

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD  
UNIVERSITY OF MALTA, MSIDA  
MATRICULATION EXAMINATION  
ADVANCED LEVEL  
SEPTEMBER 2016

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|----------------------|--------------------------------|
| <b>SUBJECT:</b>      | COMPUTING                      |
| <b>PAPER NUMBER:</b> | I                              |
| <b>DATE:</b>         | 2 <sup>nd</sup> September 2016 |
| <b>TIME:</b>         | 9.00 a.m. to 12.05 p.m.        |

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### 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.
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### Section A

1. The following algorithm represents a sort routine. The algorithm will sort an integer array `numbers[ ]` into ascending order.

```
public void sorting(int[]numbers, int dataItems){
//dataItems holds the number of integers in the array numbers

    int temp;

    do{
        for(int j=1; j<dataItems; j++){
            if(numbers[j-1]>numbers[j]){
                temp= numbers[j-1];
                numbers[j-1]=numbers[j];
                numbers[j]=temp;
            }
        }
        dataItems= dataItems-1;
    }
    while( dataItems>1);
}
```

Assume that `dataItems` represents the number of elements in the array, and that the array `numbers[ ]` already contains the following four elements:

`numbers[0]=10`

`numbers[1]=3`

`numbers[2]=6`

`numbers[3]=2`

- a. Copy and complete the trace table below for the first run through the algorithm found on page 1.

The first run of the for loop has already been done for you.

| j | j<dataItems? | numbers[0] | numbers[1] | numbers[2] | numbers[3] |
|---|--------------|------------|------------|------------|------------|
| 1 | true         | 10         | 3          | 6          | 2          |
| 2 |              |            |            |            |            |
| 3 |              |            |            |            |            |
| 4 |              |            |            |            |            |

[3 marks]

- b. Discuss whether this sort algorithm is a good choice for a company that sorts large amounts of data regularly. Justify your answer. [2 marks]

**Section B**

2. Using the Karnaugh map technique, determine a minimised Boolean expression for the function having the following truth table:

| A | B | C | D | F |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 1 | 0 |
| 0 | 0 | 1 | 0 | 1 |
| 0 | 0 | 1 | 1 | 1 |
| 0 | 1 | 0 | 0 | 0 |
| 0 | 1 | 0 | 1 | 1 |
| 0 | 1 | 1 | 0 | 0 |
| 0 | 1 | 1 | 1 | 1 |
| 1 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 1 | 0 |
| 1 | 0 | 1 | 0 | 0 |
| 1 | 0 | 1 | 1 | 1 |
| 1 | 1 | 0 | 0 | 0 |
| 1 | 1 | 0 | 1 | 1 |
| 1 | 1 | 1 | 0 | 0 |
| 1 | 1 | 1 | 1 | 0 |

[5 marks]

3. A computer memory chip has a capacity of 128 Megabits, that is,  $128 \times 2^{20}$  bits. The bits are grouped into words of 32 bits each.
- How many 32-bit words does the memory contain? [2 marks]
  - How many address bits are required in order to be able to address the 32-bit words individually? [2 marks]
  - Write down the capacity of the memory chip in Megabytes. [1 mark]
4. a. Using a block diagram show the internal structure of a computer processor and describe briefly the *Control Unit* (CU). [3 marks]
- b. Describe briefly how cache memory is used to improve processor performance. [2 marks]
5. Explain each of the following terms in relation to the assembly and execution of a program:
- Assembler; [1 mark]
  - Linker; [2 marks]
  - Loader. [2 marks]
6. Indicate which of the assembly instructions below, if any:
- ```
MOV  BX, CX
PUSH AX
POP  AX
CALL foo
JGE  lab
RET
```
- may modify the contents of register AX; [2 marks]
  - modify the stack. [3 marks]
7. a. In which stage of the compilation process does *compile-time error detection and handling* occur? [1 mark]
- b. Explain what is meant by the:
- syntax of a computer language; [2 marks]
  - semantics of a computer language. [2 marks]
8. a. What does *Reverse Polish Notation* (RPN) represent? [2 marks]
- b. Briefly explain how RPN is employed to carry out the representations mentioned in (a). [3 marks]

9. a. Name the **TWO** graphical techniques used during the Systems Analysis stage of the *Software Development Life Cycle* (SDLC). [2 marks]
- b. Describe **ONE** of the graphical techniques mentioned in (a) above. [3 marks]
10. a. Why is maintenance important during the *Software Development Life Cycle* (SDLC)? [2 marks]
- b. Briefly explain each of the following maintenance categories:  
i. Perfective;  
ii. Predictive;  
iii. Corrective. [3 marks]
11. a. In which stage of the *Software Development Life Cycle* (SDLC) are change-over techniques used? [1 mark]
- b. Using suitable examples compare the *parallel* and *phased* change-over techniques. [4 marks]
12. This question refers to a class that has been written to define a Stack. Within it there are the following properties:
- ```
int allData[]; //first index is 0
int top; //holds the index of the last item on the stack
```
- This class also contains the following two methods:
- ```
push(int x)
pop()
```
- a. Explain the purpose of the *push()* and *pop()* methods. [2 marks]
- b. Show the value of the property `top` when:  
i. The stack is empty;  
ii. The stack is full. [2 marks]
- c. What is the difference between a static and dynamic stack? [1 mark]
13. a. What kind of systems are Batch, Online and Real-time? [1 mark]
- b. What is the main purpose of the system mentioned in part (a)? [1 mark]
- c. Give an application area for each one of the systems mention in part (a). [3 marks]

