L-Università
ta' Malta

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE
EXAMINATIONS BOARD

**ADVANCED MATRICULATION LEVEL
2024 FIRST SESSION**

SUBJECT:	**Computing**
PAPER NUMBER:	I
DATE:	21st May 2024
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.

1. Given an 8-bit binary number representation, perform the following tasks.

    a. Convert the binary number 10110101 to its decimal equivalent. (1)
    b. Add the binary numbers 01101011 and 10110100 using binary arithmetic. (1)
    c. Calculate the range of numbers that can be represented using sign and magnitude representation in an 8-bit system. (1)
    d. Explain the concept of overflow and provide an example using 8-bit binary numbers. (2)

    (Total: 5 marks)

2. Consider the following logic statement:

    "If the temperature is above 30°C and the humidity is below 60%, or if the system is in manual mode, then turn on the cooling fan."

    a. Draw a logic circuit diagram that represents the entire given statement using appropriate logic gates. (2)
    b. Create a truth table for the combined logic circuit representing the given conditions. (2)
    c. Write the Boolean function for the given logic statement. (1)

    (Total: 5 marks)

3. Consider the following code snippet:

```java
public class AddingFifty {

    public static void main(String[] args) {

        int result = 0;

        for (int i = 0; i < 10; i++) {

            result = result + constantAddition();

        }

        System.out.println("The result is: " + result);

    }


    public static String constantAddition() {

        String a = "5";

        return a;

    }

}
```

Question continues on the next page.

    a. Name **ONE** error in the code above and state which phase of the compilation process would detect the error. (2)

    b. Mention **ONE** optimisation that could be applied to this code and produce a version of the code with the code optimisation being applied. (3)

(Total: 5 marks)

4. Consider the following assembly code snippet written for an 8086 processor:

```
MOV AX, 0300H;  Initialise AX with the value 0300H
ADD BX, AX;     Add the contents of AX to BX
MOV [BX], CX;   Move the value in CX to the memory address pointed to by BX
SUB DX, [SI];   Subtract the value at the memory address pointed to by SI from DX
JMP Label;      Unconditional Jump to the label 'Label'
```

Identify and explain the addressing modes used in **each** instruction. (5)

(Total: 5 marks)

5. The IT department of a growing organisation has assigned you the role of a Network Consultant to enhance their existing network infrastructure. The goal is to optimise data transmission, minimise errors, and ensure a reliable and efficient communication environment.

    a. What factors differentiate shielded and unshielded twisted pair cables? In your answer consider the factors of maximum length, speed, and EMI immunity. (3)

    b. What are the primary factors leading to errors in data transmission, with a focus on EMI and noise? Explain the potential consequences of these factors on the reliability of network communication. (2)

(Total: 5 marks)

6. The IT department of a multinational organisation is tasked with enhancing the data integrity of its network communication system. The focus is on implementing error detection measures through parity and checksum checks.

    a. Provide a brief comparison between parity checks and checksum checks in terms of their effectiveness as error detection measures. (2)

    b. Propose a specific scenario within the organisation where implementing parity checks would be instrumental in maintaining data integrity. Justify your choice. (2)

    c. Name **ONE** limitation or consideration associated with parity checks. (1)

(Total: 5 marks)

7. As the designated project manager for the implementation phase of a new Customer Relationship Management (CRM) system in a medium-sized retail company, the organisation aims to enhance customer interactions and streamline sales processes by transitioning from a legacy system. Your task is to carefully plan and execute the implementation phase, considering the tasks, changeover techniques, and potential challenges associated with the transition.

    a. Identify and describe the specific tasks that need to be addressed before the changeover to the CRM system is considered complete. (2)

    b. Outline the fundamental concept of **each** changeover technique, namely Direct, Parallel, and Phased Pilot. (3)

(Total: 5 marks)

8. A shop in Valletta maintains a database of products that it sells to customers. Now it wants to develop an e-commerce system and connect it to its database so it can sell products online. The company aims to streamline its operations, enhance decision-making processes, and improve overall efficiency. Your task is to conduct a comprehensive feasibility study to determine whether proceeding with the implementation of the e-commerce system is viable.

