MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD

UNIVERSITY OF MALTA, MSIDA

MATRICULATION EXAMINATION
ADVANCED LEVEL
SEPTEMBER 2017

SUBJECT:	COMPUTING
PAPER NUMBER:	I
DATE:	4th September 2017
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 snippet of Java code:

```
int[] structure;
for (int  i=0; i<10; i++) {
    structure[i] = i;
}
```

a. Explain what is wrong with this code, and how you would modify it to ensure that it compiles and runs correctly? (2)
b. Explain how the binary search algorithm would locate the element *22* in the sorted array [1, 22, 78, 99, 105]. (2)
c. Is the linear search algorithm faster than binary search? Use the big-"O" notation to justify your answer. (1)

(Total: 5 marks)

2. a. Which data type would you use to store the value 1,000,000? (1)
b. Show the contents of myArray after each iteration of the while loop in the code below:

```
int a = 1;
int[] myArray = new int{0, 0, 0, 0, 0};
while (a < 5) {
   for (int i = 0; i < 6-a; i++) {
            myArray[i]++;
       }
       a++;
}
```

(4)

(Total: 5 marks)

SECTION B

3. a. Briefly describe **THREE** characteristics of object-oriented programming. (3)
   b. Distinguish between errors and exceptions in Java. (2)

(Total: 5 marks)

4. a. Sort the array with values [7, 3, 5, 1, 2] in ascending order using the bubble sort algorithm. Show the state of the list after each pass through the algorithm. (3)
   b. Name and briefly describe another **TWO** sorting algorithms other than bubble sort, which can be used to sort the array. (2)

(Total: 5 marks)

5. a. Define and briefly describe a PAN, LAN and WAN. (3)
   b. Why are error checking and error recovery important in data transmission over a network? (2)

(Total: 5 marks)

6. a. Give **THREE** examples of wireless network elements. (3)
   b. What is the difference between peer-to-peer and broadcast networks? (2)

(Total: 5 marks)

7. a. What is meant by the term Normalisation in Database Design? (2)
   b. How do we normalise a database to 2^{nd} normal form? (2)
   c. How do we normalise a database to 3^{rd} normal form? (1)

(Total: 5 marks)

8. a. Name and explain the **THREE** states that a process can be in. (3)
   b. What is the difference between preemptive and non-preemptive in the context of scheduling algorithms? (2)

(Total: 5 marks)

9. A palindrome is a sequence of characters that reads the same backwards as forwards. Two examples are *"madam"* and *"level"*. Define a palindrome using BNF notation, assuming you have an alphabet of only five letters {a, b, c, d, e}. **(Total: 5 marks)**

10. How is the following arithmetic expression **(6(4+5)-25)/(2+3)** represented using Reverse Polish Notation (RPN)? Show all of your working. **(Total: 5 marks)**

11. Name and describe **FIVE** feasibility aspects to consider when performing a feasibility study.

(Total: 5 marks)

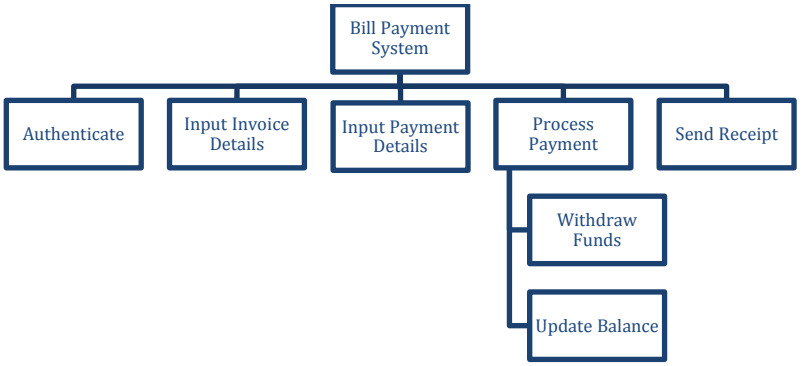
12. Assuming we have three resources and three processes using these resources. Explain with the use diagrams:
    a. a system which is not in deadlock. (1)
    b. a system which is in deadlock. (2)
    c. how a deadlock can be avoided? (2)