14. a. Can file attributes be used to protect computer files? Explain. [2 marks]
- b. Identify **THREE** ways how to protect computer files. [3 marks]
15. a. Draw a diagram for each of the bus, ring and star topologies. [3 marks]
- b. Choose **ONE** of the above topologies and mention **ONE** advantage and **ONE** disadvantage. [2 marks]
16. a. Define the terms *TDM* and *FDM* in relation to communication networks. [2 marks]
- b. Briefly explain **ONE** of the methods mentioned in (a) above. [3 marks]
17. a. Explain in one sentence what is the *WWW*. [2 marks]
- b. Explain in one sentence what is the *Internet*. [2 marks]
- c. What does *TCP/IP* stand for? [1 mark]
18. a. Define the term *database*. [1 mark]
- b. Describe the difference between a *flat file database* and a *relational database*. [2 marks]
- c. Identify **TWO** functions of a *Database Management System (DBMS)*. [2 marks]
19. Consider the following schema:
- Project:** Project\_ID, Project\_Name, Budget
- Department:** Department\_ID, Department\_Name
- Employee:** Employee\_ID, Name, Job\_Description, Wage
- Construct an *Entity Relationship (ER) Diagram* to show how a relational database could be designed to make this possible. [5 marks]
20. a. Explain how the process of *normalisation* can complement the process of *Entity Relationship (ER) modelling* in database design. [3 marks]
- b. Are foreign keys allowed to have null values? Explain why using an example. [2 marks]

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| <b>SUBJECT:</b>      | COMPUTING                      |
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**Directions to Candidates**

- Answer any **FIVE** questions.
  - Good **English** and orderly **presentation** are important.
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- 

1. a. Distinguish between a half adder and a full adder. [2 marks]
- b. Draw the truth table showing all outputs of a full adder. [3 marks]
- c. Using Karnaugh maps, determine minimised Boolean expressions for each of the full adder outputs in terms of the full adder inputs. [6 marks]
- d. Using Boolean algebra, show that

$$ABC + \bar{A}BC + \bar{A}\bar{B}C + \bar{A}\bar{B}\bar{C} = \bar{A}B + \bar{A}C + BC$$

[5 marks]

- e. Describe the operation of an Arithmetic Logic Unit (ALU). Give an example of an ALU operation that makes use of adders, and an example of an ALU operation that does not make use of adders. [4 marks]

2. An assembly subroutine `nxpow2` is defined as follows:

```

nxpow2: DEC  AX           ;decrease AX by 1
        MOV  DX, AX      ;set DX equal to AX
        SHR  DX, 1       ;logical shift right DX by 1 bit
        OR   AX, DX      ;set AX to bitwise OR of AX, DX
        MOV  DX, AX      ;set DX equal to AX
        SHR  DX, 2       ;logical shift right DX by 2 bits
        OR   AX, DX      ;set AX to bitwise OR of AX, DX
        MOV  DX, AX      ;set DX equal to AX
        SHR  DX, 4       ;logical shift right DX by 4 bits
        OR   AX, DX      ;set AX to bitwise OR of AX, DX
        MOV  DX, AX      ;set DX equal to AX
        SHR  DX, 8       ;logical shift right DX by 8 bits
        OR   AX, DX      ;set AX to bitwise OR of AX, DX
        INC  AX           ;increase AX by 1
        RET              ;return from function nxpow2

```

The assembly snippet below makes use of the subroutine `nxpow2`.

```

begins: MOV  AX, 1001H    ;set AX equal to hex 1001
        CALL nxpow2      ;call function nxpow2
        MOV  BX, AX      ;set BX equal to AX
        MOV  AX, 1000H   ;set AX equal to hex 1000
        CALL nxpow2      ;call function nxpow2
ends:   ;end of snippet

```

- a. Determine the contents of the registers `AX` and `BX` in hexadecimal after the instructions in the snippet between `begins` and `ends` are executed. [15 marks]
  - b. Count the number of instructions executed when running the snippet between `begins` and `ends`. [3 marks]
  - c. Name **TWO** addressing modes used in the assembly instructions above. In each case, write down **ONE** example picked from the instructions above. [2 marks]
3. An essential part of a computer system is the operating system.
- a. What is its purpose? [4 marks]
  - b. What is the primary reason behind the choice of a specific operating system? Explain. [8 marks]
  - c. Identify **FOUR** types of operating systems. [4 marks]
  - d. Explain in some detail **ONE** of the operating system functions. [4 marks]