    Consider the following aspects in your feasibility study:
    i.   Technical Feasibility;
    ii. Operational Feasibility;
    iii. Timeliness Feasibility.

    a. Evaluate the compatibility with existing infrastructure, potential technical challenges, and the feasibility of integration with current systems. (3)
    b. Identify potential disruptions during the implementation phase and assess the ease of adaptation by end-users. (2)

    (Total: 5 marks)

9. A local library system is looking to improve its database management system (DBM's). The library maintains information about books and authors. Each book is written by one author, but an author can write multiple books. Design an Entity-Relationship (ER) diagram for these two entities with reasonable attributes, relationships and keys. (5)

    (Total: 5 marks)

10. In the evolving landscape of DBM's, understanding the strengths and weaknesses of various database models is crucial for effective data organisation and retrieval.

    a. Compare and contrast the hierarchical, network, and relational database models. Provide a brief scenario where **each** model might be most suitable. (3)
    b. Explain the key characteristics of object-oriented database models. In what scenarios would an object-oriented database be preferred over a relational database? (2)

    (Total: 5 marks)

11. Imagine you are tasked with designing a new computer system based on the Von Neumann architecture for a specialised application in scientific research.

    a. Discuss the specific features or enhancements you would incorporate into the CPU to maximise processing power and efficiency within the constraints of scientific computations. (2)
    b. Outline strategies to optimise the main memory to accommodate large datasets and ensure fast access times, considering the demands of scientific research applications. (2)
    c. Describe your approach to optimising the connectivity between the CPU, main memory, and Input/Output Subsystems through the System Bus, considering the unique requirements of scientific data transfer and external device interactions. (1)

    (Total: 5 marks)

Please turn the page.

12. A smart home automation system requires efficient communication between the various devices connected to it.

    a. In the context of a smart home system, explain how optimising the Address Bus, Data Bus, and Control Bus contributes to effective communication between different devices. (2)
    b. What would be the strategies you embark on to enhance system attributes that are specific to a smart home? Take into consideration:
       • Bus size considerations in relation to Data Bus and Address Bus widths.
       • The significance of the System Clock in ensuring timely interactions.
       • How devices like sensors, lights and thermostats are interconnected to a common bus using decoders to improve overall home automation efficiency. (3)

    (Total: 5 marks)

13. An engineering team is designing a computer system with a focus on I/O peripherals.

    a. Name **ONE** difference between USB ports and flash RAM. How can the two be used together? (2)
    b. Provide a brief example to differentiate between serial data transmission, synchronous data transmission and asynchronous data transmission. (3)

    (Total: 5 marks)

14. A large organisation has complex operations requiring an integrated computer system that utilises different types of operating systems for various purposes.

    a. Describe a specific scenario within the organisation where a batch operating system could optimise workflow and resource utilisation. (2)
    b. How can an online operating system enhance real-time collaboration and communication among employees? Provide a brief example to illustrate its practical application. (2)
    c. Identify **ONE** critical aspect of the organisation where a real-time operating system is important. (1)

    (Total: 5 marks)

15. You have been employed as a consultant for a company seeking to understand more about interrupt handling and Direct Memory Access (DMA).

    a. Briefly explain the significance of interrupt handling in computer systems and how it contributes to overall system efficiency. (2)
    b. Contrast software polling and vectored interrupts. Mention the pros and cons associated with both approaches. (3)

    (Total: 5 marks)

16. Consider the following matrix of integer values:

5	2
3	1

    a. What data structure would best be used to store the above matrix in Java? (1)
    b. Produce a Java code snippet which stores the values in a data structure and then, using loops, prints out the contents in a list as follows:

    ```
    5
    2
    3
    1
    ```

    (4)

    (Total: 5 marks)

17. The electoral register contains the details of all the people who are eligible to vote in the next election. This currently stands at around 400,000 people. Authorities asked you to store the details in a list and provide a linear search functionality to look up an individual voter's details using their ID card number. You think this will be too inefficient.

    a. Recommend a different search algorithm which is more efficient. State a prerequisite for the use of this algorithm. (2)
    b. What other data structure can be used which provides very efficient data retrieval? Briefly explain how it works, how data is stored and retrieved. (3)

    (Total: 5 marks)

18. An online quiz platform allows users to participate in quiz competitions whereby they need to answer questions within a specific amount of time. They are then given a score and the system displays a leaderboard showing the ranking of all the players who participated. Different programming paradigms can be used to implement different features of this system.

