the binary representation of the hexadecimal number BC; (1)
    d. determine the decimal representation of the hexadecimal number BC. (2)
    (Total: 5 marks)

17. In this question, all ranges and code points are given in hexadecimal.

    UTF-8 is a Unicode encoding that requires:
    • 1 byte to store a code point in the range 0 to 7F,
    • 2 bytes to store a code point in the range 80 to 7FF,
    • 3 bytes to store a code point in the range 800 to 7FFF, and
    • 4 bytes to store a code point in the range 8000 to 10FFFF.

    These characters have the specified code points:

Character	Code point
$	24
.	2E
0–9	30–39
£	A3
€	20AC

    Determine the number of bytes required to encode the following strings in UTF-8:
    a. $100 (1)
    b. £75.99 (2)
    c. €10 (2)
    (Total: 5 marks)

18. a. Describe how a device that triggers an interrupt is serviced when using vectored interrupts. (2)
    b. Describe how a device that triggers an interrupt is serviced when using software polling. (2)
    c. State **ONE** advantage of vectored interrupts over software polling. (1)
    (Total: 5 marks)

19. A host computer is to be connected to a set of speakers for audio streaming using USB.
    a. State whether USB uses serial or parallel transmission, and give **ONE** advantage of the used kind of transmission. (2)
    b. The set of speakers has its own clock which is independent from the host computer's clock. State whether the communication is of the synchronous or asynchronous kind, and give **ONE** advantage of the used kind. (2)
    c. Name **TWO** other applications that make use of USB communication apart from audio streaming. (1)

(Total: 5 marks)

20. The following is part of an assembly program. Determine the contents of the register `ax` when the execution reaches the end of the program.

```
        mov ax, 5    ; set ax = 5
        mov cx, 0    ; set cx = 0
        mov dx, 0    ; set dx = 0
label1: cmp ax, 0    ; compare
        jle label2   ; jump if ax ≤ 0
        add dx, ax   ; set dx = dx + ax
        add dx, cx   ; set dx = dx + cx
        shr ax, 1    ; shift right by one bit
        inc cx       ; increment cx
        jmp label1   ; unconditional jump
label2: add dx, cx
```

(Total: 5 marks)

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE
EXAMINATIONS BOARD

**ADVANCED MATRICULATION LEVEL
2019 FIRST SESSION**

SUBJECT:	**Computing**
PAPER NUMBER:	II
DATE:	14th May 2019
TIME:	4:00 p.m. to 7:05 p.m.

Directions to Candidates

· Answer any **FIVE** questions.
· Good English and orderly presentation are important.
· All answers are to be written on the booklet provided.
· The use of flowchart templates is permitted but calculators may **not** be used.

1. a. Sketch a diagram showing how a process can transition from one state to another. (6)
   b. Suppose you are designing an operating system and need to decide how to organise file data using blocks. You would like to use a simple technique in which damage to a single block results in only localised loss of data. Which technique would you use? Explain the reasoning behind your choice. (3)
   c. What is thrashing? Describe how it can be avoided. (3)
   d. Describe how a batch operating system works. (6)
   e. Name **TWO** other types of operating systems other than batch operating systems. (2)
   (Total: 20 marks)

2. a. Distinguish between analogue and digital signals in networking. (6)
   b. Explain what is meant by multiplexing and describe **TWO** multiplexing techniques. (6)
   c. You have been asked to design a network for a company. For security reasons, the company would like to ensure that each packet transmitted by a company computer to another computer passes through their main server.
      i. Which network topology would you select, and why? (3)
      ii. Discuss **ONE** disadvantage of this network topology. (3)
      iii. If the network is to be located within the company's headquarters, which of the following network categories would you use, and why: PAN, LAN, MAN or WAN. (2)
      (Total: 20 marks)

3. a. An online marketplace allows sellers to log in and post adverts related to products they want to sell, and shoppers to view the products and purchase them. Draw a Use Case Diagram which depicts this specification. (8)
   b. What is meant by prototyping in system design? (2)
   c. Give the names of the stages in the system development life cycle (SDLC) for each of the following **FOUR** tasks: conducting interviews, determining which hardware is needed, developing a flowchart, checking whether there are any legal implications. (4)
   d. Compare and contrast the Waterfall lifecycle model with that of Rapid Application Development (RAD). (6)
   (Total: 20 marks)

4. Consider the following table:

Supplier code	Country code	City	Product code	Quantity
DX15	DE	Berlin	PR1	250
DX15	DE	Berlin	PR2	150
QP07	FR	Paris	PR1	350
DX15	DE	Berlin	PR3	200
QP07	FR	Paris	PR2	200
QP07	FR	Paris	PR3	250

a. Transform the table above to the 3rd Normal Form, showing all steps involved. (12)
b. Discuss **TWO** applications where databases are useful. (4)
c. Describe **TWO** types of database models. (4)

(Total: 20 marks)