4. *Point-to-point* connections form the backbone of all networking communications.
- Briefly describe the basic concept behind *point-to-point* connections. [2 marks]
  - Identify and briefly explain **THREE** communication modes. [15 marks]
  - Give an example of each of the **THREE** modes named in (b) above. [3 marks]
5. a. Explain the main difference between the *prefix* and *postfix* methods in relation to the *Reverse Polish Notation* (RPN) for representing computer logic and arithmetic. [4 marks]
- b. Discuss why computers find it easier to employ RPN rather than the infix notation. [4 marks]
- c. How would these conventional infix expressions be represented in RPN?
- $(1 + 2) / (3 - 4)$  [2 marks]
  - $1 + 2 / 3 - 4$  [2 marks]
  - $1 + 2 / (3 - 4)$  [2 marks]
- d. Represent these RPN expressions as their conventional infix equivalents.
- $1\ 2\ 3\ 4\ *\ +\ 5\ -\ /$  [2 marks]
  - $1\ 2\ 3\ *\ -\ 4\ 5\ /\ +$  [2 marks]
  - $1\ 2\ 3\ ++$  [2 marks]
6. a. Name the **FOUR** exercises or tasks that need to be performed during the initial stages of the *Software Development Life Cycle* (SDLC) so that the problem is properly identified. [4 marks]
- b. Discuss in some length why each of the **FOUR** exercises mentioned in (a) are very important for a successful system. [16 marks]
7. A car rental company rents cars for tourists. The current renting system was developed a long time ago and it contains a lot of bugs. Therefore it was decided that a new system is to be developed using an *Object Oriented Programming* (OOP) approach.
- As a rule, each client is not allowed to borrow more than **five** cars at one go.
- Outline **TWO** advantages that the car rental company should expect from using an OOP approach. [4 marks]



Two classes were created. One was called **Client** and has three variables:

```
int clientId, String clientName and int numCars.
```

It also has one array: `Rent[] carsRented = new Rent[5];`

All variables are privatized.

A constructor is created as shown below:

```
public Client(int clientId, String clientName){
    this.clientId = clientId;
    this.clientName = clientName;
}
```

Four methods were created. These are their method signatures:

```
public Rent getRent (int n)
```

```
public void addCar(Rent car)
```

```
public int getClientId()
```

```
public String getClientName()
```

- b. Explain by referring to the **Client** class, how security can be improved by using encapsulation. [3 marks]

The second class is called **Rent** and is shown below:

```
import java.util.*;
public class Rent{

    private String numberPlate;
    private String carBrand;
    private Date d;
    static int numCarsRented = 0;

    public Rent(String numberPlate, String carBrand){
        this.numberPlate = numberPlate;
        this.carBrand = carBrand;
        this.d = new Date(); //set date rented
        numCarsRented = numCarsRented+1;
    }

    public String getNumberPlate(){
        return this.numberPlate;
    }
}
```

```

public String getCarBrand(){
    return this.carBrand;
}

public Date getDate(){
    return this.d;
}

public void setNumberPlate(String plate){
    this.numberPlate = plate;
}

public void setCarBrand(String brand){
    this.carBrand = brand;
}

public void setDate(Date d){
    this.d = d;
}
}

```

- c. Explain the use of the term *static* for the variable *numCarsRented* in the **Rent** class. [3 marks]
- d. The team has decided to use inheritance in its design. Describe **ONE** benefit that inheritance brings to the project. [2 marks]
- e. Construct the code required to add an object of a rented car with a number plate ABC-001 and car brand “Toyota” to a **Client** object called cl. [2 marks]
- f. The company wants that the system would be able to locate cars quickly, so that it knows who the client that rented the car was.
- i. Explain why it is a slow process to locate the cars rented in the current system design. [4 marks]
  - ii. Suggest a suitable data structure besides an array that would speed up the access of the *clientId* who has rented a specific car. [2 marks]
8. A ski resort offers ski equipment for rental. A member can make multiple rentals. A rental can be initiated by one member only. A sport equipment can be in one or more rental and a rental has one or more sport equipment.
- a. Draw a detailed *ER diagram* for this database. Use the *Crow’s Foot notation* to show the degree of the relationships that exist between the entities. [6 marks]
  - b. Explain what a conceptual data model is. What are the terms used in building a diagram of the data requirements. [4 marks]

SQL stands for *Structured Query Language*. SQL is used to communicate with a database.

- c. Explain the use of the following SQL commands:
- i. SELECT;
  - ii. FROM;
  - iii. WHERE;
  - iv. ORDER BY;
  - v. GROUP BY;
  - vi. HAVING. [6 marks]
- d. Define the following:
- i. Candidate key;
  - ii. Secondary key. [2 marks]
- e. Give an example of:
- i. A one-to-one relationship;
  - ii. A many-to-many relationship. [2 marks]