(Total: 5 marks)

13. Assuming we are creating a database about humans and we would like to create an Entity Relationship Diagram. What is the cardinality of each of the following relationships in just the direction given? (State any assumptions).
    a. Husband to wife; (1)
    b. Child to parent; (1)
    c. Human to Birthday; (1)
    d. Player to team; (1)
    e. Student to course. (1)

(Total: 5 marks)

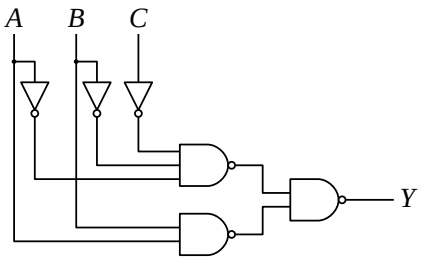
14. Consider the following Hierarchical Input Output Processing (HIPO) chart and answer the questions below.



    a. What is a HIPO chart? (1)
    b. Explain the HIPO chart above in relation to the system it is modelling. (4)

(Total: 5 marks)

15. Consider the following system:



    a. Draw a truth table for the system depicted above (3)
    b. Draw the truth table for the following system:

$$Z = (\bar{A} + B)(B + \bar{C})$$

(2)

(Total: 5 marks)

16. a. Convert the hexadecimal value 37_{16} to binary. (1)
    b. Convert the hexadecimal value $E5_{16}$ to decimal. (2)
    c. Convert the decimal value 99_{10} to binary. (2)

(Total: 5 marks)

17. a. Input/output (I/O) addressing refers to the method used by the CPU to address peripheral devices. Describe the difference between memory-mapped I/O addressing and isolated I/O addressing. (Isolated I/O is sometimes called port-mapped I/O.) (2)
    b. A RAM device is connected to a processor using data lines, address lines, and some control lines. Describe how these lines are used when the processor is required to store the value 50 in the RAM device at location 1000. (3)

(Total: 5 marks)

18. A 64 megabit (64×2^{20} bits) memory device is organised in 16-bit words. In one memory operation, a single word can be stored to or retrieved from this device.
    a. Write down the size of the data bus in bits. (1)
    b. Determine the capacity of the device in words. (2)
    c. Hence determine the required size of the address bus in bits. (2)

(Total: 5 marks)

19. From the assembly language instructions below, list:
    a. the data transfer instructions; (1)
    b. the arithmetic instructions; (1)
    c. the instructions that can write data to main memory; (1)
    d. the instructions that use the stack. (2)

    In your lists, you can refer to the instructions using the labels `i1`, `i2`, etc. Each instruction can be in one or more lists, or in none of them.

```
i1: cmp ax, bx  ;compare the contents of ax and bx
i2: je label    ;jump to label if equal
i3: mov ax, 0   ;store 0 into register ax
i4: mov [bx], 3 ;store 3 in location at address bx
i5: push ax     ;push the contents of ax onto the stack
i6: ret         ;return from subroutine
i7: sub ax, dx  ;subtract dx from ax
```

(Total: 5 marks)

20. Determine the contents of the register ax after the following assembly code snippet is executed. All working must be shown.

```
        mov ax, 0  ;set ax = 0
        mov cx, 5  ;set cx = 5
loop:   add ax, 10 ;set ax = ax + 10
        dec cx     ;subtract one from cx
        jnz loop   ;jump to label loop if cx is not 0
```

(Total: 5 marks)

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MATRICULATION EXAMINATION
ADVANCED LEVEL
SEPTEMBER 2017

SUBJECT:	COMPUTING
PAPER NUMBER:	II
DATE:	5th September 2017
TIME:	9.00 a.m. to 12.05 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. Write down, in decimal, the minimum and maximum values that can be represented by:
   i. a two's-complement integer consisting of six bits. (2)
   ii. a two's-complement fixed-point number consisting of four integer bits and four fractional bits. (You can use fractions in your answers.) (3)

   b. A digital system has a four-bit two's complement binary number A as its input. The output Y needs to be 0 when $A < -3$ and 1 when $A \geq -3$.
   i. Draw the truth table for Y. (3)
   ii. Using a Karnaugh map, determine a minimised expression for Y in terms of the four bits of A. (3)
   iii. Draw an implementation of Y using either NAND gates **or** NOR gates. (4)

   c. Using Boolean algebra, show that

$$\overline{(AB + AD)}(\bar{B} + \bar{C}) = \bar{A}\bar{B} + \bar{A}\bar{C} + \bar{B}\bar{D}$$