    a. Explain, with an example, how an imperative programming approach would be beneficial in implementing a feature of your choice for the quiz platform. (3)
    b. Identify a feature where functional programming characteristics can contribute to efficiency. Elaborate on how functional programming principles can enhance the development of this feature. (2)

    (Total: 5 marks)

19. Maltese ID card numbers consist of 8 digits followed by one of the letters M, L, G, or A. Formalise this definition using Backus-Naur Form (BNF) notation. (5)

    (Total: 5 marks)

20. You are developing a simple task manager application Java which enables users to maintain a list of tasks that they need to do, and then mark them as complete when they are done. A task consists of a task title, description, number of days in which to complete the task, and an indication of whether it has been completed or not. Every task starts off as being incomplete by default. Design a class named `Task` that represents a single task. The class should have the following components:

    a. Appropriate instance variables to store the task properties using correct datatypes. (2)
    b. A constructor to intialise these properties using parameters for the initial values. (2)
    c. A method called `completeTask()`, which marks the task as completed. (1)

    There is no need to create code for getters and setters.

    (Total: 5 marks)

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MATRICULATION AND SECONDARY EDUCATION CERTIFICATE
EXAMINATIONS BOARD

ADVANCED MATRICULATION LEVEL
2024 FIRST SESSION

SUBJECT:	**Computing**
PAPER NUMBER:	II
DATE:	21st May 2024
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. Imagine you are tasked with designing a combinational logic circuit for an automated greenhouse monitoring system. The system has four input sensors: Temperature Sensor (A), Humidity Sensor (B), Light Sensor (C), and Soil Moisture Sensor (D). The objective is to control various actuators based on specific environmental conditions for optimal plant growth.

   The system has three output variables, each controlling a different actuator:
   - Temperature Control (T): Activate the temperature control system if the temperature is too high.
   - Light Control (L): Adjust the artificial light source if natural light is insufficient.
   - Moisture Control (M): Activate the irrigation system if the soil moisture level is low.

   To simplify the design process, you are provided with the following truth table:

A	B	C	D	T	L	M
0	0	0	0	0	0	0
0	0	0	1	1	1	0
0	0	1	0	0	0	0
0	0	1	1	0	0	1
0	1	0	0	0	0	0
0	1	0	1	0	0	1
0	1	1	0	1	1	0
0	1	1	1	1	1	1
1	0	0	0	0	0	0
1	0	0	1	1	1	0
1	0	1	0	0	0	0
1	0	1	1	0	0	1
1	1	0	0	0	0	0
1	1	0	1	0	0	1
1	1	1	0	1	1	0
1	1	1	1	1	1	1

   a. Develop separate Karnaugh maps for **each** output variable (T, L, M). Clearly label the rows and columns of the Karnaugh maps. (6)
   b. Utilise the Karnaugh maps to derive simplified Boolean expressions for **each** output variable (T, L, M). Show the step-by-step process of grouping and simplification. (6)
   c. Design a combinational logic circuit using the simplified Boolean expressions. (3)

Please turn the page.

You are now required to integrate a seven-segment display into the greenhouse monitoring system. The display will serve as a visual indicator of the current environmental conditions or any alerts. Assume that the temperature range is from 0 to 9 degrees Fahrenheit. Each segment of the display is labelled a, b, c, d, e, f, and g.

Consider the binary input labelled ABCD provided to the decoder. The segments needed to form each digit are as follows:

Digit	INPUT				OUTPUT						
	A	B	C	D	a	b	c	d	e	f	g
0	0	0	0	0	1	1	1	1	1	1	0
1	0	0	0	1	0	1	1	0	0	0	0
2	0	0	1	0	1	1	0	1	1	0	1
3	0	0	1	1	1	1	1	1	0	0	1
4	0	1	0	0	0	1	1	0	0	1	1
5	0	1	0	1	1	0	1	1	0	1	1
6	0	1	1	0	1	0	1	1	1	1	1
7	0	1	1	1	1	1	1	0	0	0	0
8	1	0	0	0	1	1	1	1	1	1	1
9	1	0	0	1	1	1	1	1	0	1	1

    d.   Derive the simplified Boolean expressions for the first 3 outputs (a, b, c) using Karnaugh maps. For other input combinations, it is acceptable to designate the output as 'don't care' (X), as there are no additional digits to display. (5)

(Total: 20 marks)

2.   Infra Corp operates in multiple geographical locations, and efficient communication is crucial for the seamless functioning of its diverse departments. The current communication infrastructure, while functional, is showing signs of ageing and is not fully aligned with emerging technological trends. The company is determined to enhance its existing communication infrastructure to meet the evolving demands of a dynamic business environment.