5. An estate agent has asked a software development company to write Java code to store information about the properties (houses and apartments) which are available for prospective buyers. The code developed so far is given below.

```java
public class Property {

  private int price;

  public int numberOfBathrooms = 1;

}


public class House extends Property {

  public void updateNumberOfBathrooms(int numOfBathrooms) {

    numberOfBathrooms = numOfBathrooms;

  }

}
public class Apartment extends Property {

  private boolean isServicedByLift = true;

}
```

a. The estate agent would like to store the floor number of each apartment entered into the system. Write code which declares a new variable in the Apartment class to achieve this behavior, and sets it to a value of 5. There is no need to copy the whole class when writing this code. (2)
b. Suppose that in future, the estate agent would also like to offer other property types (e.g. villas) for sale. Describe how you would modify the code written by the software development company in order to cater for the new property type. (2)

c. Write code which creates a new instance of the `House` class and sets the number of bathrooms to two. (4)

d. Mention where inheritance and information hiding are being used in the above code. (4)

e. State and discuss **TWO** advantages which OOP principles provide over imperative programming. (4)

f. Consider the following code:

```
public class Exceptions {
        private void myMethod() throws NullPointerException {
          throw new NullPointerException();
        }
}
```

i. Explain the purpose of the "throws" keyword. (2)

ii. What is the output when executing the code below?

```
try {
        e.myMethod();
        System.out.println("Hello World");
} catch (NullPointerException npe) {
        System.out.println("Exception caught!");
} finally {
        System.out.println("Final block");
}
```

(2)

(Total: 20 marks)

6. a. Describe the processor's fetch/execute cycle. Your answer should include details of how the program counter (PC), memory address register (MAR), memory data register (MDR) and current instruction register (CIR) are used. (8)

   b. State which of the following assembly instructions modify the program counter (PC) during their execution:

Instruction	Description
push	Push a word onto the stack.
jc	Jump if the carry flag is set.
call	Call a function.
stc	Set the carry flag.

(2)

Question continues on next page

c. A memory device is connected to a processor via the data lines, address lines and control lines. Describe the read cycle, that is how the processor reads a word from the memory device. Your answer should include details of how the data lines, address lines and control lines are used during the read operation. (4)

d. A processor has a 32-bit wide address bus and uses byte addressable memory. The processor makes use of memory mapped I/O addressing and dedicates 500 Mb of address space to the I/O subsystem.

    i. Determine an approximation from the total address space that can be accessed using a 32-bit wide address bus. Hint: 2^{10} is approximately equal to 1000, 2^{20} is approximately equal to 10^6, … (3)

    ii. Hence determine the size of the address space dedicated to memory access. (1)

    iii. Determine an approximation for the percentage of the address space dedicated to I/O. (2)

(Total: 20 marks)

7. The following is an assembly program, where `ax`, `bx`, `cx`, `dx` and `di` are 16-bit registers. You can assume that all memory access instructions in the program read or write one byte only.

```
init:     mov bx, 1000h       ; set bx = hexadecimal 1000
          mov [bx], 97        ; write byte to memory location bx
          mov [bx + 1], 76    ; write byte to memory location bx + 1
          mov [bx + 2], 40    ; write byte to memory location bx + 2
          mov ax, 83          ; set ax = 83
          mov dx, 3           ; set dx = 3
          call insert         ; call function
          jmp finish          ; unconditional jump
                        ; ...
insert:   mov di, 0           ; set di = 0
loop:     mov cx, [bx + di]   ; read byte from memory location bx + di
          cmp ax, cx          ; compare
          jle cont            ; jump if ax ≤ cx
          mov [bx + di], ax   ; write byte into memory location bx + di
          mov ax, cx          ; set ax = cx
cont:     add di, 1           ; set di = di + 1
          cmp di, dx          ; compare
          jl loop             ; jump if di < dx
done:     ret                 ; return from function
finish:
```

a. Write down the contents of the three bytes at memory locations `1000h`, `1001h` and `1002h` when the execution reaches the `insert` label. (2)

b. Write down the contents of the same three memory locations each time the execution reaches the `cont` label. Hint: This happens four or fewer times. (7)

c. Write down the contents of the same three locations when the execution reaches the `finish` label. (2)

d. Deduce the functionality of the `insert` function. (3)

e. This program currently operates on a three-element byte array. The program is to be modified to operate on a five-element byte array instead. State what would need to be modified:

    i. in the initialisation code (before `insert` is called); and (1)

    ii. in the function itself (between the `insert` and `done` labels). (2)

f. Name **THREE** different addressing modes used in the assembly program. For each of these addressing modes, write down an example from the program. (3)

(Total: 20 marks)

8. *A* is a four-bit unsigned integer. An output *F* needs to be set as

   - $F = 0$ if $1 \leq A \leq 5$ or if $A = 13$
   - $F = 1$ if $7 \leq A \leq 12$
   - don't care otherwise

   a. Draw the truth table for *F*. (3)
   b. Using Karnaugh maps, find an optimised Boolean expression for *F*. (5)
   c. Draw a diagram showing how the Boolean expression obtained in (b) can be built using only two-input NAND gates. (8)
   d. NAND gates can be used to implement any function. Name another kind of gate that can be used to implement any function. (1)
   e. Using Boolean algebra, show that

$$\overline{XY + \overline{XY}\overline{Z}} = \overline{XY}\ \overline{\overline{Y}\overline{Z}}$$

(3)
(Total: 20 marks)