(5)

(Total: 20 marks)

Please turn the page

2. a. Briefly describe the use of the following CPU registers:
   i. memory address register (MAR); (1)
   ii. memory data register (MDR); (1)
   iii. current instruction register (CIR); (1)
   iv. program counter (PC). (1)

   b. Describe the fetch operation in the fetch, decode and execute cycle of a processor. In your answer, include details of how each of the MAR, MDR, CIR and PC registers are used. You do **not** need to describe the decode or execute operations. (6)

   c. Briefly describe the function of the Control Unit (CU) and the function of the Arithmetic Logic (AL) unit in the fetching and execution of an addition instruction. (2)

   d. Describe how the stack is used during a subroutine call and during the subsequent return from the subroutine. (4)

   e. For a typical expansion bus (AGP, PCI, etc.), describe the significance of:
   i. the throughput; (2)
   ii. the width. (2)

(Total: 20 marks)

3. a. Consider the following Java code snippet:

```
// Add two numbers
int     n1 = 5;
String  n2 = 2;
int result = n1 + n2;
```

   i. Rewrite the above code in the way you think it might look after it has been processed by a lexical analyser. (6)
   ii. Distinguish between a syntactic analyser and a semantic analyser. What errors, if any, would each one of these two discover when they process the program above? (4)

   b. Describe the portability provided by a compiler and provide examples. (5)

   c. Explain **TWO** code optimisation techniques, using examples to demonstrate your point. (5)

(Total: 20 marks)

4. This question is about error detection and recovery in communications.
   a. Name **TWO** possible reasons for error in communications. Why is error detection and recovery needed? (4)

   b. Explain how the even and odd parity checks work, giving an example in each case. (4)

   c. Name and describe the operation of **THREE** retransmission schemes used in error correction. (12)

(Total: 20 marks)

5. a. Define JCL and state what it is used for. (2)

   b. Discuss how an operating system protects files against access by unauthorised users and system failure. (8)

   c. Explain what relocate-ability means in the context of memory management processes. Give **TWO** reasons for relocate-ability to happen. (6)

   d. You are designing a computing system which should process safety-critical tasks with minimal delay. Which operating system would you use, and why? (4)

(Total: 20 marks)

6. The following is an assembly language program. Execution is to begin at the `start` label. The registers `ax`, `cx` and `dx` are 16-bit registers.

```
start:
        mov ax, 0      ;set ax = 0
        mov cx, 0      ;set cx = 0
repeat1:
        add ax, cx     ;set ax = ax + cx
        push ax        ;push ax onto the stack
        inc cx         ;add one to cx
        cmp cx, 5      ;compare cx to 5
        jl repeat1     ;jump to repeat1 if cx < 5
middle:
        mov dx, 0      ;set dx = 0
repeat2:
        pop ax         ;pop stack onto ax
        add dx, ax     ;set dx = dx + ax
        shl dx, 1      ;shift dx to the left by 1 bit
        dec cx         ;subtract one from cx
        jg repeat2     ;jump to repeat2 if cx > 0
finish:
```

   a. Identify **TWO** addressing modes used in the program. In each case, include the name of the addressing mode and an example instruction from the program. (2)

   b. Determine the values that are on the stack when execution reaches:
      i. the `middle` label; (3)
      ii. the `finish` label. (3)

   c. What is the arithmetic operation equivalent to shifting `dx` to the left by one bit in the instruction `shl dx, 1`? (2)

   d. Determine the value of `dx` when execution reaches the finish label. (5)

   e. Count the number of instructions, including conditional jump instructions, executed:
      i. between the start and middle labels; (1)
      ii. between the middle and finish labels. (1)

   f. In the program, identify the instructions, if any, that:
      i. write data to main memory; (1)
      ii. read data from main memory; (1)
      iii. modify the stack pointer (SP). (1)