As part of this initiative, you have been assigned the responsibility of formulating a comprehensive plan for the complete revamp of the organisation's networking and data communication systems.

    a.   Define computer network. Explain its significance in modern computing. (2)

    b.   Differentiate between point-to-point data communications and multipoint data communications. Provide **ONE** example of each. (4)

    c.   Compare serial and parallel data communication, highlighting their basic differences and specifying scenarios where **each** technology is more suitable. (4)

    d.   Define and distinguish between simplex, half duplex, and full duplex data communications. Illustrate scenarios where **each** mode is appropriate. (6)

    e.   Differentiate between analogue and digital data communication. Use diagrams to explain key differences. (2)

    f.   Describe the role of modems in data communication, emphasising analogue wave modulation and demodulation. (2)

(Total: 20 marks)

3. A university currently faces challenges with its Student Enrolment System. The existing system, while functional, operates on outdated technology, resulting in inefficiencies and delays in the enrolment process. As the university continues to grow, it becomes increasingly evident that a modernised and streamlined enrolment system is crucial to meet the evolving needs of students and administrative staff.

   Current challenges include:

   - Technological Obsolescence: The existing enrolment system relies on outdated technology, leading to slow processing times and occasional system downtimes.
   - Complex Processes: The enrolment process involves multiple steps, paperwork, and manual verification, leading to an increased likelihood of errors and delays.
   - Communication Gaps: Communication between different departments involved in the enrolment process is not seamless, causing misunderstandings and hindrances.
   - Limited Accessibility: Students face challenges accessing the enrolment system remotely, affecting the overall user experience and convenience.

   You are tasked with analysing and modelling a new system for the university.

   a. Create a Level 1 Data Flow Diagram (DFD) to represent the Student Enrolment System. Ensure **not** to exceed the detail of a Level 1 diagram. (4)
   b. Develop a Use-Case Diagram (UCD) illustrating the various actors and use cases within the Student Enrolment System. (4)
   c. Design a Class Diagram for the Student Enrolment System, considering classes related to students, courses, and enrolment. (4)
   d. Explain how UML diagrams, including DFDs, UCDs, and Class Diagrams, aid a system analyst in modelling different aspects of a software solution. (2)
   e. List and briefly describe **THREE** advantages of employing a modular design approach. (3)
   f. Explain the concept of prototyping and its significance in system development. Discuss a situation where using prototyping might be particularly beneficial for the Student Enrolment System. (3)

   (Total: 20 marks)

4.
   a. Select either RISC or CISC architecture. Provide a detailed explanation of the chosen instruction set, highlighting key features and differences from the other architecture. Emphasize practical considerations in programming and execution. (7)
   b. Explain in detail the functions of the Control Unit (CU) and the Arithmetic Logic Unit (ALU) in a CPU. Provide examples of scenarios where each unit plays a crucial role in instruction execution. How do these components contribute to overall system performance? (4)
   c. List and explain the steps involved in the "fetch," "decode," and "execute" cycles of a CPU. Emphasize the role of buses and registers during each phase. Discuss the implications for program efficiency. (4)
   d. Describe a practical application of a stack structure in the context of subroutine transfer. How does the stack facilitate efficient management of program execution flow? (3)
   e. Imagine you are a software architect tasked with optimising the performance of a complex software application. Briefly explain how a deep understanding of CPU architecture, including instruction sets, registers, control units, ALUs, and the fetch-decode-execute cycle, would influence your decisions in optimising the software. (2)

   (Total: 20 marks)

Please turn the page.

5. As a seasoned database architect, you've been assigned to develop a sophisticated database system for a multinational e-commerce platform specialising in electronics. The system must efficiently handle information about products, suppliers, customers, orders, and shipment tracking.

   Entities:
   - **Products:** Each product has a unique product ID, name, description, price, stock information, and details about its specifications.
   - **Suppliers:** Each supplier has a unique supplier ID, name, contact details, and a list of products they supply.
   - **Customers:** Each customer has a unique customer ID, name, email address, shipping address, and order history.
   - **Orders:** Record details of each customer's order, including order ID, product(s) purchased, quantity, total amount, and order status.
   - **Shipments:** Track information about shipments, including shipment ID, order ID, shipping date, expected delivery date, and delivery status.

   a. Create a comprehensive E-R model illustrating the relationships between Products, Suppliers, Customers, Orders, and Shipments. Indicate cardinality and participation constraints, considering the complexity of interactions. (5)
   b. Transform the detailed E-R model into a relational database design. Define tables for Products, Suppliers, Customers, Orders, and Shipments. Ensure appropriate use of primary keys, foreign keys, attributes, and complex table relationships. (5)
   c. Explain **TWO** responsibilities assumed by the role of a database administrator. (2)
   d. Discuss the role of HAVING in SQL queries. How does it differ from WHERE, and in what situations is HAVING preferred? (3)
   e. Describe the basic objectives of database normalisation. How does normalisation contribute to efficient data management? (2)
   f. What is the Third Normal Form (3NF)? Explain the conditions that must be met for a table to be in 3NF. (3)

   (Total: 20 marks)

6. In operating systems, processes go through different states - run, wait, and suspend - each playing a very important role in system efficiency. Moreover, scheduling also adds a dynamic layer to process orchestration.

   a. Explain the run, wait, and suspend states, highlighting the characteristics and activities associated with each state. (3)
   b. Provide a real-world scenario where a process transitions between these states. Explain the significance of these transitions in terms of system efficiency. (4)
   c. Explain the concept of Round Robin scheduling in process management. Highlight key characteristics including time slicing and circular queue. (3)
   d. Explain the concept of Priority scheduling in process management. Discuss how processes are prioritised and selected for execution. (3)
   e. Describe a scenario where Round Robin scheduling would be more suitable for process management. Justify your choice based on the nature of the tasks and system requirements. (3)
   f. Discuss the trade-off involved in choosing between Round Robin and Priority scheduling. Consider factors such as responsiveness, resource utilisation, and system efficiency. (2)
   g. Define what a deadlock is in the context of operating system process management and describe **ONE** method an operating system can use to prevent or avoid it. (2)

   (Total: 20 marks)

7. You are a new developer at a games development company and you are tasked with designing a futuristic space simulation game. The first thing that you need to do is to model the various spaceships that will be part of this game.

   a. Create a base class named `Spaceship` with important attributes like `name` and `fuelCapacity`. Include a constructor to initialise these attributes. (3)

   b. Implement a method named `launch()` that prints a message indicating the spaceship's launch. (2)

   c. Create two subclasses `FighterJet` and `CargoShip`, both extending the `Spaceship` class. In the `FighterJet` class add a unique attribute `weaponry` and a method called `attack()`. In the `CargoShip` add an attribute `cargoCapacity` and a method `loadCargo()`. (6)

   d. Introduce an abstract class named `SpaceshipPart` with an abstract method `activate()`. (2)

   e. Create **TWO** concrete classes that extend `SpaceshipPart`: `Engine` and `Shield`. Implement the `activate()` method differently in each subclass. (5)

   f. Overload the `launch()` method in the Spaceship class to take another parameter called destination. (2)

(Total: 20 marks)

8. A team has been tasked with implementing a new programming language. Their goal is to design and integrate language translators to make the language executable on various platforms. Demonstrate your understanding of language translators, virtual machine concepts, and related topics through the following challenges:

   a. Explain the key differences between assemblers and compilers, highlighting their roles in the translation process. Provide a real-world scenario where each is preferable. (4)

   b. Outline the main characteristics of interpreters and how they differ from compilers. Discuss a situation where using an interpreter would be advantageous over a compiler. (4)

   c. Briefly describe the functions of macro pre-processors, cross-compilers, and p-code compilers. Highlight a specific use case for each type. (6)

   d. Provide an overview of virtual machines in the context of programming languages. Explain how virtual machines facilitate platform independence and their role in executing high-level code. (3)

   e. Explore the concept of just-in-time compilation. Discuss its advantages in terms of performance and memory usage. Provide an example where the just-in-time compilation is particularly beneficial. (3)

(Total: 20 marks)