(Total: 20 marks)

7. a. Explain the difference between any **TWO** types of JOIN clauses in SQL. (4)

b. Given the following tables:

```
SELECT * FROM runners;
+----+--------------+
| id | name         |
+----+--------------+
|  1 | John Smith   |
|  2 | Jane Smith   |
|  3 | Tom Jones    |
|  4 | Bobby Joe    |
|  5 | Lisa Thomson |
+----+--------------+

SELECT * FROM races;
+----+----------------+-----------+
| id | event          | winner_id |
+----+----------------+-----------+
|  1 | 100 meter      |  2        |
|  2 | 500 meter      |  3        |
|  3 | cross-country  |  2        |
|  4 | triathalon     |  2        |
+----+----------------+-----------+
```

What is the result of the query below? Explain your answer.

```
SELECT * FROM runners WHERE id IN (SELECT winner_id FROM races)
```

(5)

c. Given the following table:

```
+----+--------------+------------+
| id | name         | ReferredBy |
+----+--------------+------------+
|  1 | John Smith   | NULL       |
|  2 | Jane Smith   | NULL       |
|  3 | Anne Green   | 2          |
|  4 | Sam Branford | NULL       |
|  5 | Pat Meekers  | 1          |
|  6 | Alice Bean   | 2          |
+----+--------------+------------+
```

What is the result of the query below? Discuss if it manages to achieve the original intent of the query.

```
SELECT Name
FROM Customers
WHERE ReferredBy <> 2;
```

(5)

d. Given the following table:

```
Table: users;
+---------+------------+
| user_id | username   |
+---------+------------+
| 1       | John Smith |
| 2       | Jane Smith |
| 3       | Tom Jones  |
| 4       | Lisa King  |
+---------+------------+

Table: training_details;

+------------------+---------+-------------+---------------+
| user_training_id | user_id | training_id | training_date |
+------------------+---------+-------------+---------------+
| 1                | 1       | 1           | "2017-09-02"  |
| 2                | 2       | 1           | "2017-09-03"  |
| 3                | 3       | 2           | "2017-09-02"  |
| 4                | 4       | 2           | "2017-09-04"  |
| 5                | 2       | 2           | "2017-09-03"  |
| 6                | 1       | 1           | "2017-09-02"  |
| 7                | 3       | 2           | "2017-09-04"  |
| 8                | 4       | 3           | "2017-09-03"  |
| 9                | 1       | 4           | "2017-09-03"  |
| 10               | 3       | 1           | "2017-09-02"  |
| 11               | 4       | 2           | "2017-09-04"  |
| 12               | 3       | 2           | "2017-09-02"  |
| 13               | 1       | 1           | "2017-09-02"  |
| 14               | 4       | 3           | "2017-09-03"  |
+------------------+---------+-------------+---------------+
```

Explain the what the following query does:

```
SELECT
      u.user_id,
      username,
      training_id,
      training_date,
      count( user_training_id ) AS count
  FROM users u JOIN training_details t ON t.user_id = u.user_id
  GROUP BY user_id,
           training_id,
           training_date
  HAVING count( user_training_id ) > 1
  ORDER BY training_date DESC;
```

(6)

(Total: 20 marks)

8. A new mobile phone application allows users to request a nearby restaurant by selecting a cuisine type (Italian, Indian, Chinese, etc) and input a budget per person (e.g. €20). The app will then use the mobile phone's location services (GPS) to determine where the user's current location, obtain a list of restaurants that match the user's criteria from an internal database that it maintains, and subsequently return the details of the closest matching restaurant to the user. After visiting the restaurant, the user can also opt to provide a review for the restaurant through the app.

   a. Describe and distinguish between Use-Case Diagrams and Data Flow Diagrams (DFD). (4)

   b. Represent the functionality of the mobile phone application described above in a Use-Case Diagram. (4)

   c. Construct a Level-0 DFD for the application. (5)

   d. Construct a Level-1 DFD for the application. (7)

(Total: 20 marks)